ICEBTM 2025

International Conference on Economics, Business and Technology Management

Dhaka, Bangladesh, 14 & 15 November 2025

Theme

Sustainability Focused Industry Trends in Global Research

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School of Business and Entrepreneurship
Independent University, Bangladesh (IUB)


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Message from the Chief Patron



Didar A. Husain
Chairman, Board of Trustees (BoT)
Independent University, Bangladesh (IUB)

On behalf of the Board of Trustees of Independent University, Bangladesh (IUB), I extend a warm welcome to all international and local participants of ICEBTM 2025. As we witness rapid transformations in technology, business practices, and environmental priorities, the need for sustainable approaches has never been greater. This conference comes at a critical moment, providing a stage where knowledge, innovation, and leadership converge to recommend new pathways for progress on sustainability.

ICEBTM 2025 intends to provide a platform for researchers, academics, and industry leaders all over the world to promote, share, and discuss various new issues and developments in the areas of Business, Economics, Technology, and Entrepreneurship. The Board of Trustees facilitates the School of Business and Entrepreneurship (SBE) in organizing such an impactful initiative that positions Bangladesh on the international stage of academic and industry dialogue. ICEBTM 2025 is not just an academic gathering but a call to action to strengthen partnerships among institutions, industries, and communities so that together we can face the challenges of sustainability and development.

This conference, ICEBTM 2025, will critically examine how businesses can transition from being part of the challenge to becoming central drivers of solutions. This will be achieved through a multidisciplinary lens, fostering a necessary dialogue on the strategic integration of business models, economic principles, and transformative technologies.

I sincerely hope that this conference will spark transformative ideas, strengthen networks, and inspire participants to play a meaningful role in shaping industries that are not only innovative but also responsible and resilient.

Message from the Patron



Prof. Dr. M. Tamim
Vice Chancellor
Independent University, Bangladesh (IUB)

It gives me immense pleasure to welcome you to the International Conference on Economics, Business and Technology Management (ICEBTM 2025), being held on 14–15 November 2025, at The Westin Dhaka. This year's theme, "Sustainability Focused Industry Trends in Global Research," reflects Independent University, Bangladesh's (IUB) continued commitment to addressing the most pressing challenges of our time through meaningful scholarship and collaboration.

The core mission of ICEBTM 2025 is to directly translate academic insight into industrial applications. The conference is designed as a collaborative workshop for the future, deliberately bringing together researchers and industry leaders to bridge the gap between academia and industry. As universities around the world strive to create greater impact in society, IUB recognizes the importance of bridging academic excellence with industry-driven practices.

I am delighted to welcome distinguished speakers, dedicated researchers, and promising young scholars to this conference. I believe the knowledge shared and networks formed here will go a long way in contributing to resilient, inclusive, and sustainable futures across industries.

Message from the Advisor



Prof. Dr. Daniel W. Lund
Pro Vice Chancellor
Independent University, Bangladesh (IUB)

On behalf of the Independent University, Bangladesh (IUB) and the Office of the Pro-Vice Chancellor, I am delighted to support the ICEBTM 2025 Conference and the publication of the Conference proceedings. As a driving force of business education in Bangladesh, IUB's School of Business and Entrepreneurship brings together a wealth of local and international scholars from a wide range of educational and topical backgrounds.

The ICEBTM 2025 Conference, likewise, has brought together scholars, industry experts, and educators from around the world to share ideas and scholarly insights, to discuss contemporary issues in economics, business, and technology management, and to build cooperative research communities. The Conference proceedings are a highly effective way for the School of Business and Entrepreneurship to highlight the innovative research and insights shared at the ICEBTM 2025 Conference.

I offer a vote of thanks to the Conference organizing teams, the proceedings' contributors and editors, and all of the administrators and participants that made ICEBTM 2025 and the publication of the proceedings possible.

Message from the Honorary General Chair



Prof. Dr. Raisul Awal Mahmood
Dean (Acting)
School of Business and Entrepreneurship, IUB

It's a great honor and privilege to welcome you to the ICEBTM 2025, organized by the School of Business and Entrepreneurship (SBE) at Independent University, Bangladesh. Power of collaboration – between faculty and students, academia and industry, research and practice, is the cornerstone of the SBE's vision. This conference enshrines that vision by offering a vibrant platform to exchange new ideas, showcase innovations, and forge enduring partnerships.

The chosen theme, ***"Sustainability Focused Industry Trends in Global Research,"*** underscores the urgency of aligning business practices and technological advancements with the imperatives of environmental responsibility and social well-being. Different sessions, discussions, and presentations will highlight the dynamic role of business and technology in advancing global challenges while promoting inclusivity and long-term growth.

As an Honorary General Chair of ICEBTM 2025, I am confident that this conference will catalyze academic excellence, industry engagement, and impactful research. I extend my heartfelt appreciation to our speakers, contributors, and participants for their support to make this conference a success.

Message from the General Chair



Prof. Dr. Md. Mamun Habib
Head, Department of Management
School of Business and Entrepreneurship (SBE)

As General Chair of ICEBTM 2025, I am delighted to welcome all distinguished guests, researchers, and practitioners to this international conference taking place on November 14-15 in Dhaka, Bangladesh.

The School of Business and Entrepreneurship (SBE), ***an AACSB member and ACBSP-accredited institution***, provides precisely such a platform through ICEBTM 2025, where diverse voices and expertise converge to address sustainability, one of the defining challenges of our time. The Board of Trustees (BoT) of IUB believes that academics should never be profit-driven; hence, all their initiatives embody this philosophy. The unconditional support of BoT in organizing ICEBTM 2025 is both unparalleled and exemplary within the landscape of private university academia.

Through the participation of about 260 registered authors/co-authors, more than 210 accepted papers, 5 keynote speeches, 8 industry talks, 3 invited talks, 26 parallel sessions for oral and poster presentations, two academia-industry discussions, Meet the journal editors, and the Ph.D. Colloquium & paper-producing workshop, Conference Proceedings with **ISBN 978-984-35-5270-9**, this event will spark dialogue, promote knowledge-sharing, and encourage practical steps toward building a sustainable future.

I am deeply grateful to our organizing committee, conference partners, and contributors who have worked tirelessly to make ICEBTM 2025 possible. On behalf of the organizing committee, we are obliged to our *Platinum, Gold, Silver and Supporting sponsors*, including Apex, Guardian, Dhaka Bank, Monem Group, New Asia Group, Rahimafrooz, ACI, and so on.

We encourage all participants to take full advantage of this platform to learn, to share, and to inspire. May this conference be a milestone in our shared journey toward a better tomorrow!

KEYNOTE SPEAKER



Professor Dr. Rajah Rasiah
University of Malaya

Saturday, 15 November 2025, 09.00 AM – 09.30 AM

Title: Sustainable Industrial Upgrading and Climate Resilience: The Southeast Asian Experience

The latecomer industrialization thesis has acted as a powerful instrument in promoting industrialization. However, not much work exists to explain why some economies that attempted to industrialize are facing premature deindustrialization, while few have managed to not only catch up economically but also leapfrog to shape the technology frontier in a number of industries. This keynote speech problematizes and assesses industrial policies and industrialization in the Southeast Asian market economies of Brunei, Indonesia, Malaysia, Philippines, Singapore, and Thailand, and the transition economies of Cambodia, Lao PDR, Myanmar, and Vietnam, and Timor-Leste, with a focus on related sustainable development goals (SDGs). Driven by an agile state, Singapore managed to become a developed economy through strong industrial upgrading. Malaysia has by 2024 launched four national industrial policies, while Indonesia, Philippines and Thailand introduced ad hoc strategies to support industrialization. Foreign transnational corporations have played a major role in stimulating manufacturing expansion in these economies.

Prof. Dr. Rajah Rasiah is currently a Distinguished Professor of Economics at the Asia-Europe Institute of the University of Malaya (58 in the QS World University Rankings 2026). Times Higher Education (THE) World University Rankings 2025: UM is within the 251-300 band, according to THE. He primarily focuses his research on technological innovation and economic development. Distinguished Professor Dr. Rajah Rasiah began to work on the economics of innovation after enrolling at Cambridge University to pursue his doctorate in economics in 1989. Since then, he has become a global pioneer in innovation and development. He introduced the Systemic Quad model, transforming the impact of strategic clustering on global employment, wages, and sustainable development.

KEYNOTE SPEAKER



Professor Dr. Jonathan Liu

International Business School, Manchester

Friday, 14 November 2025, 3.15 PM – 3.45 PM

Title: Getting Published: Tricks of Trade

Professor Jonathan Liu serves as Executive Dean at the International Business School in Sale (Manchester), and is Professor of Global Business Management, with a distinguished academic career spanning Aston, Middlesex, Regent's, and the Global Banking School. A prolific scholar and committed mentor, he has authored over 100 articles and nine books on business, management, performance, and entrepreneurship. As Editor-in-Chief of the International Journal of Business Performance Management and active on several editorial boards, he brings firsthand knowledge of academic progression and publishing standards.

Along with his experience with the British Academy of Management, the National Conference of University Professors, and the Chair of Ming-Ai Association, Professor Liu will share his experiences on getting published and how to deal with the challenges along the way. Drawing on his experience as a seasoned editor and successful researcher, Professor Liu's talk will guide scholars—especially early-career researchers—through the publication process.

Prof. Liu is an adjunct Professor at the University of Wales, Trinity St. David (in the 2025 QS World University Rankings, the University of Wales, Trinity Saint David (UWTSD), is ranked at #128), where he supervises doctoral research students. Jonathan has in-depth and hands-on experience in launching new academic ventures and start-up businesses. He has been involved in transforming established businesses in both academic and public institutions in the United Kingdom, Europe, Southeast Asia, and China.

KEYNOTE SPEAKER



Professor Dr. Maniam Kaliannan
The University of Nottingham Malaysia

Friday, 14 November 2025, 3.45 PM – 4.15 PM

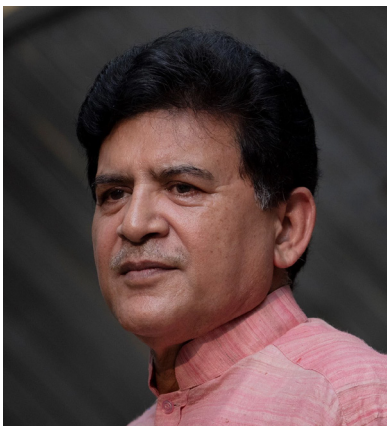
Title: Leadership in the Age of Digital Transformation: A New Business Paradigm

In a world increasingly driven by rapid technological advancements, digital transformation is no longer a choice; it is a necessity. Leadership styles must evolve to navigate the complexities and opportunities of the digital era. Traditional management approaches are giving way to agile, innovation-driven strategies that demand new mindsets, skills, and organizational cultures.

Leaders today must not only embrace emerging technologies like AI, big data, and automation but also inspire adaptability, resilience, and ethical responsibility within their teams. Drawing on real-world examples and global trends, this presentation will offer insights into how forward-thinking leaders can foster innovation, enhance customer value, and drive sustainable growth in digitally disrupted markets. Participants will gain a clearer understanding of the competencies required to lead successfully in the new business paradigm—and how to future-proof their organizations in an increasingly dynamic global landscape.

Dr. Maniam Kaliannan is Professor of Human Resource Management and Associate Dean of the University of Nottingham Malaysia (The University of Nottingham Malaysia is ranked among the top 100 universities globally and is also ranked 20th in the UK based on the QS World University Rankings 2025). His research interests include human resource management, talent management, knowledge management, public sector management, and economics. He has presented and published his work in both conferences and international journals.

KEYNOTE SPEAKER



Dr. Hossain Zillur Rahman

Executive Chairman
Power and Participation Research Centre (PPRC)
& Chairperson, BRAC

Friday, 14 November 2025, 09.30 AM – 10 AM

Dr. Hossain Zillur Rahman is an economist and social thinker, currently the Executive Chairman of the Power and Participation Research Centre (PPRC) and Chairperson of Brac. He studied economics at the University of Dhaka and earned a PhD in political sociology from the University of Manchester. He worked for over two decades at the Bangladesh Institute of Development Studies (BIDS) before founding PPRC in 1996. In 2008–09, he served as Adviser (equivalent to a Cabinet Minister rank) in Bangladesh's Caretaker Government, overseeing education and commerce.

Dr. Rahman has led key national policy initiatives, including Bangladesh's first Poverty Reduction Strategy Paper, and has made significant contributions to the fields of poverty, governance, and social inclusion. He is also a Senior Trustee on BRAC's Global Board and has received international recognition, including the Dr. John Meyer Global Citizenship Award (2009).

KEYNOTE SPEAKER



Dr. Ahmad Ahsan

Director
Policy Research Institute of Bangladesh

Saturday, 15 November 2025, 09.30 AM – 10.00 AM

Dr. Ahmad Ahsan is the Director of the Policy Research Institute of Bangladesh. He obtained his PhD in Economics from Columbia University and BSS and MSS in Economics from Dhaka University. A macroeconomist by training, he is currently researching Bangladesh's growth, economic geography, urbanization, and decentralization issues in addition to writing on current economic developments. He is a former Lead Economist of the World Bank, Consultant to the United Nations, New York, Food and Agriculture Organization, the Bangladesh Institute of Development Studies and a Dhaka University faculty member.

He led World Bank teams in policy dialogues and development policy reform lending in Africa, East Asia, and South Asia regions. He has worked closely with the IMF, regional bodies such as the ADB, AfDB, APEC, and ASEAN, as well as with the Governments of Japan and the United States, and with researchers from universities and think tanks in various countries. He was the lead author of several World Bank reports and has published well-cited research papers in journals and books.

INDUSTRY TALK



Dr. Derek Westfall

Former Senior Supply Chain Project Manager
The Boeing Company, USA

Friday, 14 November 2025, 10.20 AM – 10.45 AM

Dr. Derek Westfall is a globally recognized supply chain thought leader, educator, and strategist, bringing over 37 years of experience in end-to-end supply chain management, innovation, and leadership. He retired after a 37-year supply chain career, culminating in 15 years as a Senior Supply Chain Project Manager at the Boeing Company. He holds a Doctorate in Organization Change and Leadership from the University of Southern California and a master's in supply chain management from Penn State University.

Dr. Westfall's career spans multiple industries and roles, including high-impact positions at PECO, Blount, Intel Corporation, and Boeing, where he consistently demonstrated mastery in S&OP, demand planning, logistics, inventory optimization, and supplier collaboration. Notably, at Blount, he led global demand chain operations for a $600M business with forecast accuracy exceeding 90%, managing $35M in inventory across 13 warehouses worldwide.

A passionate educator, Dr. Westfall has been shaping future supply chain leaders since 2017 as an adjunct professor at Portland State University and currently serves as a full-time instructor at Oregon State University, where he teaches courses on operations, strategic sourcing, and project management. In addition to 12 professional supply chain certifications, he also teaches ASCM and other certification programs and is the author of How to Create a Winning 3PL Partnership.

INDUSTRY TALK



Dr. Ben Bvepfepfe

FCILT, FCIPS, CAPM
Specialist, Strategic Supply Chain Management Design

Saturday, 15 November 2025, 10.00 AM – 10.25 AM

Dr. Ben Bvepfepfe is a specialist in strategic supply chain management design, implementation, and operational performance for both public and private sectors. Sound knowledge and practical experience in Europe, Africa, the Middle East, and Asia. PhD holder in corporate social responsibility (CSR), an MSc Graduate in Supply Chain Management, a Fellow of the Chartered Institute of Logistics and Transport (FCILT), a Fellow of the Chartered Institute of Procurement and Supply (FCIPS) and a Certified associate in project management (CAPM).

He has been an active member of CILT for over 30 years, having chaired CILT Zimbabwe and served as Regional Chair for CILT UAE. He is an External Examiner for UK Universities and Chief Moderator for Logistics and Supply Chain Professional Programmes.

He published in international journals and presented papers at numerous international conferences, workshops, and seminars on various aspects of logistics and supply chain management. He has research interests in Supply Chain Risk Management, Corporate Social Responsibility, and the broader supply chain environment. Has authored various learning and teaching materials for professional institutes.

INDUSTRY TALK



Syed Nasim Manzur

Managing Director
Apex Footwear Limited

Friday, 14 November 2025, 10,00 AM – 10.20 AM

Syed Nasim Manzur completed his B.Sc. in Economics with a focus on Entrepreneurial Management from the Wharton School at the University of Pennsylvania. He currently serves as the Chairperson of Apex Tannery Ltd., Blue Ocean Footwear Ltd., Landmark Footwear Ltd., Apex Pharma Ltd., Quantum Consumer Solutions Ltd., Apex Investments Ltd., Grey Advertising Bangladesh Ltd., Apex Enterprises Ltd. and as Managing Director of Apex Footwear Ltd. He is a Director of Mutual Trust Bank PLC, International Publications Ltd., Biman Bangladesh Airlines, Infrastructure Investment Facilitation Company (IIFC). Nasim is also a member of the Board of Trustees, BRAC University and has been selected as an Honorary Senior Fellow of Bangladesh Institute of Development Studies (BIDS).

He currently serves as President of the Leathergoods and Footwear Manufacturers & Exporters Association of Bangladesh (LFMEAB). He has served as President of MCCI twice and as Chairperson of Pioneer Insurance Co. Ltd. and Vice President of Bangladesh Association of Publicly Listed Companies (BAPLC). Nasim works to promote art and culture through the Society for Promotion of Bangladesh Art (SPBA). He is also an Executive Member of an internationally acclaimed Non-Government Organization called FRIENDSHIP which provides health and educational services in remote and inaccessible chars of the Northern region of the Country through self-propelled floating hospitals and riverine ambulances. He is a regular guest speaker at the National Defence College (NDC), Mirpur, Dhaka and Public Administration Training Centre, PATC.

INDUSTRY TALK



Abdul Hai Sarker

Chairman of the Board of Directors
Dhaka Bank PLC

Friday, 14 November 2025, 04.15 – 04.30 PM

Mr. Abdul Hai Sarker is one of the most successful entrepreneurs and industrialists in Bangladesh for more than 4 decades with eminence. He was born on 15 December 1946 in a respectable Muslim family of Sirajganj. He obtained his Post-Graduation Degree in Management from the University of Dhaka in the year 1970. Soon after completing his studies, he established his own business named Purbani Traders. Subsequently, he turned this business undertaking into a full-fledged 'Purbani Group' in 1974. Now it is one of the largest & oldest Textile conglomerates spreading over agro-processing & seafood business in Bangladesh.

Mr. Sarker was a fellow member of Liverpool-based International Cotton Association (ICA), an internationally accredited body of cotton in the world, of which he was the Associate Director for 6 (six) consecutive years. Over and above, he is also one of the founders of Dhaka Bank Limited, holding the position of founder Chairman. He was President of Bangladesh Textile Mills Association (BTMA), a national trade body of Yarn & Fabrics manufacturers, for successive 2 (two) terms. In addition, he was the Director of the Federation of Bangladesh Chambers of Commerce & Industries (FBCCI). Mr. Abdul Hai Sarker, Chairman of the Board of Directors of Dhaka Bank PLC, has been elected Chairman of the Bangladesh Association of Banks (BAB). He has been awarded as a Commercially Important Person (CIP) several times by the Government of Bangladesh in recognition of his remarkable contribution to the national economy.

Mr. Sarker has also been elected as the President of the Bangladesh Tennis Federation (BTF). Apart from his business activities, Mr. Sarker is also actively involved with various CSR activities in Bangladesh. He was also the former Chairman of the ESTCDT (Education, Science, Technology & Cultural Development Trust) of the Independent University, Bangladesh (IUB) for 2 terms, as well as Chairman of the Board of Trustees. He has also established schools, colleges, mosques, etc.

INDUSTRY TALK



A. Matin Chowdhury

Managing Director
New Asia Group

Friday, 14 November 2025, 04.30 – 04.45 PM

Mr. A. Matin Chowdhury is a prominent Bangladeshi industrialist and philanthropist, serving as the Managing Director of New Asia Group, a vertically integrated textile conglomerate encompassing entities like Rahim Textile Mills Ltd., Malek Spinning Mills Ltd., Knit Asia Ltd., and New Asia Ltd. A veteran of the 1971 Liberation War, he voluntarily retired from the Bangladesh Army as a Major to join the family business. His leadership has been instrumental in the group's expansion and sustainability initiatives, including achieving LEED Platinum certification for Knit Asia Ltd., recognized as the third-best green factory globally.

Beyond his corporate roles, Mr. Chowdhury is deeply involved in social causes, serving as the founder trustee and former Chairman of the Education, Science, Technology and Cultural Development Trust (ESTCDT), the founding body of Independent University, Bangladesh (IUB). He has also held significant positions in various non-profit organizations, including the Diabetic Association of Bangladesh (DAB), Bangladesh Enterprise Institute (BEI), Bangladesh Legal Aid and Services Trust (BLAST), and Underprivileged Children's Education Programme (UCEP). With over five decades of experience in the textile sector, Mr. Chowdhury continues to influence both industry and society through his visionary leadership and commitment to sustainable development.

INDUSTRY TALK



A.S.M. Mainuddin Monem

Managing Director and CEO
Abdul Monem Limited

Saturday, 15 November 2025, 02.30 – 02.55 PM

A.S.M. Mainuddin Monem is a Harvard Business School–trained entrepreneur and the Managing Director and CEO of Abdul Monem Limited, one of Bangladesh's most respected conglomerates with interests in beverages, ice cream, food, dairy, construction, energy, and more recently green energy. Before returning to Bangladesh, he began his career in the United States in investment banking, gaining global financial and strategic experience. A visionary industrialist, he established the country's first private economic zone and has championed partnerships with world-leading brands such as Coca-Cola, Honda, and Archroma.

Mr. Monem envisions the **Abdul Monem Economic Zone** as a **next-generation industrial ecosystem**. An **incubator for innovation, advanced manufacturing, and the digital economy**. Designed with **Environmental, Health, and Social (EHS) excellence** at its core, the Zone aims to foster sustainable growth while nurturing technology-driven enterprises, startups, and IT-sector investments. His vision is to create a smart, inclusive platform where sustainability, innovation, and entrepreneurship converge to position Bangladesh within the global value chain while opening avenues for future partnerships in this grand venture of innovation and growth. Finally, a member of the South Asia Advisory Board (SAAB) at Harvard Business School, Mr. Monem contributes to advancing regional collaboration, leadership development, and sustainable enterprise across South Asia.

Under his leadership, Abdul Monem Limited has played a pivotal role in nation building through landmark infrastructure projects including the **Padma Multipurpose Bridge, Dhaka Metro Rail (MRT),** and **major national highways under ADB and World Bank financing**, initiatives that have redefined connectivity and economic opportunity across Bangladesh. Widely recognized for his leadership in governance, sustainability, and industrial transformation, Mr. Monem continues to drive Bangladesh's progress through innovation, ethics, and inclusive enterprise.

INDUSTRY TALK



Niaz Rahim

Group Managing Director
Rahimafrooz Bangladesh Ltd.

Saturday, 15 November 2025, 10.25 – 10.45 AM

Niaz Rahim is the Group Managing Director at Rahimafrooz Bangladesh Ltd., one of the country's most respected business conglomerates, founded by his father, Abdur Rahim, in 1954. As a key member of the second generation leading the family enterprise, Niaz Rahim has been instrumental in driving Rahimafrooz's transformation, expanding its footprint from traditional trading into diversified sectors such as automotive aftermarket, power and energy solutions, solar technology, and modern retailing through the pioneering brand Agora. He is widely respected for his unwavering commitment to integrity and values in business, often reaffirming that Rahimafrooz will never compromise on honesty for the sake of profit — a principle that continues to shape the group's legacy and leadership.

Academically, Niaz Rahim completed his graduation in law at the University of Dhaka and later earned an MBA from Concordia University in Canada. In addition to his business leadership, he has been actively involved in various professional and social organizations. He has served as a General Body Member of the Federation of Bangladesh Chambers of Commerce and Industry (FBCCI), representing the country's accumulator and Battery industry, as well as the supermarket industry. He is also the founding chairman of the Center for Zakat Management (CZM). He had also served as an independent Board member of the Bangladesh Development Bank (BDBL), Agrani Bank, and Asia Pacific General Insurance Co. Ltd.

INDUSTRY TALK



Dr. Arif Dowla
Managing Director
ACI PLC

Saturday, 15 November 2025, 02.55 – 03.15 PM

Dr. Arif Dowla is the Managing Director of Advanced Chemical Industries (ACI) Limited, a leading Bangladeshi conglomerate with a diverse portfolio in pharmaceuticals, agribusiness, consumer goods, and retail. He has been with ACI since 2000, first as Deputy Managing Director and later as Managing Director from 2005. Dr. Dowla holds a Ph.D. in Mathematics from the University of California, San Diego, and is recognized as a Young Global Leader by the World Economic Forum in 2009.

His leadership has been pivotal in ACI's expansion and innovation, with notable ventures like SHWAPNO. Additionally, he serves as the Honorary Consul of Belgium in Bangladesh and holds key positions in various organizations, including being the Vice Chairman of Mutual Trust Bank Limited. His strategic vision has played a crucial role in ACI's growth and its impact on Bangladesh's economic landscape.

INVITED SPEAKER



Emeka Egeson

Assiniboine Community College
Peters School of Business, Canada

Emeka Egeson is a business educator, organizational leader, and award-winning practitioner in human resources, continuous improvement, and community economic development. He currently serves as Faculty at Assiniboine Community College's Peters School of Business, where he was recognized with the **2025 ACBSP Teaching Excellence Award (Region 11)** for innovation in business and HR education. With over 15 years of leadership experience across Canada and internationally, Emeka has held senior roles, including CEO of Sioux Valley Economic Development Corporation, Executive Director of the Brandon Downtown Development Corporation, and senior management positions in banking and manufacturing.

A Certified Professional in Human Resources (CPHR), Project Management Professional (PMP), PROSCI Change Management Practitioner, and Lean Greenbelt, Emeka combines technical expertise with a people-centered leadership style. Emeka holds dual MBAs in Community Economic Development (Cape Breton University) and Finance & General Management (Obafemi Awolowo University), as well as advanced credentials in leadership and municipal administration. His research focuses on financial inclusion, ethical business practices, and the impact of technological and pedagogical innovation on shaping sustainable business education.

INVITED SPEAKER



Prof. Dr. MD Baniamin Sarder

Bowling Green State University (BGSU), USA

Dr. Sarder, a Distinguished Professor and Director at BGSU's School of Engineering, has a prolific career in academia and research. With a vast portfolio of publications and grants, he's recognized for his significant contributions to the fields of industrial and systems engineering. Dr. Sarder has authored five books, seven book chapters, and published more than 100 scholarly articles, predominantly in the logistics and supply chain domains. Two of his textbooks, including "Fundamentals of Economics for Applied Engineering" with CRC Press and "Logistics Transportation Systems" with Elsevier, are used in many universities nationally and internationally.

Dr. Sarder served as a PI and Co-PI on more than 30 grants ($35+ million) funded by several agencies, including the U.S. Department of Transportation, the U.S. Department of Commerce, the U.S. Department of Defense, and the National Science Foundation. Notably, he served in various leadership roles within professional societies, including IISE, ASEE and ABET. He received multiple awards in research, teaching, and professional services. He is a U.S. Fulbright scholar and collaborated internationally in supply chain resiliency research. Dr. Sarder's multifaceted expertise has made a lasting impression in the academic and industrial realms alike.

INVITED SPEAKER



Dr. Ferdoush Saleheen

Sharjah Maritime Academy, UAE

Dr. Ferdoush Saleheen is an accomplished academic and industry professional with over 20 years of combined experience in Supply Chain Management (SCM), Logistics, and Business Transformation across multinational corporations, national conglomerates, and higher education institutions in Asia and the Middle East.

Before joining Sharjah Maritime Academy (SMA) as an Assistant Professor in March 2025, he served full-time at the Higher Colleges of Technology (HCT), UAE, and as Academic Program Chair. In academia since 2014, Dr. Saleheen has taught at leading Bangladeshi universities such as BRAC University and the University of Liberal Arts Bangladesh (ULAB) and served as a guest speaker at the University of Hull (UK).

Earlier, he held several C-level and senior leadership roles in the FMCG, electronics, retail, and agribusiness sectors, including Chief Supply Chain Officer at Partex Star Group (Danish), Akij Food and Beverage Limited, and Head of Supply Chain at LG Butterfly Bangladesh. He has conducted over 100+ corporate training programs, produced 34+ publications, including book chapters, Scopus/WoS journal articles, and international conference papers, and serves on editorial boards of various journals.

He holds a Ph.D. in Operations Management from Universiti Utara Malaysia (UUM) and an M.S. in Logistics from the University of Texas at Arlington (USA), and an MBA from Victoria University (Australia). He is a Chartered Fellow (FCILT) of the Chartered Institute of Logistics and Transport (CILT International, UK) and currently acts as series co-editor of Sustainable Industry-Focused Supply Chain Management, a new book series with Taylor & Francis Group (CRC Press, USA).

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Sustainable Profitability under Macroeconomic and Monetary Pressures: A Panel Study of Cement and Ceramic Industries in Bangladesh (2013–2023)

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Abstract: **This study analyzes panel data from five cement and five ceramic businesses over an eleven-year period (2013–2023) in order to investigate the sustainable profitability dynamics of Bangladesh's manufacturing industry. The study looks at how firm-level profitability, as determined by Return on Assets (ROA), is impacted by the interactions between internal financial metrics like Return on Equity (ROE) and Net Profit Margin (NPM), macroeconomic indicators like GDP growth, inflation, and trade volumes, and monetary policy variables like M2 money supply and remittances. The report is predicated on sustainability-focused industry trends. Feasible Generalized Least Squares (FGLS) and robust diagnostic testing are used in the econometric technique to account for heteroskedasticity, autocorrelation, cross-sectional dependency, and multicollinearity. The findings indicate that operational efficiency (NPM) consistently drives sustained profitability, whereas expansionary monetary policy (M2 growth) has a slight negative effect. The cement business is more resilient to macro financial shocks due to its structural advantages and demand inelasticity, per a sector-specific study. These findings demonstrate how important it is to put targeted macro financial planning and legal frameworks into place in order to promote long-term industrial sustainability in emerging countries. The research contributes to the corpus of work on sustainable business performance in the face of changing macroeconomic conditions and has strategic implications for policy design in resource-intensive industries.**

Keywords: **Sustainable Profitability, Panel Data Econometrics, Monetary Policy, Cement and Ceramic Industry, Emerging Market Resilience**

I. INTRODUCTION

An essential component of the building industry, the cement sector is inextricably related to urbanization, infrastructure growth, and economic development. Cement, the main ingredient of concrete, the most used building material in the world, is essential to the construction of residential buildings, roads, factories, dams, and other civil engineering projects. The industry has grown to be a vital component of both developed and emerging economies as a result of its strategic importance [2]. The main method of producing cement involves heating calcareous (limestone) and argillaceous (clay) materials in rotary kilns to create clinker, which is subsequently crushed with gypsum to create cement powder. A variety of cement varieties, including Portland Pozzolana Cement (PPC), Ordinary Portland Cement (OPC), and blended cements, are designed to meet particular durability, environmental, and structural needs. However, because of its significant environmental impact, the business is coming under more and more scrutiny. About 7–8% of the world's carbon dioxide (CO_2) emissions come from it, mostly as a result of the energy-intensive clinker production process. This has sparked a global movement toward environmentally friendly cement production, which includes the use of carbon capture and storage (CCS) technology, waste heat recovery systems, alternative fuels and raw materials (AFR), and supplemental cementitious materials (SCMs) [3].

To increase operational effectiveness, lower energy costs, and improve quality control, the industry has also used digitalization and Industry 4.0 technologies in recent years [17]. The worldwide cement industry is changing toward more resilient, data-driven, and environmentally friendly production methods as a result of these developments, as well as regulatory challenges and changing consumer demands. The purpose of this paper is to examine how the cement business is now being shaped by its structure, procedures, difficulties, and innovations. A varied and technologically advanced subset of the materials manufacturing industry, the ceramics industry is defined by the thermal processing of inorganic, non-metallic raw materials, including kaolin, clay, feldspar, quartz, and alumina, to create decorative and useful products [18]. With its origins in ancient craftsmanship, ceramics has grown into a contemporary business with a wide range of uses, from consumer items and building to cutting-edge technologies. There are two main groups into which the industry can be broadly classified:

- Traditional ceramics, such as pottery, dinnerware, sanitary ware, tiles, and bricks. These are mostly utilized in domestic and construction settings.

- Advanced ceramics, also known as technical ceramics, are designed to be used in high-performance settings like electronics, renewable energy systems, biomedical implants, aerospace, and automobiles.

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These ceramics have remarkable qualities like great mechanical strength, chemical inertness, and resilience to high temperatures. Processing raw materials, shape (using techniques like pressing, extrusion, or slip casting), drying, fire (in kilns that can reach temperatures of 1600°C), and surface finishing (glazing, polishing, etc.) are the usual steps involved in the production of ceramics. Desired product qualities, energy consumption, and material composition all have a significant impact on the production process. Similar to the cement sector, the production of ceramics has made sustainability a top priority. Energy-efficient kilns, digital glaze printing, zero-waste formulas, and recycling ceramic waste are examples of innovations that are becoming more popular. Furthermore, productivity gains and product consistency are being facilitated by Industry 4.0 technology, such as robotics, real-time monitoring, and intelligent quality control systems [11].

II. LITERATURE REVIEW

The manufacturing of cement is essential to the construction sector. Cement production requires a significant amount of energy. It entails acquiring clay, shell, and limestone. Limestone, the main raw material, is only found in particular places. To make cement, Bangladesh imports raw ingredients from other nations. Clinkers are created by crushing the basic materials and heating them to temperatures greater than 1,000 degrees Celsius [4]. Following this, gypsum and clinkers are combined and processed into a fine powder. It is an extremely complex procedure with a convoluted supply chain. The rate of urbanization and the numerous ongoing development projects in the nation determine the demand for cement [11]. Unlike other nations, Bangladesh does not have a long history of using building materials. During British India's rule, the first cement factory was founded in 1941 in Sylhet, in the northeastern region of the nation, under the name "Khattak Cement Factory Ltd" (previously known as Assam Bengal Cement Company Ltd). Heidelberg Cement currently owns "Chittagong Cement Clinker and Grinding Factory Ltd," which was founded in Chittagong in 1973 following the liberation of Bangladesh. Bangladesh's need for cement increased rapidly as it attempted to construct infrastructure to support the newly formed nation. A tremendous amount of cement was needed for bridges, schools, hospitals, and roads. Until the early 1990s, no further cement factories were built, despite the growing need [5].

Numerous small, medium, and large businesses began to enter the market in the 2000s, such as Premier Cement Ltd. Heidelberg Cement Bangladesh Ltd., Meghna Group of Industry's Unique Cement Industries Ltd., and Mir Cement Ltd. of Mir Group of Companies Ltd. The cement industry in Bangladesh is supported by a large number of domestic manufacturers as well as international corporations. In 1958, Ogura saw the establishment of the first ceramic plant. It was a modest porcelain tableware production facility owned by Tajima Ceramic Industries [12]. Monnow Ceramics, one of Bangladesh's biggest ceramic producers, was founded in 1985 with the goal of producing porcelain dinnerware before expanding into other ceramic products. In 1997, Shimabukuro Ceramics was founded to produce porcelain and bone China tableware. With Shimabukuro now capturing nearly 60 percent of the domestic market share, we can easily recognize the importance of brands in the country. RAK Ceramics was incorporated in Bangladesh on 26 November 1998 and started its commercial production on 12 November 2000. Bangladesh holds a significant position in the global market of the growing manufacturing sector. The initial phase of this industry began during the late 1950s as the first ceramic industrial plants were set up. The industry primarily manufactures dishware, sanitary ware, and tiles. By the year 2011, the number of ceramic industrial units increased to 21, providing employment to approximately 500,000 people in Bangladesh. Sustainability and CSR cut through the environmental, social and, governance (ESG) issues. Sustainability and CSR—herein termed as “reporting”—serves as a strong example of addressing and focusing on environmental, social and governance (ESG) factors. These factors go beyond financially oriented metrics and demonstrate a company’s performance in the areas of sustainable and ethical governance [6]. They enable businesses to address compliance and societal expectations and align with international benchmarks of responsible business. Such reports, which are often voluntary, present the firm’s commitments in ethical standards, ecological responsibility, social responsibility, equitable economic growth through employment, and just trade. Current and quick ratios may measure short-term liabilities a company owes, whereas profitability ratios such as return on assets and equity demonstrate a firm’s profit earning efficiency. Assessing leverage and risk levels is done through debt ratios like debt-to-equity. These ratios serve as key indicators for the company and for the sustaining ability of the enterprise alongside providing the capital. Recent studies, such as Chouhan et al., validate the claim that the Altman Z-score forecasts financial distress with high accuracy. The higher the score, the healthier the firm is and the lower the chances of bankruptcy. Legitimacy theory claims that a firm is bound to comply with popular business practices in order to remain operational. Such reports capture the essence and recommend that firms should comply beyond the minimum required by law to gain social trust. The Companies Act of 2013 in India mandates corporations to engage in social responsibility. This law reveals the increasing importance of social responsibility for corporate governance. For investors, policymakers, and regulators, understanding the financial and operational longevity of a cement company is critical. The studies in this research indicate that there is an abundance of literature that focuses on the cement industry from both a financial and a technical perspective [13]. These assessments are aimed at evaluating the performance of a firm. Strong performance signals the investors and other relevant stakeholders about the sound prospects of the firm.

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III. RESEARCH METHODOLOGY

With this study, we apply a quantitative research approach, using secondary data sources to study the financial and macroeconomic aspects of the cement and ceramic industry of Bangladesh. The primary objective of this research is to study the profitability of different firms and evaluate the impact of macroeconomic factors on firms' performance in a given period of time (2013–2021). The data were obtained from an Excel file shared by the user, which contained three structured sheets labeled "Data," "Result," and "Data (2)." These sheets hold panel data with a firm-year dimension for a number of firms which are grouped as cement and ceramic manufacturers. The dataset includes key financial performance metrics like Return on Assets (ROA), Return on Equity (ROE), and Net Profit Margin (NPM) as well as macroeconomic variables like the growth rate of GDP, exports, imports, inflation rate, remittance inflow, and broad money (M2) supply.

To differentiate between cement and ceramic companies, the dataset uses a binary classification variable called "Dement." Cement firms are indicated by a value of 1, and ceramic companies are indicated by a value of 2. A comparison of the two sectors' financial performance and reactions to macroeconomic events is made possible by this classification. With time-series data from 2013 to 2021, each row indicating a firm's annual performance, the dataset also guarantees consistency across firms. The dataset was first examined for outliers and missing values to guarantee data quality and dependability. In order to eliminate unnecessary rows and align column heads, the structure was tidied. To guarantee consistency in interpretation, special emphasis was paid to standardizing financial and economic indicators across years and enterprises. Python and Excel were used for the analysis, with tools like pandas for data processing and stats models for regression being used [20].

A systematic and data-driven approach to comprehending the financial dynamics of Bangladesh's cement and ceramic sectors is established by this research methodology. It provides a detailed understanding of how sector-specific businesses perform under various economic conditions by fusing descriptive statistics with panel regression models and macroeconomic variables. This approach provides the groundwork for deriving well-informed findings that can help industry stakeholders, investors, and legislators navigate and maximize their strategic choices within these crucial sectors [8].

IV. DATA ANALYSIS & RESULTS

One of the most important areas of research in both finance and economics is the connection between monetary policy, macroeconomic conditions, and business profitability. In order to investigate these patterns, this study makes use of a balanced panel dataset that includes 110 observations from 10 entities (presumably businesses or nations) across an 11-year period (2013–2023). The dataset comprises monetary variables (M2 money supply, reserve money), macroeconomic indicators (GDP growth, inflation, trade volumes), and financial performance metrics (ROA, ROE, and NPM) [7]. This study intends to examine the influence of monetary and macroeconomic factors, separate the drivers of profitability, and solve methodological issues inherent in panel data analysis by combining sectoral analysis and econometric diagnostics [9].

This dataset includes 110 observations from 10 businesses over 11 years (2013–2023), including 5 cement and 5 ceramic producers in Bangladesh. The information combines monetary variables (M2 money supply, remittances), macroeconomic indicators (GDP growth, inflation, trade), and financial performance measurements (ROA, ROE, NPM). Cement (dement=1) and ceramic (dement=0) companies are distinguished by the dummy variable dement. An organized examination of the dataset's relationships, trends, and econometric insights can be found below.

Goals of Research

1. Profitability Determinants: Determine how external factors (trade, GDP), leverage (ROE), and operational efficiency (NPM) affect ROA.
2. Macroeconomic Linkages: Evaluate how trade, monetary policy (M2), and inflation affect business performance.
3. Echometric Rigor: Identify and resolve problems such as cross-sectional dependency, heteroskedasticity, and multicollinearity.
4. Sectoral Heterogeneity: Use a sectoral dummy variable to examine performance differences.

Foundations of Theory

● Profitability Metrics: NPM records operating margins, ROE represents shareholder returns, and ROA gauges asset efficiency (Damodaran, 2012).

Macroeconomic Impact: While inflation reduces buying power, GDP growth increases demand (Blanchard, 2016).

● Monetary Policy: Expansionary measures, like M2 expansion, reduce borrowing costs but run the risk of causing inflation (Mishkin, 2018).

Empirical Perspectives

● Trade and Profitability: Because of economies of scale, export-focused businesses frequently have larger margins (Melitz, 2003).

Sectoral Variations: Because fixed assets predominate in capital-intensive industries like cement, these sectors may be resilient to monetary shocks (Beck & Demirgüç-Kunt, 2006).
Methodological Flaws ● A lot of research overlooks autocorrelation and cross-sectional dependence, which results in skewed estimates (Pesaran, 2004). To overcome these problems, this study uses diagnostic testing and FGLS.

Overview of Data
Important variables

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● Dependent factors: Return on assets, or ROA, is a measure of profitability in relation to total assets.
o Return on Equity (ROE): The ratio of profitability to equity held by shareholders.
o Net profit margin, or NPM, is the ratio of net income to revenue.
The independent variables include:
o GDP Growth: The GDP growth rate each year.
o Trade quantities (in millions of US dollars) for imports and exports.

o Consumer pricing index: inflation.
The broad money supply, or M2 money supply, is measured in crore BDT.
o Remittances (Rm): Inflows of money from employees abroad (in millions of US dollars).

Description of the Data and Initial Analysis
Structure of Datasets
Ten panels (countries/firms) with eleven yearly observations each (2013–2023) comprise the entities.

Variables:
o Financial: ROE, NPM, and ROA.
o Macroeconomic: inflation, imports, exports, and GDP growth.
o Monetary: wide money supply (M2) and reserve money (RM).
o Dummy: 0 indicates otherwise, 1 indicates cement sector.
Descriptive Statistics

Variable	Mean	SD	Min	Max	Interpretation
ROA	3.20%	5.89%	-37.89%	16.42%	High volatility, indicating risk.
ROE	7.54%	16.13%	-66.13%	128.40%	Extreme swings due to leverage.
NPM	6.04%	8.96%	-50.30%	26.86%	Operational efficiency varies widely.
GDP	6.44%	1.12%	3.45%	7.88%	Stable growth, typical of emerging markets.
M2	1,171,246	404,076	603,506	1,887,168	Rapid monetary expansion.

Important Findings: ● Profitability: ROA and NPM exhibit moderate averages but wide variations (for example, ROE varies from -66% to 128%), indicating cyclical or sectoral shocks.
Macro Variables: GDP growth is steady, although there is a risk of inflation (mean = 6.34%).

● Trade: The number of imports and exports varies greatly, reflecting cycles in the world economy.
Analysis of Correlation Metrics related to finances
● ROA-NPM: Correlation = 0.936 o Implication: Leverage is overshadowed by operational efficiency (NPM), which is the foundation of profitability (ROE's correlation with ROA = -0.046).
● ROE-Inflation: Correlation = 0.188 o Interpretation: Businesses may temporarily increase ROE by passing inflationary expenses on to customers. Monetary and Macroeconomic Connections
● Exports-M2: Correlation = 0.928 o Conclusion: Monetary expansion promotes trade finance, which in turn propels export expansion.
The "productivity-augmented Phillips Curve," which holds that growth reduces inflation through efficiency improvements, is supported by the correlation between inflation and GDP of -0.241.

Disparities by Sector
● ROA: 1.38% for non-cement and 5.15% for cement.
● NPM: 4.25% vs 7.97%.

The cement industry's lower M2 (1,147,609 vs. 1,193,225) indicates focused liquidity utilization, according to the monetary variables.
Sectoral Advantages:
1. Inelastic Demand: Stable revenue is ensured by the necessity of cement for infrastructure.
2. Pricing Power: Price controls are made possible by oligopolistic marketplaces.
3. Government Support: Tax breaks or subsidies in economies that rely heavily on building.

Regression Analysis

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Full Model: Financial and Macro Drivers

ROA=β0+β1ROE+β2NPM+β3GDP+β4Exp+β5Imp+β6Inf+β7RM+β8M2+ϵROA=β0+β1ROE+β2NPM+β3GDP+β4Exp+β5Imp+β6Inf+β7RM+β8M2+ϵ

Variable	Coefficient	p-value	Interpretation
NPM	0.597	0.000	Dominant driver: 1% ↑ NPM → 0.597% ↑ ROA.
ROE	-0.012	0.358	Leverage has no net impact.
M2	-2.86e-8	0.064	Monetary expansion weakly reduces ROA.

Results:

Model Fit:

- R^2 = 89.1%: Strong explanatory power, but multicollinearity inflates SEs (VIF > 10 for exports/imports).

Parsimonious Model: Macro/Monetary Focus

ROA=β0+β1GDP+β2Exp+β3Imp+β4Inf+β5RM+β6M2+ϵ
ROA=β0+β1GDP+β2Exp+β3Imp+β4Inf+β5RM+β6M2+ϵ

Results:

Variable	Coefficient	p-value	Interpretation
M2	-7.71e-8	0.074	Monetary growth harms profitability.
GDP	0.532	0.332	Insignificant due to collinearity.

Model Fit:

- R^2 = 11.8%: Macro factors alone poorly explain profitability.

Econometric Diagnostics

Non-Normality

- Shapiro-Wilk Tests: All variables reject normality (p = 0.000).
- Solution: Log-transform skewed variables (e.g., M2, trade volumes).

Multicollinearity

- VIFs: Exports (42.29), Imports (31.81), M2 (10.01).
- Remedy: Drop exports/imports or use PCA for dimensionality reduction.

Performance Drivers in the Cement Industry
1. Demand Inelasticity: Regardless of economic cycles, infrastructure projects maintain demand.
2. Cost Benefits: Input costs are reduced by vertical integration, such as owning limestone quarries.
3. Regulatory Shields: Domestic cement producers are protected by import levies. Impact of Monetary Policy M2 Sensitivity: Compared to non-cement (β = -1.02e-7), cement's ROA is less impacted by M2 growth (β = -6.86e-8).

- Implication: Industries that rely heavily on capital are better able to withstand liquidity shocks.

Suggestions for Policy
1. Monetary Policy: o Be Wary of M2 Growth: Steer clear of excessive liquidity that reduces profitability in industries other than cement.

Direct finance to high-productivity industries, like cement, is known as sectoral lending.
2. Fiscal Policy: o Infrastructure Investment: Use the durability of the cement industry to propel GDP expansion.
o Export Diversification: Promote domestic industry to lessen dependency on imports.
3. Reforms to Regulations:
o Anti-Monopoly Measures: Make sure oligopolistic industries have competitive prices.
o Target inflation: Maintain pricing stability to safeguard profit margins. Approach-Based Suggestions
1. Deal with multicollinearity by removing correlated variables or using ridge regression.
2. Non-Parametric Models: Investigate quantile regression to identify tail risks, such as sharp fluctuations in ROE.
3. Spatial Models: To take cross-sectional dependence into consideration, include spatial lags.

This study emphasizes how operational efficiency (NPM), which is tempered by macroeconomic stability and sound monetary policy, is the primary factor driving profitability. The superior performance of the cement industry emphasizes how crucial sectoral targeting is when creating policies. To improve these findings, future studies should incorporate nonlinear dynamics and qualitative elements (such as governance).

1. Parameters of the Study

Panel Coverage

- Period: 2013–2023 (11 years)
- Firms Analyzed: 10 leading cement manufacturers (e.g., Confidence Cement, Crown Cement, LafargeHolcim)
- Observations: 110 firm-year observations

Dependent Variables (Financial Performance Indicators)

- ROA (Return on Assets)
- ROE (Return on Equity)

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- NPM (Net Profit Margin)

Independent Variables (Macroeconomic & Policy Indicators)

- GDP: GDP Growth Rate (%)
- EXP: Export (Million USD)
- IMP: Import (Million USD)
- INF: Inflation Rate (%)
- RM: Remittance (Million USD)
- M2: Broad Money Supply (Crore BDT)
- DCEMENT: Dummy variable for structural/policy impact

2. Data Results Summary
Descriptive Statistics

- ROA: Mean = 3.2%, Range = [-37.9%, 16.4%]
- ROE: Mean = 7.5%, Range = [-66.1%, 128.4%]
- NPM: Mean = 6.0%, Range = [-50.3%, 26.9%]
- GDP Growth: Avg = 6.4%
- Inflation: Avg = 6.3%
- Broad Money Supply (M2): Mean ≈ 1.17 million crore BDT, upward trend

Correlations (from Stata)

- ROA and NPM: Strong positive ($r = 0.936$, $p < 0.01$)
- ROA negatively correlated with:
  - Export ($r = -0.245$, $p < 0.05$)
  - Import ($r = -0.189$, $p < 0.05$)
  - M2 ($r = -0.285$, $p < 0.01$)

Regression Insights
OLS Regression (Full Model)

- Model Fit: $R^2 = 89.1\%$, Adj. $R^2 = 88.2\%$
- Significant Variable:
  - NPM ($\beta = 0.597$, $p < 0.01$) → Major driver of ROA
  - M2 (borderline negative, $p = 0.064$)

Random Effects (RE)

- M2: Significant negative ($p = 0.020$)
- Other variables (GDP, INF, EXP, IMP, RM) were not statistically significant

FGLS (Corrected for Autocorrelation & Panel Bias)

- M2: Negative and significant ($p = 0.042$)
- RM: Borderline positive ($p = 0.079$)
- Dement: Positive and significant ($\beta = 0.045$, $p = 0.018$)

3. Interpretation & Report Impact
Financial Efficiency

- Firms with higher NPM tend to have higher ROA, confirming operational efficiency is key to performance.

Monetary Policy Effect

- Negative influence of M2 (money supply) indicates:
  - Possible inflationary pressure
  - Misallocation of capital or excess liquidity with limited productive investment
  - Importance of monetary tightening for asset efficiency

Policy Intervention (DCEMENT)

- The dummy variable dements showed significant positive effect on ROA, indicating:
  - Structural reforms
  - Government support or market corrections (e.g., infrastructure stimulus, subsidy changes)
  - Likely turning point in cement sector performance

External Sector

- Despite being macro-critical, export/import variables lacked significance, possibly due to:
  - Internal demand dominance in the sector
  - Trade volatility or lag effects

V. RECOMMENDATIONS

Careful Management of Monetary Policy
In order to protect macroeconomic stability and company profitability, authorities should be cautious while expanding the broad money supply (M2). The inverse relationship between M2 growth and business profitability suggests that too much liquidity might result in capital misallocation and inflationary pressures, which are especially detrimental to non-cement industries [19]. Thus, it will be essential to avoid excessive monetary growth and to execute targeted liquidity interventions. Monetary tightening should also be taken into account in order to keep inflation under control and preserve asset efficiency, particularly when the money supply is expanding quickly. Sectoral Policy and Supporting Infrastructure
The government should give priority to infrastructure expenditures that leverage the cement industry because of

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its resilience, which is fueled by cost savings, regulatory protections, and inelastic demand. In addition to boosting GDP growth, accelerating infrastructure projects strengthens the cement industry's ability to maintain profitability. Additionally, the influence of external trade volatility on sector stability can be lessened by encouraging export diversification and lowering reliance on imports.

Interventions Particular to a Sector

The cement industry's favorable reaction to government assistance and structural changes highlights the significance of focused policy. Its performance can be further enhanced by ongoing assistance in the form of import taxes, infrastructure purchases, and subsidies. Price stability and innovation depend on the regulatory and anti-monopoly frameworks being strengthened in order to guarantee fair competition and stop oligopolistic market behaviors [16].

Inflation control and regulatory reforms

Profit margin protection across industries depends on maintaining price stability through efficient inflation targeting. Enhancing market competition, lowering barriers to entry for new businesses, and increasing transparency should be the main goals of regulatory reforms. A more robust and dynamic industry landscape will result from these actions.

Overcoming Methodological Difficulties

It is advised that multicollinearity be addressed using principal component analysis (PCA) or ridge regression techniques in order to increase the robustness of subsequent studies. Furthermore, investigating nonlinear models like quantile regression and spatial econometric models might offer more profound understanding of the disparate effects of macroeconomic factors in various contexts and geographical areas.

Prospects for Further Research

To further understand the factors that influence profitability, future research should take into account managerial effectiveness, governance quality, and nonlinear dynamics. The generalizability of these findings could be improved by comparative studies with other emerging markets, which would aid in the creation of more specialized policy interventions.

VI. CONCLUSION

The effectiveness of a firm's operational efficiency, as characterized by NPM, is critical for driving profitability within the cement and ceramic industry firms in Bangladesh. Controlling for operational parameters, macroeconomic indicators like GDP and inflation have very weak direct impacts, although some macroeconomic stability is still essential for the economy. Most importantly, a firm's operational performance has a significantly negative relationship with expansionary monetary policy, as measured by M2. This accentuates the importance of sector-based approaches, particularly the cement industry marked with greater resilience, reinforced by policy, regulatory, and infrastructural support. Robust analysis through precise echometric techniques such as heteroskedasticity and multicollinearity clearly demonstrate the importance of careful diagnostic testing. Researchers should be encouraged to focus on nonlinear and governance-centric cross-country models for a greater triangulation of profitability analysis [15]. Targeted operational shift focus, empowering monetary control, and constructive policy frameworks prioritized by policymakers should amplify sustainable industrial advancement.

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Sustainable Agriculture and Farmland Productivity nexus in Bangladesh: An Empirical Study

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Abstract: **This paper employs national aggregated data on the indicators of sustainable agricultural practice in Bangladesh for estimating a multivariate timeseries model that produces plausible simulated outcomes for agricultural land productivity due to 1% change (increase and decrease) in the relevant sustainable agricultural activities. The estimated model has been subjected to a battery of sensitivity analysis and found robust. Plethora of papers exist that have utilized disaggregated primary data for model estimation purpose on this topic. However, authors that have employed national aggregated data claim that these are less susceptible to noticeable human errors and produce better outcomes for policy implications.**

JEL Classifications: (B16: Quantitative and Mathematical: C22: Time-Series Models, C51: Model Construction and Estimation, C52: Model Evaluation, Validation, and Selection)

I. INTRODUCTION

Despite experiencing a declining share in national economic output during recent years, agriculture is a predominant sector of Bangladesh. The sector still provides the largest share of total employment. As of 2017, the agricultural share of total employment stood at 41% compared to 39% of the service and 20% of the industrial sector[1]. More importantly, agriculture absorbs a higher percentage of female labor force than industrial and service sectors. In 2019, agriculture absorbed 58% of female labor force, whereas service and industry engaged 18% and 25% of female labor force in the same year[2]. It may be concluded that agricultural sector plays a significant role in overall labor force employment, as well as, promoting woman empowerment of this nation. On the other hand, Bangladesh is one of the most densely populated countries in the globe and the amount of per capita arable land stood at a meagre 0.05 hectares as of 2018 [4]. Consequently, the nation feels an intensifying stress for increasing agricultural land productivity to ensure food security for its vast population. However, increasing land productivity may not ensure sustainability without which long term agricultural growth will be deterred. Sustainable agricultural practice may apparently seem an unattractive proposition as it requires stringent resource use and deters indiscriminate use of chemical fertilizer and pesticides for short term gain, but this practice is more likely to enhance agricultural productivity over long run. According to the Food and Agricultural Organization (FAO), there are three dimensions of agricultural sustainability, namely, environmental, economic, and social. Sustainability documents of FAO stipulate that farms will be deemed compliant if they attain an acceptable combination of the sub-indicators of sustainable agriculture across these dimensions. As Bangladesh is eyeing on fulfilling the targets of sustainable development by 2030, attaining agricultural sustainability within this timeframe is of prime importance for the nation. At his backdrop, this paper empirically examines if there exists a long run equilibrium relationship between agricultural productivity and other measures of sustainable agricultural practice in Bangladesh. Firstly, the paper attempts to estimate the long run equilibrium relationship between agricultural productivity and some selected measures of sustainable agriculture in Bangladesh using the multivariate time series methodology. Secondly, the paper conducts a simulation analysis by estimating impulse responses of agricultural productivity due to unexpected shocks to the other measures of agricultural sustainability. Unlike many other studies, this paper utilizes national macrolevel data on model variables for the purpose of estimating the long run relationship between the indicators of agricultural sustainability in Bangladesh. All data are procured from the World Development Indicators (WDI) databank that are relatively accurate compared to survey data on individual regions and allows researchers to replicate model estimation for individual country case studies and compare estimation outcomes. This paper finds plausible long run equilibrium relationship between agricultural land productivity and the selected indicators of sustainable agriculture in adherence with relevant literature. In addition, the paper also obtains plausible impulse responses of agricultural productivity due to unexpected shocks to the other indicators of sustainable agriculture. Findings of this paper may have important implications for agricultural policy in Bangladesh.

II. LITERATURE REVIEW:

In accordance with Food and Agricultural Organization (FAO), sustainable agriculture refers to agricultural activities that comply with the needs of present generations without compromising with those of future generations and simultaneously ensures profitability, environmental health, as well as social and economic equity. There are abundant literal works on agricultural sustainability, but few of them focus on empirical analyses relating to the nexus between agricultural productivity and sustainability. Some of the early works [5] conclude that agricultural activities inflict negative externalities on environment and human health and

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therefore should be controlled either by punitive taxation equivalent to the social damages caused or by ensuring the prudent use of available technology on part of the peasants. However, in the face of rising global population, nations have limited choices left other than increasing food production through intensive agricultural practices that ultimately create environmental unsustainability. Intensive use of chemical fertilizer in Europe has caused the leaching of excess nutrients into water bodies and initiated environmental pollution [16]. This mineral rich inorganic fertilizer is also observed to reduce organic carbon in soil and causes infertility [18]. Reducing excess soil nutrients may have a positive long-term effect on agricultural productivity, soil fertility, and biodiversity [10].

Shortly after independence, Bangladesh faced a rampant food price inflation induced by oil price shock in 1973 and an upsurge in global inflation that followed. To ensure food security in a war-torn economy, the government emphasized cultivation of high yielding varieties (HYV) of rice crop, which required intensive ground water irrigation, usage of chemical fertilizer and pesticides that eventually caused environmental unsustainability [7]. High yielding varieties of rice were first introduced in the country in 1967 and after independence in 1971, growth rate of rice production went up from a meagre 1.6% in 1972 to a lofty 18% in 1973. Despite a noticeable initial success of green revolution, Bangladesh agriculture somewhat fails to sustain its growth potential due to climate change challenges, lack of adoption of more pest and disease resilient rice varieties, less efficient irrigation, and excessive usage of chemical fertilizer [17]. Most recent data indicate a downfall in the growth rate of agricultural value addition from 3.4% in 2020 to 3.2% in 2021[4].

On the other hand, notwithstanding a noticeable decline in total fertility rate, current total population of Bangladesh stands at a staggering 164.7 million, resulting in a population density of 1,265 people per square kilometer and the agricultural sector needs to fulfill the ever-increasing demand for staple food items without sacrificing agricultural sustainability. Bangladesh government is aware of this challenge and the National Environmental Policy (2018) comprises recommendations that encourage sustainable agricultural practices, such as, crop rotation, legume cultivation, and crop diversification for increasing long term agricultural productivity. Although sustainability is a complex notion that involves combination of measurable and unmeasurable indicators, there are three broad dimensions that may incorporate them. These dimensions are environmental, economic, and social in nature and despite the difficulty of gauging them in quantifiable units, 'United Nations Development Program' (UNDP) and 'Food and Agricultural Organization' (FAO) have devised certain measures that can capture their significance. Among these indicators, productivity of agricultural land may capture sustainable growth in this sector, which in turn may positively influence overall sustainable economic growth. This paper employs a multivariate time series methodology to estimate the long run effects of selected indicators of sustainable agriculture on long run farmland productivity of Bangladesh. National data on macroeconomic indicators are utilized for this purpose that are collected from World Development Indicators (WDI) database, which are both readily available, as well as, accessible and therefore, makes it possible for other researchers to replicate the model estimation methodology for other countries as individual case studies.

Most of the research works on sustainable agriculture in relation to Bangladesh are based on primary disaggregated farm level data [12]. These studies have produced valuable observations on the practice of sustainable agriculture and its impacts on agricultural performance at selected farms of rural Bangladesh. However, very few of these seem to have focused on the long run effects of sustainable agriculture or lack of this practice on agricultural growth of the nation. Among these few research works, [4] is worth mentioning, although they have focused on the impacts of unsustainable agricultural practice on environmental degradation. Specifically, the paper finds that producing agricultural crops, such as, rice, and cereal, as well as practices such as, livestock rearing, and land cultivation for cereal production under conventional agriculture increase carbon emission and eventually lead to environmental degradation. [5] evaluated the relationship between twenty-two indicators of sustainable agriculture utilizing the Partial Least Squares (PLS) method applied to a Structural Equation Model (SEM), which is duly estimated using a dataset collected from 357 listed farmers at Teesta Barrage area. The researchers have concluded that ecological, social, and economic indicators of sustainable agriculture are highly and positively correlated with each other. [23] draws attention to the relationship between crop diversity and agricultural sustainability and concludes that a decline in crop diversity reduces agricultural sustainability as well. They have constructed a crop diversity index for Bangladesh and concluded that currently the farmers heavily rely on cultivating few High Yielding Varieties (HYV) of rice that require intensive use of ground water irrigation, usage of chemical fertilizer, and pesticide that eventually reduces environmental sustainability. However, none of the empirical literature focuses on the impact of sustainable agriculture on farmland productivity. On the other hand, the current paper estimates the long run impacts of sustainable and unsustainable agricultural practices in Bangladesh utilizing a multivariate time series model that includes statistical indicators of both. From this standpoint empirical findings of this paper may have significant policy implications as the nation is eyeing on attaining UN announced sustainable development goals by the end of 2030.

III. CONCEPTUAL FRAMEWORK

Food and Agricultural Organization defines sustainable agricultural practice as the management and conservation of natural resource base and the orientation of technological change such that continued satisfaction of human needs for present and future generations are fulfilled. Accordingly, sustainable agriculture is environmentally non-degrading, technically appropriate, economically viable and socially acceptable, which is supposed to conserve land, water, plant, and animal based genetic resources [10]. In general,

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sustainable agriculture incorporates three broad dimensions, namely environmental, economic, and social. For empirical analysis, it is imperative that we utilize measurable statistical indicators of each of these dimensions.

On the other hand, measures of sustainable agriculture may appear region specific that are likely to evolve in line with changing environmental and socio-economic factors. Hence, it appears to be a daunting task to precisely identify the measures of sustainable agriculture and measure them for the purpose of empirical estimation of an econometric model. In addition, there is no guarantee that a certain agricultural practice will comply with all dimensions of sustainability simultaneously. A certain agricultural activity may appear environmentally and economically sustainable, but it may not be socially sustainable.

Bangladesh has already eyed on attaining the targets of UN set sustainable development goals by 2030. Putting an end to hunger is one of these goals. To attain this goal, the nation needs to ascertain sustainable agricultural practices that will ensure primary food production using resilient means, which simultaneously enhances productivity and conserves eco system by enhancing soil quality in the face of climate change induced natural calamities. According to the UN documents, the indicator of sustainable agriculture is gauged by the 'proportion of agricultural land under productive and sustainable agriculture', which encompasses the environmental, economic, and social dimensions of sustainability. The more disaggregated forms of this indicator involve productivity, profitability, and resilience of land and water resources in agriculture. At this backdrop, it appears immensely important that agricultural sustainability is gauged in terms of quantifiable measures of its three dimensions. [21] mention that a large part of literature focusing on sustainable management of agriculture is guided by the norm 'what gets measured gets managed'.

For empirical analysis this paper deploys annual time series data spanning 1961—2018 on five major aggregative measures of sustainable agriculture in Bangladesh. The paper deliberately utilizes aggregative data on selected indicators of sustainable agriculture presuming that the ensuing empirical outcome may have policy implications of national economic importance. All data are compiled from the 'World Development Indicators' (WDI) databank. Variables are assumed endogenous as these are explained within the estimated model.

Arguably, the first and foremost indicator of sustainable agriculture is productivity of agricultural land. We define this indicator as the agricultural value added in constant 2015 USD per square kilometers of land used in agricultural activities. Higher value added per square kilometers of agricultural land reduces the stress on existing land mass, especially when it is generated by sustainable practices. The amount of arable land is another statistical indicator of sustainable agriculture that we employ estimating our empirical model. 'Food and Agricultural Organization' (FAO) defines arable land as agricultural land cultivated with temporary crops, temporary meadows for mowing, or for pasture. It also includes land under market or kitchen gardens and land that remains temporarily fallow. Different crops have different root systems and when land is cultivated with variegated crops, efficiency of soil fertility increases as plants with deeper root systems bring nutrients from deeper layers of soil to the surface and make these available for plants that use a relatively shallow root network. On the other hand, as arable land is planted with temporary crops, agricultural practices involving this type of land replicates crop rotation, which eventually enhances soil fertility and better pest management on part of the peasants as different crops are vulnerable to different kinds of pests, weeds, and diseases.

Cereal yield per hectare of agricultural land is an important indicator determining the productivity of total agricultural land mass. Cereals include rice, wheat, barley, corn, buckwheat, and other granular seeds that are used for human and animal consumption. These crops constitute the major agricultural output since time immemorial and sustainable cultivation of cereal crops is the main challenge for attaining agricultural sustainability in upcoming days. Considering the food habit of a majority of human population and the importance of a major source of staple food intake of existing global livestock we consider cereal yield per hectare of agricultural land as an important indicator of sustainable agriculture in Bangladesh which is still predominantly agrarian in nature.

The livestock production index is another statistical indicator that we have used estimating our empirical model for analyzing the agricultural sustainability and productivity nexus. Livestock plays a crucial role maintaining agricultural sustainability, especially in developing countries, such as, Bangladesh, where commercial livestock farming is not so prevalent yet. Livestock production system encompasses all three dimensions of sustainability; environmental, economic, and social. For instance, livestock production structure bears the potential of contributing to the preservation of biodiversity. It also contributes to carbon sequestration in soils and biomass and acts as an important source of natural fertilizer, food, income, collateral, and store of wealth. Livestock provides draft animals in places where mechanization is poor and boosts labor productivity.

Lastly, we have considered the usage of inorganic fertilizer as a variable that acts against sustainable agricultural practices. Inorganic or chemical fertilizer products include nitrogenous, potash and phosphate-based fertilizer. These types of fertilizer cause environmental hazards, such as, water and soil pollution, interfere with natural balance of soil microflora and release high levels of nitrate and nitrite in natural source of fresh water and eventually harm human health. In short, usage of inorganic fertilizer is unsustainable as it may enhance soil productivity over the short run at the cost of multidimensional damages inflicted upon environment, nature, and human health condition over a longer time span.

IV. THEORETICAL CONSTRUCT OF THE MODEL

We assume that productivity of agricultural land in Bangladesh follows a Cobb-Douglas type production function, which involves variables such as, arable land,

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cereal yield, livestock production, and use of chemical fertilizer. We also assume that the production function in this sustainable agricultural setting is captured by an endogenous growth model where the state of technology evolves through research. At this backdrop, the theoretical construct of sustainable productivity in agricultural sector is as follows.

$$y_t = f(A_t, ARB_t, CRLYD_t, LVSTK_t, FRT_t) \quad \text{.... (1)}$$

Equation (1) can be more specifically mentioned in terms of equation (2).

$$y_t = A_t^{\beta_0} + ARB_t^{\beta_1} + CRLYD_t^{\beta_2} + LVSTK_t^{\beta_3} + FRT_t^{\beta_4} \quad \text{..... (2)}$$

where y_t: value added per square kilometer of agricultural land in year 't'.

〖ARB〗 _t: amount of arable land in agricultural sector in year 't'.

〖CRLYD〗 _t: amount of cereal produced per hectare of agricultural land in year 't'.

〖LVSTK〗 _t: livestock production index in year 't'.

〖FRT〗 _t: kilograms of chemical fertilizer used per hectare of arable land in year 't'.

Equation (2) can be rewritten as follows in natural logarithmic levels of model variables. Equation (2) can be rewritten as follows in natural logarithmic levels of model variables.

$$lny_t = \beta_0 lnA_t + \beta_1 lnARB_t + \beta_2 lnCRLYD_t + \beta_3 lnLVSTK_t + \beta_4 lnFRT_t \text{ ..... (3)}$$

Excluding the technology variable, we estimate a reduced form long run equilibrium relationship including the productivity of agricultural land and other indicators of sustainable agriculture in case of Bangladesh.

V. EMPIRICAL MODEL

The major objective of this paper is to examine if sustainable practice enhances agricultural land productivity. We assume that sustainable agricultural practice requires more time on part of farmers and the desired outcome of this pursuit can be achieved over a longer period. On this ground, we have built a multivariate Vector Error Correction (VEC) model for estimating the long run equilibrium relationship between land productivity in agricultural and four measurable indicators of sustainable agriculture. All variables in a VEC model are endogenous and hence these are treated with equal importance. Initially, we develop a reduced form VAR model in the logarithmic levels of the relevant model variables as follows and we include one lag in these variables for the sake of simplicity.

$$\begin{bmatrix} log\,(y_t) \\ log\,(ARB_t) \\ log\,(CRLYD_t) \\ log\,(LVSTK_t) \\ log\,(FRT_t) \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \\ a_{30} \\ a_{40} \\ a_{50} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{bmatrix} \begin{bmatrix} log\,(y_{t-1}) \\ log\,(ARB_{t-1}) \\ log\,(CRLYD_{t-1}) \\ log\,(LVSTK_{t-1}) \\ log\,(FRT_{t-1}) \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \\ u_{4t} \\ u_{5t} \end{bmatrix} \text{ ..... (4)}$$

With reference to equation/model (4) we developed a Vector Error Correction model as follows.

$$\begin{bmatrix} dlog(y_t) \\ dlog(ARB_t) \\ dlog\,(CRLYD_t) \\ dlog\,(LVSTK_t) \\ dlog\,(FRT_t) \end{bmatrix} = \Gamma_1 \begin{bmatrix} dlogy_{t-1} \\ dlogARB_{t-1} \\ dlogCRLYD_{t-1} \\ dlogLVSTK_{t-1} \\ dlogFRT_{t-1} \end{bmatrix} + \Pi \begin{bmatrix} logy_{t-1} \\ logARB_{t-1} \\ logCRLYD_{t-1} \\ logLVSTK_{t-1} \\ logFRT_{t-1} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \\ e_{5t} \end{bmatrix} \text{ ..... (5)}$$

Model (5) includes current and lagged first differenced endogenous variables in their logarithmic forms. The model also includes lagged logarithmic levels of these variables. All variables in this model are assumed stationary. Lagged variables in their first differences are assumed stationary. The matrix contains the error correction terms (ECT) in a sense that the elements of this matrix are coefficients of long run equilibrium relationships among the variables concerned and the self-correcting adjustment parameters that rectify any deviations from their said long run equilibrium levels. Model (5) can be rewritten as follows that conspicuously shows the ECT terms.

$$\begin{bmatrix} dlog(y_t) \\ dlog(ARB_t) \\ dlog\,(CRLYD_t) \\ dlog\,(LVSTK_t) \\ dlog\,(FRT_t) \end{bmatrix} = \Gamma_1 \begin{bmatrix} dlogy_{t-1} \\ dlogARB_{t-1} \\ dlogCRLYD_{t-1} \\ dlogLVSTK_{t-1} \\ dlogFRT_{t-1} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \\ a_{31} & a_{32} \\ a_{41} & a_{42} \\ a_{51} & a_{52} \end{bmatrix} \begin{bmatrix} b_{11} & b_{21} & b_{31} & b_{41} & b_{51} \\ b_{12} & b_{22} & b_{32} & b_{42} & b_{52} \end{bmatrix} \begin{bmatrix} log(y_{t-1}) \\ log(ARB_{t-1}) \\ log(CRLYD_{t-1}) \\ log(LVSTK_{t-1}) \\ log(FRT_{t-1}) \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \\ e_{5t} \end{bmatrix} \text{ ....}$$

(6)

For the sake of further clarification, we may focus on the error correction part of the first equation of model (6) as follows ignoring the error terms for simplification.

$$\Pi \begin{bmatrix} logy_{t-1} \\ logARB_{t-1} \\ logCRLYD_{t-1} \\ logLVSTK_{t-1} \\ logFRT_{t-1} \end{bmatrix} = a_{11}(b_{11}logy_{t-1} + b_{21}logARB_{t-1} + b_{31}logCRLYD_{t-1} + b_{41}logLVSTK_{t-1} + b_{51}logFRT_{t-1}) + a_{12}(b_{12}logy_{t-1} + b_{22}logARB_{t-1} + b_{32}logCRLYD_{t-1} + b_{42}logLVSTK_{t-1} + b_{52}logFRT_{t-1}) \text{ .... (7)}$$

The first two equations on the right-hand side of (7) reflect the two cointegrating equations along with their speed of adjustment parameters and respectively.

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Data description and Unit Root test outcome

For empirical analysis this paper estimates an unrestricted VAR model in the logarithmic levels of variables including agricultural land productivity, arable land, livestock production, usage of inorganic fertilizer, and cereal yield, which are also the statistical indicators of sustainable agriculture. Annual time series data on these variables spanning 1961—2018 are obtained from 'World Development Indicators' databank. Year specific dummy variables are used to neutralize the undesirable effects of residual outliers on estimation outcome. Table 1 shows the detailed data description, data sources and variable abbreviations that are used to estimate the empirical models. For estimating the multivariate time series models, such as VAR and VEC, it is imperative that we check the order of integration of relevant model variables. We conduct the Augmented Dickey Fuller (ADF) test for all model variables for this purpose. Table 2 compiles the ADF test outcomes.

Table 1: Variables and Data sources

Variables	*Acronyms*	*Measurement*	*Data Source*
Productivity of agricultural land	$AGLNDPRD_t$	Constant 2015 US dollars per square kilometer	Calculated from data procured from World Development Indicators (WDI) Databank
Land under temporary crops	$ARABLAND_t$	Hectares	WDI Databank
Cereal productivity of land	$CEREALYIELD_t$	Kilograms per hectare	WDI Databank
Usage of inorganic fertilizer in agriculture	$FERTILIZERUSE_t$	Kilograms per hectare of arable land.	WDI Databank
Livestock production	$LIVESTOCKPRDN_t$	Index number (2014—2016 = 100)	WDI Databank

We proceed by plotting the data series on all model variables in their logarithmic levels to inspect if these exhibit some definite time trends and/or deterministic components. Expressing data in logarithm has the advantage of eliminating any nonlinearity if there is any. In addition, logarithmic conversion of level data allows us to interpret estimated coefficients of the normalized cointegrating equation in terms of percentage change in the response variable due to one percentage change (either positive or negative) in the right-hand side source variable in consideration.

Figure 1: Logarithmic level of agricultural land productivity (1961--2018)

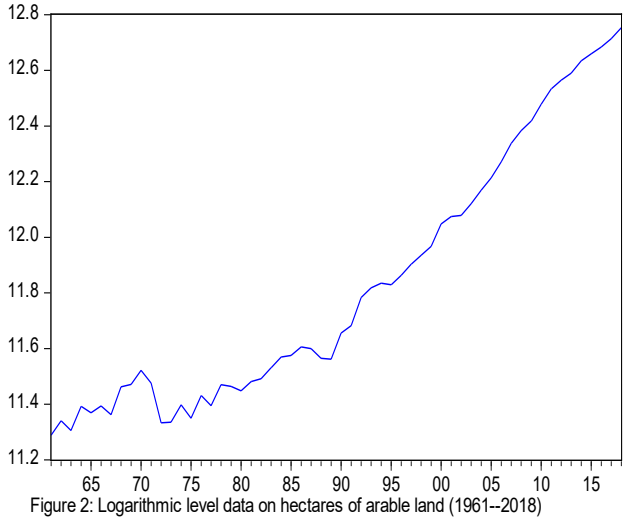


Figure 2: Logarithmic level data on hectares of arable land (1961--2018)

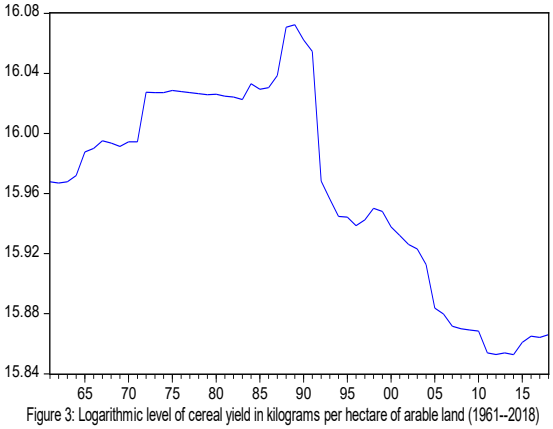
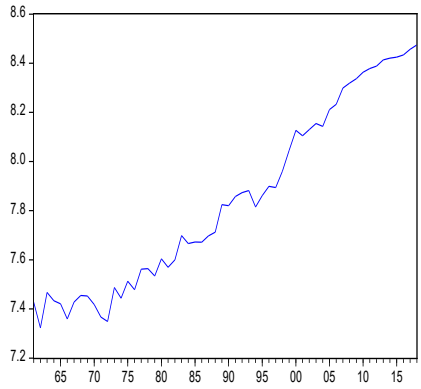


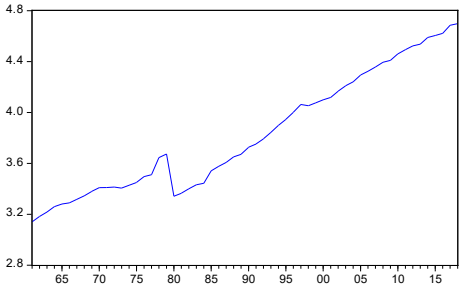
Figure 3: Logarithmic level of cereal yield in kilograms per hectare of arable land (1961--2018)



Visual inspection of figure 1, 3, 4, and 5 reveals these data series have conspicuous positive time trends with positive vertical intercepts. Figure 2 on the other hand, shows a drifting behavior without any definite positive or negative trending behavior.

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Figure 5: Logarithmic level of livestock production index (2014--2016=100), data range: 1961--2018



Following the visual inspection of logarithmic level data on model variables, we utilize the specific Augmented Dickey Fuller (ADF) test equation (8) for checking the order of integration in log-level data series of all model variables.

$$\Delta Y_t = \alpha_0 + \gamma Y_{t-1} + \alpha_1 t + \sum_{i=1}^{p} \beta_i \Delta Y_{t-i} + u_t \ \ldots\ldots\ldots (8)$$

Equation (8) specifies a time series variable in its first difference, which includes a deterministic time trend 't', a vertical intercept , an augmentation term with a lag length equals 'p' and a stochastic error term . The null hypothesis of this test states that the level data series has a unit root against the alternative that the data series does not contain a unit root. On the other hand, the null hypothesis of this test also states that the first differenced data series contains a unit root against the alternative that such a data series does not contain a unit root. If a data series contain a unit root, it is said to be nonstationary, signifying a variable time trend. In contrast, if a data series is found stationary it will signify a constant time invariant trend value.

Table 2 reports the unit root test outcome. All model variables in their logarithmic levels are tested for unit roots. The presence of unit roots in time series data is indicative of their non-stationarity. All data series are visually examined if they show any trending behavior and consequently assigned trend and intercept components in their ADF test equations. Table 2 shows that all model variables contain unit roots in their logarithmic levels or in other words, all of these are non-stationary in their logarithmic levels but prove stationary in their first differences. In other words, the null hypothesis of a unit root cannot be rejected in the logarithmic levels of these variables, but in their logarithmic first differences the null hypothesis of a unit root is strongly rejected at 1% level of significance. Therefore, it may be concluded that all model variables are integrated of order 1, or alternatively I (1), as these are non-stationary in their logarithmic levels, but stationary in their logarithmic first differences. Hence, we conclude that the model variables are integrated of the same order.

Table 2: ADF Test results for Unit Root

Variables	Levels				First Difference			
	ADF Test statistic	Trend	Intercept	p-value	ADF Test statistic	Trend	Intercept	p-value
Log ($AGLNDPRD_t$)	-1.12	Yes	Yes	0.92	-7.91***	No	Yes	0.00
Log ($ARABLAND_t$)	-0.16	No	Yes	0.94	-5.80***	No	No	0.00
Log ($CEREALYIELD_t$)	-3.44	Yes	Yes	0.06	-11.2***	No	Yes	0.00
Log ($FERTILIZERUSE_t$)	-2.36	Yes	Yes	0.40	-7.58***	No	Yes	0.00
Log ($LIVESTOCKPRDN_t$)	-1.85	Yes	Yes	0.67	-7.29***	No	Yes	0.00

Note: *** denotes 1% level of significance

VAR Model selection, estimation, and diagnostic tests

For empirical analysis, we estimate a VAR model in the logarithmic levels of variables in consideration. The VAR model consists of simultaneous equations, each of which expresses every endogenous variable in terms of its own past values and those of other endogenous variables included in the model. The advantage of a VAR model is that all variables are endogenous and therefore these are treated in equal footing and consequently the model avoids complicacy of preselecting variables into two distinct groups, such as 'endogenous' and 'exogenous.' In this sense, a VAR model avoids the 'biasness' that may arise because of categorizing some variables as 'independent' and others as 'dependent' by the very way it is constructed. Each individual equation in the VAR model is estimated independently using the OLS method.

However, our level VAR model is susceptible to producing spurious regression coefficients as these are estimated by the OLS method applied to each individual equation that includes nonstationary variables. By nature, the spurious regression coefficients are overly statistically significant as their standard deviations are underestimated due to the nonstationary nature of model variables. Hence, we start the data analysis part of this paper with the 'unit root' test to detect the stationarity status of variables and to determine their order of integration. Augmented Dickey Fuller (ADF) test is conducted for this purpose. All variables are found non-stationary in their logarithmic levels and stationary in their first differences at 5% level of significance with the implication that all of these are integrated of order one. Consequently, a VAR model is estimated in the logarithmic levels of relevant model variables and Johansen-Juselius (1988, 1992) cointegration test is conducted for detecting any cointegrating relationship among these non-stationary variables. According to this test, if there exists a cointegrating relationship among the non-stationary variables, it represents a long run equilibrium relationship that proves to be stationary.

Finally, we estimate a VAR model in the logarithmic levels of variables using a balanced sample of annual observations spanning 1961-2018. Considering a rather limited amount (57 observations) of time series data, the primitive level VAR model is estimated using a relatively small number of lags (=5). VAR (5) is found stable, but as the test for residual heteroskedasticity cannot be conducted due to the presence of negative numbers in the test equation, four lags

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are used for re-estimating the initial VAR model. VAR (4) is found stable as the largest root of the autoregressive characteristic polynomial of this model equals 0.9915 and hence proves less than unity. Table 3 reports the lag selection test outcome for the level VAR model. According to lag selection test outcome, VAR (4) is supported by AIC criterion that attains the lowest value for this lag length. Eventually, four lags are used for estimating the initial level VAR model. Conventionally, lag length in VAR model is selected by AIC or SC criterion.

Table 3: Lag selection criteria in the level VAR model

Sample: 1961—2018
Number of observations: 57

Lag	LR	FPE	AIC	SC	HQ
0	NA	5.82e-10	-7.096890	-5.255238	-6.386637
1	595.74	3.60e-16	-21.44627	-18.68379*	-20.38089
2	49.10	2.39e-16	-21.96434	-18.28104	-20.54384
3	43.20*	1.66e-16*	-22.52799	-17.92386	-20.75236*
4	26.26	1.94e-16	-22.69628*	-17.17132	-20.56552

Note: Indicates significant at 5% level of significance

We have also conducted the lag exclusion test to check if we can pare down the lag length in our level VAR (4) model. Table 4 reports the lag exclusion test outcome for estimated VAR (4) model. Each column shows the Chi-square test statistic and its corresponding p-value in relation to the null hypothesis that lag of the relevant endogenous variable in that equation of VAR model equals zero. For instance, the first column of table 4 shows the Chi-square test statistic values for lag 1, lag 2, lag 3, and lag 4 for other endogenous variables in log (AGLNDPRD) equation of VAR (4) model. In this equation, the null hypothesis that lags 1 and 2 of other variables in this equation can be rejected as the p-value of the corresponding Chi-square test statistic are equal to zero.

Table 4: VAR Lag Exclusion Wald Tests
Included observations: 54
Joint Null Hypothesis: estimated parameters of lag 4 are zero in all equations of VAR (4)

Chi-squared test statistics for lag exclusion:
Numbers in [ ] are p-values

	LOG(AGLNDPRD)	LOG(ARABLAND)	LOG(CEREALYIELD)	LOG(FERTILIZER USE)	LOG(LIVESTOCK PRDN)	Joint
Lag 1	106.1358	189.3293	17.04956	33.79366	160.5229	562.9892
	[0.000000]	[0.000000]	[0.004407]	[2.62e-06]	[0.000000]	[0.000000]
Lag 2	32.05862	1.544882	4.645643	3.183660	0.705422	58.44468
	[5.78e-06]	[0.907833]	[0.460636]	[0.671695]	[0.982670]	[0.000171]
Lag 3	7.268870	3.271721	5.710021	15.65836	0.775020	48.23952
	[0.201400]	[0.658174]	[0.335465]	[0.007890]	[0.978599]	[0.003491]
Lag 4	2.725113	2.797858	21.19994	6.801193	2.937847	34.96860
	[0.742275]	[0.731116]	[0.000743]	[0.235851]	[0.709568]	[0.088773]
df	5	5	5	5	5	25

The last column of this table shows Chi-square test statistic values of the joint null hypothesis that a certain lag for all endogenous variables in all equations of VAR (4) are jointly equal to zero. For instance, the first entry of the last column of this table shows that Chi-square value (=562.99) of the joint null hypothesis that lag 1 of all endogenous variables in all equations of VAR (4) are equal to zero with the associated p-value of zero. Hence, the null hypothesis can be rejected and lag 1 proves significant. Similarly, lags 2 and 3 also prove statistically significant in the estimated VAR (4) model. However, lag 4 appears statistically significant at 10% level of significance.

After estimating VAR (4) model, we conducted the residual normality test for this model. Table 5 shows residual normality test outcome for VAR (4), which does not indicate significant Skewness and Kurtosis. Overall, the residuals of the estimated VAR (4) model are normally distributed.

Table 6: Residual serial correlation LM test for VAR (4)
: No residual serial correlation at the chosen lag

Lags	LM statistic	p-value
1	39.98761	0.0292
2	16.64920	0.8941
3	18.52359	0.8194
4	12.80775	0.9788
5	10.52186	0.9950
6	30.22811	0.2159

Table 6 reports residual serial correlation test outcomes for VAR (4) model. For each lag of the estimated VAR model, the LM statistic value and the corresponding probability is reported. The null hypothesis of no serial correlation at lag 1 is rejected as the probability value of the LM statistic for this lag is less than 5%. Hence, the null hypothesis of an absence of residual autocorrelation is rejected for this lag. However, the LM statistic value for lag 4 is 12.81 with a corresponding probability value of 0.98. Hence, the null hypothesis of no residual autocorrelation for this lag cannot be rejected.

Cointegration test outcome for level VAR (4) model

Table 7 reports the outcome of Johansen-Juselius test for detecting cointegrating relationships in VAR (4) model. Both Trace and maximum Eigenvalue tests detect two cointegrating relationships at 5 percent level of significance. Both tests identify the cointegrating relationships specified by model 3 that allows deterministic

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trends in data and an intercept in the cointegrating equations.

Table 7: Johansen-Juselius cointegration test outcome
Sample (adjusted): 1965--2018, Included observations: 54 after adjustments
Lags interval (in first differences): 1 to 3

Maximum rank		5% critical value		5% critical value
r = 0	101.88	68.52	44.80	33.46
r = 1	57.08	47.21	31.69	27.07
r = 2	25.39**	29.68	16.78*	20.97
r = 3	8.61	15.41	8.33	14.07

Estimation of the Vector Error Correction Model:

Since the initial VAR (4) model is estimated using 4 lags in the logarithmic levels of variables concerned, the multivariate counterpart of the (Engle-Granger) error correction model (VECM) is estimated using 3 lags of these variables. One lag disappears due to first differencing the log-level data series that accounts for the short run part of the VECM. The VECM (3) model is duly estimated by normalizing the long run part for logarithmic level of 'agricultural land productivity' variable in terms of others. Subsequently, we impose zero restrictions on the short run adjustment parameters. The restrictions identify all cointegrating vectors. Table 8 reports outcomes of the LR (Log-Likelihood ratio) test for the binding restrictions imposed on VECM (3).

Table 8: Loglikelihood Ratio (LR) test for binding restrictions imposed on VECM (3)

LR test for binding restrictions (rank = 1):
Restrictions imposed on the cointegrating vector is valid
Cointegrating restrictions: B (1,1)=1, A(1,1)=0, A(2,1)=0, A(5,1)=0 — p-value = 0.105

Note: Convergence achieved after 108 iterations
Restrictions identify all cointegrating vectors

Implications of the cointegrating restrictions:
B (1,1) =1 implies that the first cointegrating equation of VECM (3) is normalized for the first endogenous variable, i.e., the left-hand side of this equation reports logarithmic level of productivity of agricultural land and the right-hand side variables are logarithmic levels of cereal yield, usage of inorganic fertilizer, arable land, and livestock production index. The estimated normalized long run equilibrium relationship is as follows.

$$logAGLNDPRD_{t-1} = ECT_t + 6.05logARABLAND_{t-1} + 0.79logCEREALYIELD_{t-1} - 0.49logFERTILIZERUSE_{t-1} + 1.9logLIVESTOCKPRDN_{t-1} + \varepsilon_t$$

…… (9)

Table 9: Estimated coefficients of the non-normalized cointegrating equation

-6.05*** (1.75)	-0.79* (0.55)	0.49*** (0.10)	-1.90*** (0.52)

Note: t-statistic values are in brackets and standard errors are in parentheses
, 10% level of significance.
, 1% level of significance.

where
AGLNDPRD: productivity of agricultural land.
ARABLAND: total amount of arable land.
CEREALYIELD: cereal yield.
FERTILIZERUSE: usage of inorganic fertilizer in agriculture.
LIVESTOCKPRDN: livestock production index.
Equation (9) is the estimated normalized long run cointegrating (equilibrium) relationship between the model variables. It is visible that except for the 'fertilizer use', other model variables have positive long run impacts on the productivity of agricultural land. On the other hand, except for the cereal yield, other indicators of sustainable agriculture are statistically significant at 1% level of significance. In addition, the long run positive impact of cereal yield on agricultural land productivity is significant at 10% level of significance. Table 10 reports short run analysis of the estimated VECM (3). However, not all (error correction terms) attain their expected negative algebraic signs.
According to Johansen-Juselius (1992) methodology, the term in VEC model must be negative so that once the relationship between nonstationary model variables deviates from their cointegrating relationship last year, the deviation gets rectified in current year as the cointegration is restored. However, this is not the case for VEC (3) that we have estimated. More specifically, the speed of adjustment parameter attached to first cointegrating relationship in the first equation of VECM (3), i.e. A (1,1) fails to attain this negative sign and so do the adjustment parameters for the first cointegrating equation in the second and fifth equations of VECM (3).

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Table 10: Analysis of the short run part of VECM (3) model with no restrictions on the short run part

Restrictions imposed:
b (1, 1) =1, no restrictions on Error Correction Terms (ECT)

	Current Endogenous Variables in First Differenced Logarithmic Terms					
	$\Delta log\,(AGLNDPRD_t)$	$\Delta log(ARABLAND_t)$	$\Delta log(CEREALYIELD_t)$	$\Delta log(FERTILIZERUSE_t)$	$\Delta log(LIVESTOCKPRDN_t)$	
Lagged Endogenous Variables in Differences						
Intercept	0.015697 (0.00709) [2.21435]	-0.00004 (0.00236) [-0.01688]	0.058890 (0.01396) [4.21805]	0.083359 (0.03417) [2.43973]	0.026680 (0.00840) [3.17747]	=
$\Delta log\,(AGLNDPRD_{t-1})$	-0.159495 (0.14858) [-1.07349]	-0.009190 (0.00495) [-0.18558]	-0.228623 (0.29263) [-0.78128]	3.086391 (0.71613) [4.30982]	-0.117237 (0.17599) [-0.66616]	=
$\Delta log\,(AGLNDPRD_{t-2})$	0.337128 (0.18615) [1.81109]	0.022903 (0.06204) [0.36917]	0.658786 (0.36662) [1.79691]	2.648380 (0.89722) [2.95177]	-0.194681 (0.22049) [-0.88294]	=
$\Delta log\,(AGLNDPRD_{t-3})$	-0.031254 (0.11765) [-0.26564]	-0.022946 (0.0392) [-0.71266]	0.425800 (0.23173) [1.83752]	0.580026 (0.56709) [1.02281]	-0.096509 (0.13936) [-0.69256]	=
$\Delta log(ARABLAND_{t-1})$	-0.300721 (0.24291) [-1.23797]	0.117435 (0.08096) [1.45052]	0.267510 (0.47843) [0.55914]	2.907467 (1.17084) [2.48324]	-0.307215 (0.28773) [-1.06770]	=
$\Delta log(ARABLAND_{t-2})$	0.457885 (0.25607) [1.78814]	0.125484 (0.08534) [1.47033]	1.083976 (0.50433) [2.14933]	0.476616 (1.23423) [0.38616]	-0.122868 (0.30331) [-0.40509]	=
$\Delta log(ARABLAND_{t-3})$	-0.047810 (0.23091) [-0.20705]	-0.019674 (0.07696) [-0.25564]	0.175027 (0.45478) [0.38486]	-0.577825 (1.11297) [-0.51917]	-0.240037 (0.27351) [-0.87760]	=
$\Delta log(CEREALYIELD_{t-1})$	0.531230 (0.07894) [6.72915]	-0.040302 (0.02631) [-1.53172]	-0.329199 (0.15548) [-2.11726]	-1.135895 (0.38051) [-2.98520]	0.011769 (0.09351) [0.12586]	=
$\Delta log(CEREALYIELD_{t-2})$	-0.078074 (0.10852) [-0.71941]	-0.006530 (0.03617) [-0.18055]	-0.030773 (0.21374) [-0.14397]	-1.705293 (0.52308) [-3.26008]	0.130700 (0.12855) [1.01673]	=
$\Delta log(CEREALYIELD_{t-3})$	-0.030727 (0.11600) [-0.26488]	-0.031979 (0.03866) [-0.82712]	-0.567785 (0.22847) [-2.48512]	-1.308224 (0.55913) [-2.33974]	0.153265 (0.13741) [1.11540]	=
$\Delta log(FERTILIZERUSE_{t-1})$	0.002017 (0.02927) [0.06892]	0.001287 (0.00976) [0.13196]	-0.123500 (0.05765) [-2.14216]	-0.069058 (0.14109) [-0.48947]	0.019238 (0.03467) [0.55486]	=
$\Delta log(FERTILIZERUSE_{t-2})$	0.017305 (0.02309) [0.74938]	0.007115 (0.00770) [0.92441]	-0.099864 (0.04548) [-2.19567]	-0.127070 (0.11131) [-1.14162]	0.016148 (0.02735) [0.59034]	=
$\Delta log(FERTILIZERUSE_{t-3})$	-0.000489 (0.02527) [-0.01937]	-0.000112 (0.00842) [-0.01332]	-0.123938 (0.04978) [-2.48980]	0.172510 (0.12182) [1.41611]	0.015297 (0.02994) [0.51097]	=
$\Delta log(LIVESTOCKPRDN_{t-1})$	0.083626 (0.05906) [1.41603]	0.003915 (0.01968) [0.19891]	0.004278 (0.11631) [0.03678]	-0.684725 (0.28465) [-2.40549]	0.038357 (0.06995) [0.54832]	=
$\Delta log(LIVESTOCKPRDN_{t-2})$	-0.075905 (0.06020) [-1.26082]	0.018191 (0.02006) [0.90663]	-0.086074 (0.11857) [-0.72592]	-0.728159 (0.29017) [-2.50939]	0.042249 (0.07131) [0.59247]	=
$\Delta log(LIVESTOCKPRDN_{t-3})$	0.026561 (0.06048) [0.43920]	0.000592 (0.02016) [0.02939]	-0.296879 (0.11911) [-2.49252]	-0.750861 (0.29149) [-2.57596]	0.040104 (0.07163) [0.55985]	=
ECT_{t-1}	0.004815 (0.03508) [0.13725]	0.009613 (0.01169) [0.82220]	-0.151474** (0.06909) [-2.19239]	-0.828954*** (0.16908) [-4.90266]	0.061093 (0.04155) [1.47027]	=
R^2	0.899631	0.912029	0.642548	0.792789	0.917398	
Log likelihood	734.2586					
Residual Normality Test	$\chi^2(df)$, H_0: *residuals are multivariate normal*					
	Skewness: 6.31(5), Prob.= 0.28	Kurtosis: 4.95(5), Prob.= 0.42	Jarque-Bera: 11.26(10) Prob.=0.34			
Residual Serial Correlation LM Test	LM -Stat (Prob.), H_0: No serial correlation at the chosen lag length					
	Lags:	1	2	3	4	
	LM -Stat (Prob.)	28.82 (0.27)	17.27 (0.87)	20.68 (0.71)	15.76 (0.92)	
Residual Heteroskedasticity Test	$\chi^2(df)$, H_0: No residual Heteroskedasticity					
	Joint Test: χ^2 (615) = 575.41, Prob. = 0.87					

second and fifth equations of VECM (3).

Note: Figures in parentheses are standard errors of the estimated coefficients and in brackets are their 't statistic' values in the model estimation part, ***indicates 1% level of statistical significance, **indicates 5% level of statistical significance, statistical significance of ECT terms are shown only.

Consequently, the VEC (3) model is re-estimated by normalizing the cointegrating equation for logarithmic level of agricultural land productivity and after imposing zero restrictions on the speed of adjustment parameters associated with the first, second and fifth short run parts of the model. Table 11 displays the estimation outcome of the restricted VECM (3) model. The 'Log-likelihood ratio' (LR) test is conducted to check if the restrictions are binding. Chi-square statistic of this test equals 6.15 with 3 'degrees of freedom' with an associated probability value of 0.104. The null hypothesis of this test states that the zero restrictions imposed on the 'error correction terms' (ECT) are binding and valid. Hence, the null hypothesis cannot be rejected as the probability of committing the type I error in such a case appears more than 10%.

Sensitivity analysis:

Sensitivity analysis of the residual behavior of VEC (3) model demonstrates that residuals of this model are multivariate normal and do not exhibit statistically significant Skewness and Kurtosis. Residual autocorrelation LM test detects no significant residual serial correlation from lag 1 to 5 for this model. Finally, the estimated model does not show any significant residual heteroskedasticity.

Figure 6: Cointegration Graph of the Unrestricted VEC (3) Model

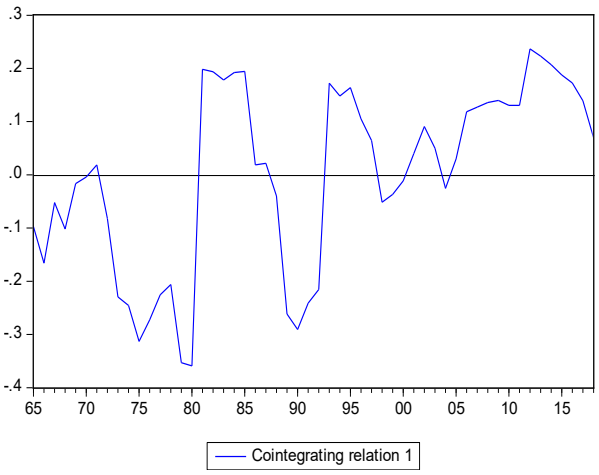


Figure 7: Cointegration Graph of the Restricted VEC (3) Model

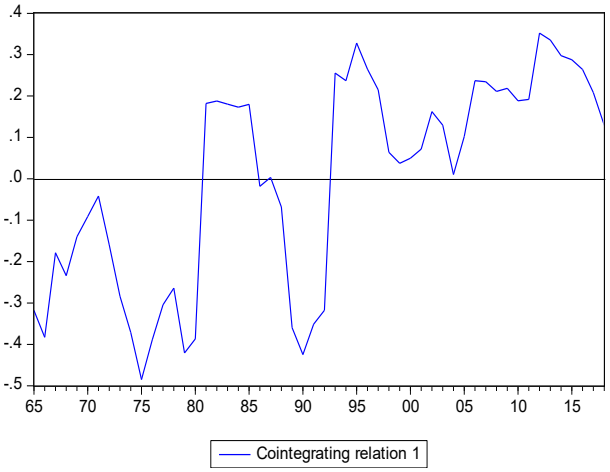


Table 11: Analysis of the short run part of restricted VECM (3) model
Cointegration Restrictions: B (1,1) =1, A (1,1) =0, A (2,1) =0, A (5,1) =0
Restrictions identify all cointegrating vectors, LR test for binding restrictions (rank = 1):
$\chi^2(3)$ = 6.15, Probability= 0.104

	Current Endogenous Variables in First Differenced Logarithmic Terms					
Lagged Endogenous Variables in Differences	$\Delta log\,(AGLNDPRD_t)$	$\Delta log(ARABLAND_t)$	$\Delta log(CEREALYIELD_t)$	$\Delta log(FERTILIZERUSE_t)$	$\Delta log(LIVESTOCKPRDN_t)$	
Intercept	0.015293 (0.00718) [2.13147]	-0.00003 (0.00242) [-0.01120]	0.059957 (0.01504) [3.98538]	0.105256 (0.03343) [3.14837]	0.025466 (0.00860) [2.96021]	=
$\Delta log\,(AGLNDPRD_{t-1})$	-0.163632 (0.14551) [-1.12455]	-0.000491 (0.04914) [-0.00999]	-0.339421 (0.30509) [1.11252]	2.812803 (0.67799) [4.14874]	-0.088800 (0.17446) [0.50900]	=
$\Delta log\,(AGLNDPRD_{t-2})$	0.310766 (0.18279) [1.70015]	0.048233 (0.06172) [0.78176]	0.380139 (0.38326) [0.99187]	2.653688 (0.85169) [3.11580]	-0.157024 (0.21916) [0.71649]	=
$\Delta log\,(AGLNDPRD_{t-3})$	-0.039888 (0.11477) [-0.34756]	-0.017560 (0.03876) [-0.45309]	0.304941 (0.24064) [1.26720]	0.460662 (0.53476) [0.86143]	-0.074234 (0.13761) [0.53947]	=
$\Delta log(ARABLAND_{t-1})$	-0.299237 (0.24236) [-1.23468]	0.119211 (0.08184) [1.45663]	0.237675 (0.50816) [0.46771]	2.720924 (1.12926) [2.40947]	-0.294946 (0.29058) [-1.01193]	=
$\Delta log(ARABLAND_{t-2})$	0.451118 (0.25376) [1.77771]	0.135839 (0.08569) [1.58531]	0.957784 (0.53207) [1.80010]	0.254320 (1.18239) [0.21509]	-0.094841 (0.30425) [0.31172]	=
$\Delta log(ARABLAND_{t-3})$	-0.028524 (0.23567) [-0.12103]	-0.029416 (0.07958) [-0.36963]	0.253794 (0.49415) [0.51360]	-1.093492 (1.09811) [0.99580]	-0.225573 (0.28256) [0.79831]	=
$\Delta log(CEREALYIELD_{t-1})$	0.528051 (0.07918) [6.66935]	-0.038573 (0.02674) [-1.44271]	-0.345950 (0.16601) [2.07174]	-1.058030 (0.36891) [2.86795]	0.009971 (0.09493) [0.10504]	=
$\Delta log(CEREALYIELD_{t-2})$	-0.070863 (0.10707) [-0.66184]	-0.014441 (0.03616) [-0.39941]	0.059319 (0.22450) [0.26423]	-1.649969 (0.49888) [3.30733]	0.115739 (0.12837) [0.90158]	=
$\Delta log(CEREALYIELD_{t-3})$	-0.016500 (0.11612) [-0.14209]	-0.044432 (0.03921) [-1.13312]	-0.434841 (0.24348) [-1.78595]	-1.382450 (0.54107) [2.55504]	0.138800 (0.13923) [0.99693]	=
$\Delta log(FERTILIZERUSE_{t-1})$	0.006112 (0.03124) [0.19566]	-0.000488 (0.01055) [-0.04625]	-0.110943 (0.06549) [1.69392]	-0.195580 (0.14555) [1.34377]	0.023708 (0.03745) [0.63304]	=
$\Delta log(FERTILIZERUSE_{t-2})$	0.019565 (0.02396) [0.81669]	0.007313 (0.00809) [0.90395]	-0.109662 (0.05023) [2.18322]	-0.265328 (0.11162) [2.37702]	0.024233 (0.02872) [0.84370]	=
$\Delta log(FERTILIZERUSE_{t-3})$	0.002686 (0.02693) [0.09973]	-0.000254 (0.00909) [-0.02798]	-0.131759 (0.05646) [2.33313]	-0.131759 (0.12548) [0.02081]	0.002611 (0.12548) [0.76362]	=
$\Delta log(LIVESTOCKPRDN_{t-1})$	0.084747 (0.05550) [1.52704]	-0.001564 (0.01874) [-0.08343]	0.078653 (0.11636) [0.67592]	-0.429119 (0.25859) [1.65947]	0.015754 (0.06654) [0.23676]	=
$\Delta log(LIVESTOCKPRDN_{t-2})$	-0.072489 (0.05661) [-1.28040]	0.011840 (0.01912) [0.61930]	-0.006390 (0.11871) [0.05383]	-0.550540 (0.26379) [2.08702]	0.022733 (0.06788) [0.33490]	=
$\Delta log(LIVESTOCKPRDN_{t-3})$	0.028979 (0.05711) [0.50744]	-0.005199 (0.01928) [-0.26959]	-0.222076 (0.11974) [1.85463]	-0.549866 (0.26609) [2.06644]	0.020110 (0.06847) [0.29370]	[
ECT_{t-1}	0.000000	0.000000	-0.023002 (0.04361) [-0.52747]	-0.563785*** (0.10066) [-5.60085]	0.000000	=
R^2	0.90	0.91	0.60	0.81	0.92	
Log likelihood	731.18					
Residual Normality Test	$\chi^2(df)$, H_0: *residuals are multivariate normal*					
Degrees of freedom are in parentheses	Skewness:6.90(5), Prob. = 0.23	Kurtosis: 2.08(5), Prob. = 0.84	Jarque-Bera: 8.98(10), Prob. = 0.53			
Residual Serial Correlation LM Test	LM -Stat (Prob.), H_0: No serial correlation at the chosen lag length					
	Lags:	1	2	3	4	5
	LM -Stat (Prob.), probability values are in parentheses	33.33 (0.12)	28.51 (0.29)	24.72 (0.48)	22.01 (0.64)	19.47 (0.77)
Residual Heteroskedasticity Test	$\chi^2(df)$, H_0: No residual Heteroskedasticity					
Degrees of freedom are in parenthesis	Joint Test: χ^2 (615) = 562.84, Prob. = 0.93, degrees of freedom are in parenthesis					

Note: Figures in parentheses are standard errors of the estimated coefficients and in brackets are their 't statistic' values in the model estimation part, ***indicates 1% level of statistical significance, **indicates 5% level of statistical significance, statistical significance of ECT terms are shown only.

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Figure 8 displays the impulse responses of logarithmic levels of agricultural land productivity due to one standard deviation positive shock to the indicators of sustainable agriculture in Bangladesh, namely, logarithmic levels of arable land, cereal yield, fertilizer use, and livestock production index. Except for arable land, impulse responses of agricultural land productivity exhibit expected dynamic behavior. The first graph in figure 3 shows that logarithmic level of agricultural land productivity declines due to an unexpected positive shock to arable land in the first year but increases thereafter. The second graph shows that agricultural land productivity immediately responds positively due to a positive shock to cereal yield. The third graph shows that agricultural land productivity experiences a prolonged downfall due to a positive shock to the usage of inorganic fertilizer use and the last graph indicates that a positive shock to livestock production index results in a prolonged positive impact on agricultural land productivity as expected. Therefore, the simulation analysis of the empirical model of this thesis are in support of the theoretical predictions of the dynamic behavior of agricultural land productivity due to sustainable agricultural practices in Bangladesh.

VI. CONCLUSION

Bangladesh is committed to attain sustainable development goals by 2030 and sustainable agriculture is one of the most important of these goals given the agrarian nature of this economy. At this backdrop, this paper effectively employs a multivariate error correction model (VEC) and estimates the long run impacts of some measurable indicators of sustainable agriculture on agricultural land productivity and found plausible responses in line with theoretical literature. More specifically, our empirical findings reflect that a 1 percent increase in the amount of arable land and cereal yield leads to 6.05% and 0.79% increase in agricultural land productivity respectively over the long run. On the other hand, a 1% increase in livestock production leads to a 1.9% increase in agricultural land productivity, but the same increase in inorganic fertilizer use leads to a 0.49% decrease in agricultural land productivity over the long run. Except for one, all estimated long run coefficients of the farmland productivity model due to 1% change (increase or decrease) in sustainable agricultural practice are found statistically significant at 1% level of significance.

These empirical findings may have important policy implications. We may deduce that government should encourage farmers to conserve their arable land or discourage them from using this land for unsustainable use, such as shrimp culture in coastal areas by trapping brackish water from nearby estuarian rivers. The government should also encourage the farmers to cultivate high yielding varieties of cereal through agricultural extension services and allocate more funds to national research facilities for developing high yielding cereal varieties. There should be government financed initiatives for discouraging the usage of chemical fertilizer that may eventually leach into nearby fresh water sources, seep into the depth of arable land and contaminate ground water table.

Most of the research papers focus on estimating empirical models using primary data on sustainable agricultural indicators. While primary data are collected from candid interviews with farmers that may have more appeal to readers, estimated models using these data may lose the much-required generalization that can be attained from models that are estimated using more aggregated national level data. Further research can be done focusing on this issue.

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Influential Factors of Consumer Buying Behavior towards Branded Products: Evidence from Dhaka

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Abstract- **Consumer behavior can be measured by the prospective user's intention as it is considered as a determinant factor of user's behavior towards the product. This is important to examine the factors that determine the consumers' purchase behavior to buy a particular product such as mobile phone. This study investigates the relationship between determinant factors such as consumers' social and economic status and various market factors with the purchasing intention of mobile phones by observing their behavioral process. This study also aims to examine the factors affecting brand formation and its effect on consumer behavior. The findings of this study are based on a cross-sectional survey collecting quantitative data where information was collected from 424 respondents through a pre-tested structured questionnaire deployed to cover different sites of Dhaka city in Bangladesh. Along with descriptive statistics, study findings are presented in univariate and bi-variate tabular format. The study presents an analysis of the correlation between branded products with various factors in relation to purchasing behavior. The study results showed that the respondents preferred foreign-branded mobile phones over local ones. The analysis of brand image against purchasing behavior initially reflected the relationship between the brand image and various factors while choosing branded mobile phones. In the statistical analyses, correlation coefficient levels according to factors found related to respondents' purchasing intention and reasons for choosing branded products. This has been conducted where all choosing statements showed a positive relationship with each other where social factors and market factors were statistically significant ($p<0.01$). Again for the economic factor, respondents' intention to buy products was only strongly determined by their income ($p<0.01$). This study concluded that brand image has a positive influence on consumers' purchase behavior. However, the study is not free of limitations, which could also be taken into consideration to make further exploration of the issue. The study particularly recommended the need for the inclusion of a qualitative approach to acquire more in-depth information with real scenarios in future research.**

Keywords- **Consumer buying behavior, Purchasing Intention, Influencing Factors**

I. INTRODUCTION

Organizational communication is crucial for organizational behavior theory, as communication is the backbone of all organizational tasks. In this context, consumer behavior can be measured by the prospective
user's intention since user's intention is considered as a determinant factor of user's behavior of any product of an organization. Every organization always focuses on consumer satisfaction by offering them products for their consumption. Market acts like a tool by fulfilling consumers' needs, demands and desires to consume all the goods that are usually available. People living in upper-class society are more aware of their social standing and they usually select branded products to maintain their social status which is also inevitable for other classes too. Generally, brand is considered as a key that consumers use when they make any buying decisions. Launching a new product always poses some risks if the present market condition is not studied properly, it may face failure as there are other factors involved. [1]. In this case,[3] said a brand name can actually give value, identity and meaning to the product. In fact, once brand image gets set in people's minds, it can stay for a very long time and can demonstrate a strong weapon in fighting with competitors. Again, brand image is also an important approach to justify any brand, i.e., consumers generally hold a deep feeling towards branded products and it may have a reflection on consumer behaviour.

Generally, a product or service is presented in the market to meet consumer needs and make them feel interested in purchasing and using that product or service again. People from any walk of life can come forward to consume any particular product which reflects their buying behavior. Global consumers are individually different in their characteristics like age, individual income, educational levels and their selection preferences etc., which may have an impact on purchasing their desired goods and services. Consumer buying behavior is the study of how people buy, what they buy and why they buy. Literature indicated that there are many components that influence people's consumption behavior, and these components are named cultural, social, personal, and psychological written by [4]. Also [2] indicated that consumers' views towards a product get changed when it does not meet their expectations or in another way, once they recognize any problems with the product they intend to switch to another one. [5] said consumer selection behavior goes through the process of individual buying decisions which is dissimilar to each buyer. The type of choice shows a positive spending habit and purchasing power among consumers of a country, which is occurring may be due to known brands of specific products irrespective of their manufacturing origin or highest price. Empirical studies show that customer satisfaction plays an important role in studying their repurchase behavior. On the other way, while making advertisements on branded products, organizations can exclusively show the techniques of products, which can be primary motivation exercises that directly impact consumers' purchase behavior.

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This research seeks to determine the customer relationship with social, economic, and market factors over the product like mobile phone purchasing intention through observing their behavioral process. These factors are interrelated with one another and influence consumers' purchase intention towards choosing branded products by keeping the brand image in their minds. Therefore, this research aims to understand the role of branded products acting towards consumer purchasing behavior. This study also aims to see the factors affecting brand formation and affect consumer behavior by these factors.

II. METHODOLOGY

This study was a cross-sectional descriptive type that used a quantitative approach and data was collected through a structured questionnaire. The study covered a targeted sample population and the covered locations were shopping malls, Educational Institutes, Banks as financial Institutes, and Non-Governmental Organizations (NGOs) where target respondents are available. The targeted population of this study were adult males and females before their availability at the selected locations in both areas and focusing on the people's behavior on branded products like mobile phone users. For the quantitative survey, the sample size was estimated with the following correctional formula[1]:

With normal deviate at 95% Confidence Interval and population prevalence is unknown and margin of error 5%. Considering the above aspects, the desired sample size is 384. Now, rr = nonresponse which is 10% of 384 = 38. Thus, the total sample size = (384+38) = 422. The estimated sample size was equally distributed according to study zone and included two additional samples (424) and those people willingly participated by fulfilling our respondent's criteria. The sample respondents were selected conveniently who fulfilled the study respondent's inclusion criteria.

The primary data was collected through face-to-face interviews using a pre-tested structured questionnaire. All questions were made with relevant aspects and to satisfy the research objectives. Along with the primary data, some secondary information had been reviewed by extracting relevant documents directly related to the research issues. To maintain the data reliability and consistent responses, the researcher was always responsible for the quality of the information at the field level including ensuring proper coverage of the study areas. The study has undertaken ethical considerations: First from Institutional Ethical Clearance which has been sorted by the Department with the permission of the university authority (Bangladesh University of Professionals). The other ethical issue was from Individual Level where careful measures were undertaken to provide the respondent's consent by deploying a written consent form before starting the interview with the respondents.

According to the tabulation plan information was organized into descriptive statistics through graphs/charts and tables. Along with the descriptive statistics in different tables, variables were analyzed through univariate and bi-variate tabular format on branded product images against purchase behavior. The analysis reflects the correlation between the branded products considering various factors on the purchasing behavior.

III. RESULTS

A higher proportion of respondents (37.3%) were interviewed from different educational institutes, followed by 32.8% from shopping mall areas. The sample respondents constitute an equal proportion of 15.1% from banks/financial institutes and 14.9% from non-government organizations (Table 1).

TABLE 1:
Sampling area by Sampling Zone (Dhaka city corporations) (n=424)

Sampling Area	Dhaka North City Corporation	Dhaka South City Corporation	Total
Shopping Mall	44.7%	24.8%	32.8%
Education Institutes	18.2%	50.0%	37.3%
Bank/Financial Institutes	18.8%	12.6%	15.1%
Non-Government Organization	18.2%	12.6%	14.9%
Total	100.0%	100.0%	100.0%

From the age-frequency curb it can be seen that the mean age of the respondents is 30.62 years with a standard deviation of 8.57 in the following Figure 1

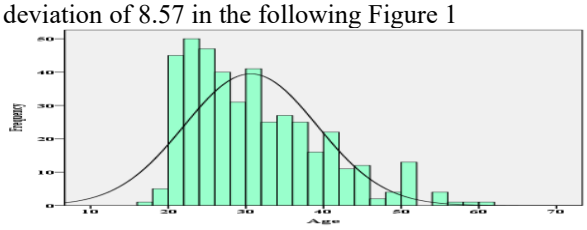


Fig. 1: Histogram with Mean Standard Deviation of Respondents age (n=424)

On the basis of income per , 66 & 100), the overall income level c as been categorized into lower-class, medium-class and upper-class families. About 32.5% of upper-class families have been recorded while 30.2% of medium-income families and 37.3% of lower-income class families have been recorded in Table 2.

[1](https://www.google.com/search?client=firefox-b-d&q=cross+sectional+sample+calculation+formula)

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TABLE II:
Income Quartile of the study respondents (n=424).

Income Quartile	Frequency	Percentage
Lower Class	158	37.3
Medium Class	128	30.2
Upper Class	138	32.5

The study respondents (100%) were currently using mobile phones and the proportion of use varied across the sampling areas (Table not shown).

Figure 2 shows the current brand trust among the respondents where the majority of the respondents (average 88.9%) preferred foreign brand mobile phones over local ones. The proportion was almost similar across the study places.

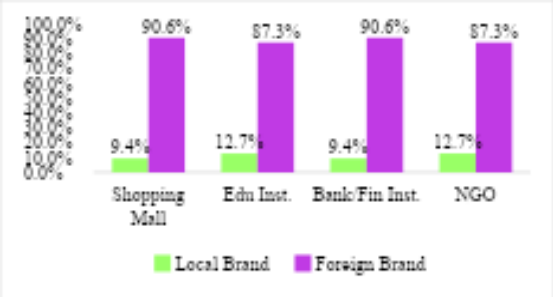


Fig. 2: Preference of brand mobile phone (n=424)

About 89.9% of respondents said that they were pleased with their branded mobile phone devices, even though satisfaction not much varied across the study places (table not shown).

The respondents' selection of branded mobile phones mainly depended on their own choice (60.4%), which was followed by recommendations from their family members (24.8%) and friends (13.0%). Other references were not that much influencing in the selection of buying a branded mobile phone (Figure 3).

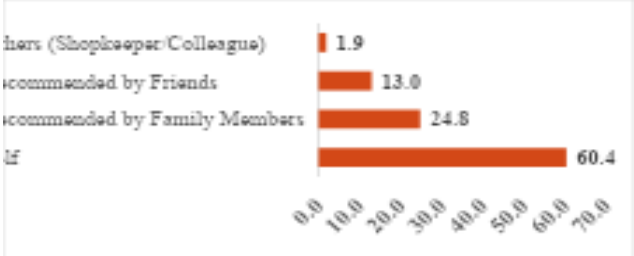


Fig.3: Selection of branded mobile phone (n=424)

In consideration to several statements included in the questionnaire and were deemed roughly 3 points of Scale (Disagree, Neutral, and Agreed), then the statements got analyzed and categorized into three factors: Social factor, Economic factor and Marketing factors. Initial results were established by frequencies which indicated level of the purchasing intention within each factor separated by Median values that pointed towards the central tendency is to be agreed with all statements.

In the following (Table 3) different factors affecting mobile phone purchasing behaviour among respondents across the study places has been depicted. Regarding the Social factors, the result indicated that it is their culture which mostly prohibited them from buying certain mobile brands (34.9%) but prior-decision and social class of respondents always play a strong factor to buy a phone (69.8%) & (63.0%) respectively. Similarly, other factors such as respondents' age (61.6%), self-esteem (61.6%), peer advice (59.9%) and family's choice (58.5%) etc. have significantly influenced respondent's purchasing behaviour to buy a certain mobile phone.

In regards to Economic factors, the results revealed that respondents lifestyle and personality factors strongly determined their choice to buy a mobile phone

Table III.
Respondent's purchasing intention (Social, Economic and Marketing Factors) to branded phone (%).

Social Factors:	Disagreed	Neutral	Agreed
Self-esteem affects buying decisions on mobile phone	21.7	16.7	61.6
Buy a mobile on own thinking	13.7	16.5	69.8
Culture prohibits from buying certain brand	29.5	35.6	34.9
Usually look to peer's advice when buying a phone	18.4	21.7	59.9
Buy a phone which is of social class.	15.6	21.5	63.0
Family/friends usually like the types of phones to purchase	18.2	23.3	58.5
Buy a mobile phone which is the role models use	34.9	21.7	43.4
Age influences the type of mobile phone to purchase	16.5	21.9	61.6
Gender affects in buying behaviour of mobile phone	19.8	24.1	56.1
Median of Social Factors	*3.0*		
Economic Factors:			
Family income affects buying decisions on brand	15.6	26.2	58.2
Personal income determines the mobile phone to buy.	15.8	24.6	59.6
Personality affects the purchase of mobile phone.	12.5	18.4	69.1
Lifestyle affects the purchase of mobile phone.	13.0	16.5	70.5
Median of Economic Factors	*3.0*		
Market Factors :			
Always consider the price of mobile phone before buying.	11.6	12.5	75.9
Promotion & adv. affect buying decisions of phone.	12.3	18.6	69.1
Only buy mobile phone which consider good	7.3	16.5	76.2
Only buy a phone which is of own social standing.	11.6	19.6	68.9
Only buy mobile phone with a good camera	9.9	19.8	70.3
Buy mobile phone which is easy to get and easy to use.	11.3	15.8	72.9

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I only buy mobile phone which have a branded name	19.6	17.7	62.7
Median of Market Factors	*3.0*		

which was (70.5% & 69.1% respectively), also followed by self-income and family income (59.6% and 58,2% respectively) as determinant factor to buy a mobile phone. The median value 3.0 indicates that the central tendency is to be agreed with all statements. In considering the Market factors, the strong determinant factors to buy a phone were quality of the products (76.2%), comparison of earlier prices (75.9%), easy accessibility (72.9%) and background technology (70.3%). On other hand, promotional advertisement (69.1%), social standing (68.9%), and brand name

In the following analyses, the "Correlation" in describing the degree to which two variables move in coordination with one another has been run. In that case of social factors, respondents opined their views and reasons towards their choice of purchasing a branded mobile phone which has been not shown in Tabler form. However, Correlation Coefficient (r) has been shown for all statements which has demonstrated a positive relationship with each other and is statistically significant ($p<0.01$). But relationship strengths were more pronounced with the respondents statement like "My age influences the type of mobile phone I purchase" ($r=0.310$), which followed by "My self-esteem affects my buying decision on mobile phone" ($r=0.291$) and "I buy a mobile phone which my role models use" ($r=0.262$).

Likewise, economic factor has showed that respondents personal income strongly determined the mobile phone they intend to buy where significantly positive relationship has been established by the two related variables ($r=0.133$). Family income also has indicated a statistical relationship ($r=0.092$) which is relatively weak than that of their individual income. The factors of personality and lifestyle did not show any effect on the relationship.
Regarding marketing factors, respondents' purchasing intention and reasons for choosing branded mobile phone All statements accumulated under marketing factor have showed a positive relationship between the variables mentioned with a statistical significance ($p<0.01$). A moderate strengthen relationship has been showed in case of "mobile phone which has brand name" ($r=0.263$) and "buy mobile phone which considered high quality" ($r=0.214$).

IV. CONCLUSIONS

This research seeks to determine the customer relationship with social, economic, and market factors in the product like mobile phone purchasing intention through observing their behavioral process. These factors are interrelated with one another and influence consumers' purchase intention towards choosing branded products by keeping the brand image in their minds. Therefore, this research aims to understand the role of branded products acting towards consumer purchasing behavior. This study also aims to see the factors affecting brand formation and affect consumer behavior by these factors. Based on the analysis and findings, it has apparently shown that there is a positive correlation between influences of brand on the customer buying behavior towards branded mobile phones in Bangladesh. The influence of brand image dimension consists of various purchasing intentions associated with the respondents' awareness, type of devices they use, perceived quality, and preferred brand of mobile phone. The study concluded that there are other related issues that can play as dominant factors to choose the branded mobile phone prior to the respondents' purchasing behavior. The study results also revealed that the correlation coefficient level according to factors (Social, Economic, and Marketing) was related to respondents' purchasing intentions. Again, the reasons for selecting brand mobile phone. were reflected by social factors and market factors which posed a positive relationship with each other. Therefore, it is further concluded that significant mediator effects on brand satisfaction towards a functional product like mobile phone share a relationship that has been established between branded product choice and customer purchasing behavior. Therefore, the study may have recommending remarks that future research might be undertaken to make a qualitative approach to acquire more in-depth information with the real scenarios which will supplement the quantitative findings whatever this study documented.

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Globalization and Foreign Government Policy Changes for Economic Development: Lessons from Bangladesh

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Abstract: **The paper aims to present globalization and government policy changes for economic development. Emphasis has been given to the prevailing situation in the economy of Bangladesh. Globalization intends to make the world economy increasingly integrated. This study has been conducted on secondary data only. It is clarified that globalization opens up many global opportunities for countries. To avail the facilities, many countries change their policies to record a high growth rate, which inspires the Government of the People's Republic of Bangladesh to start liberalization in the case of investment policy and fiscal policy for creating a conducive environment to attract foreign investors to invest in Bangladesh to accelerate economic growth. It is clear in the study that despite the liberation policy adopted by the Government of the People's Republic of Bangladesh, the FDI inflows in the country are not up to the mark. The study has outlined some modest possible suggestions for better FDI inflows.**

Keywords: **Globalization, world economy, Investment policy, Fiscal policy, Economic development, Foreign direct investment.**

I. INTRODUCTION

The present century is the century of globalization. The world economy is becoming increasingly integrated in this century. It refers to an emerging "global culture" and a common business language, which is "English," to facilitate economic integration in the world [1]. Globalization started functioning after the collapse of communism and the disintegration of the Soviet Union into a dozen states [2]. It is seen in the world that one group of countries has developed technologies and know-how and adequate equity capital, and the other group of countries has rudimentary infrastructures along with huge natural resources, called emerging countries [3]. So, the mutual transformation of available resources is required among the countries for economic development Globalization brings many changes [3] as (a) huge flows of private capital (b)rapid expansion in global trade and a change in its composition (c) the revolutionary change in information and telecommunication (d) the growth in the power of multinational corporations and their penetration into the emerging markets (e) the growth of civil society (f) the evolution of the international institutional structure (g) the demographic change in the industrial world and many parts of the developing world
National governments, firms, and people in the world affect everyone through the interconnection of the said aspects [4]. Exciting business opportunities, rapid growth of knowledge and innovation, and the transformation of new ideas lead to the economic development of the world in general and a country in particular.

II. LITERATURE REVIEW

To find out the research gap, the following literature is reviewed: Transfer of factors of production from one country to another has been emphasized during globalization [5]. Globalization points out the motives for improving profitability and enhancing shareholders' wealth of multinational companies. Revenue-related and cost-related motives under the purview of globalization and the transfer of factors of production from one country to another have been emphasized. With the changes over time, possible benefits also change from using the changing environment in various countries based on positively bearing advanced technology management and practices for economic development. In a study by [6], it is seen that innovation and the transfer of factors of production of a developing country may be the result of the government's initiatives on changing investment policy and fiscal policy relating to the investment recipient country.
Globalization is considered to be a movement towards open economic policies for international economic flows in the countries of the world for economic development [7]. Globalization accelerates to bring down the trade barriers, increasing the transformation of factors of production, utilizing the available resources optimally for economic development [8]. Judging on the above-mentioned review of literature, the present study on "Globalization and Government Policy Changes for Economic Development: Lessons from Bangladesh".

III. OBJECTIVES

The objectives are:

i) To present globalization and its impact.
ii) To understand the Government's policy for economic development with the advent of globalization, emphasizing the economic development of the world.
iii) To know the policy changes of the Government of the People's Republic of Bangladesh for economic Development;
iv) To assess the FDI flows for the betterment of the economic development of Bangladesh.

IV. METHODOLOGY

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The study is conducted on secondary data, which has been collected from different books, published articles, published reports of the Asian Development Bank, Economic outlooks of different countries, and the economic review of the Government of the People's Republic of Bangladesh. The data used in the study have been analyzed in tabular form.

V. GOVERNMENT POLICY CHANGES

As mentioned earlier, one group of countries has modern technologies, know-how, and equity capital, but has a shortage of material and physical resources. Another group of countries has huge material and physical resources but has a shortage of modern technology, know-how, and equity capital. Optimum utilization of available resources may be the result of the economic development of the world in general. So, factors of production are required to be transferred among countries mutually. Since the 1980s, exciting opportunities have been provided by many countries globally through the liberalization of investment policy, fiscal policy, and the reforming of financial institutions. Some countries in Asia, Latin America, and Eastern Europe started growing economically at rates considered to be far outpaced by more developed countries [9]. Urbanization and a burgeoning middle class give rise to generation consumers with a high demand for consumer goods and infrastructure development for new lifestyles. So, investors enjoy a period of exceptional returns on major asset classes. Today's world economy presents a new investment proposition. Developing economies hold 86% of the world's population, 75% of the world's land and resources, and hold 50% of world GDP in terms of purchasing power parity, and count about 12% of the global equity market capitalization on a float-adjusted basis, as referred to by BlackRock Investment Institute. For optimum resource utilization, developing countries need to transfer factors of production like advanced technology, know-how, and equity capital. Mutual transfer may happen through Foreign Direct Investment (FDI).Macroeconomic indicators of the top six developing countries are shown in Table 1 Four macroeconomic indicators of six developing countries are shown in Table 1. All countries adopt liberalization policies. Five years of data are shown in the table. Fluctuation in data is seen among the countries. Data from China and South Korea have fluctuated less. In terms of per capita GDP, South Korea recorded the highest GDP, followed by Turkey and China, and the lowest per capita GDP is seen in India. China has the highest GDP growth rate, followed by India, Indonesia, Turkey, and so on. China showed the highest exports than imports, followed by South Korea, and all other countries recorded more imports than exports in most of the year.

Table I
Macro-economic Indicators of the Top Six Countries

Name of the Countries	Macro-economic indicators	Years				
		2014	2015	2016	2017	2018
China	Per Capita GDP (US$ $)	7,650	7,945	8,134	8,858	9,916
	GDP Growth rate (%)	7.3	7.0	6.8	6.9	6.7
	Exports (US$ billions)	2,342	2,273	2,098	2,263	2,487
	Imports (US$ billions)	1,959	1,680	1,588	1,844	2,136
India	Per Capita GDP (US$)	1,614	1,633	1,763	2,017	2,027
	GDP Growth rate	7.4	8.0	8.3	7.0	6.1
	Exports (US$ billions)	311	262	275	305	330
	Imports (US$ $billions)	448	379	384	463	512
Indonesia	Per Capita GDP (US$)	3,532	3,368	3,607	3,885	3,946
	GDP Growth rate (%)	5.0	4.9	5.0	5.1	5.2
	Exports (US$ $billions)	176	150	145	169	180
	Imports (US$ billions)	178	143	136	157	189
South Africa	Per Capita GDP (US$ $)	6,635	6,022	5,291	6,220	6,137
	GDP Growth rate (%)	1.8	1.2	0.4	1.4	0.8
	Exports (US$ billions)	94.9	81.9	77.0	86.6	94.1
	Imports (US$ billions)	102	85.5	74.8	81.8	92.3
South Korea	Per Capita GDP (US $)	29,254	28,723	29,273	31,555	33,308

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	GDP Growth rate (%)	3.2	2.8	2.9	3.2	2.7
	Exports (US$ $billions)	573	527	495	574	605
	Imports (US$ billions)	526	436	406	478	535
Turkey	Per Capita GDP (US$)	12,026	10,898	10,805	10,556	9,384
	GDP Growth rate	5.2	6.1	3.2	7.5	2.8
	Exports (US$ billions)	169	155	153	169	179
	Imports (US$ billions)	233	204	193	228	222

Source: www. Google search; Focus-economics.com/countries/economic data

VI. ECONOMY OF BANGLADESH

On December 16, 1971, Bangladesh became independent. The Government of Bangladesh, since then, has been planning for the economic development of the country. Her location is in South Asia, and her land area is 147570 KM^2 where 170 million people are living. Bangladesh ranks as the eighth-largest country in the world in terms of population. Her economy consists of the agricultural sector, industrial sector, and service sector. The Gross Domestic Product (GDP) of the sectors is shown in Table 2.

Available natural resources of the country are gas, coal, limestone, hard rock, glass, ceramic clay, etc. Of these resources, gas, limestone, and coal are being extracted, and others are in the process of extraction.

The economic development of the country needs a huge investment. It is a function of mobilization of resources, and it depends upon the interaction of the economic activities of the country. Clarified it with some macroeconomic indicators, which are shown in Table 3.

Table 2
Sector-wise GDP change in percentage during 2014-2018

Year	Agriculture (%)	Industry (%)	Service (%)	Total (%)
2018	14	33	53	100
2019	13	34	53	100
2020	13	35	52	100
2021	13	34	53	100
2022	12	36	52	100

Source: Bangladesh Economic Survey 2022, Ministry of Finance, Government of the People's Republic of Bangladesh.

From Table 2, it is seen that the agriculture sector recorded the lowest contribution to the economy of the country. But with time, the other sectors' contribution to the GDP is more and a little bit fluctuating.

Table 3
Some macroeconomic indicators of Bangladesh

Items	2018	2019	2020	2021	2022
Population (Million)	163	165	167	169	171
GDP per capita (US $)	1964	2122	2234	2462	2723
Economic growth rate(% to GDP)	7.2	7.88	3.45	6.94	7.20
Inflation rate (CPI)	5.78	5.48	5.65	5.56	5.30
Current Account (% of GDP)	-2.98	-1.45	-1.26	-0.91	-0.06
Exports (% of GDP)	6.7	9.1	-17.1	15.4	12.0
Imports (% of GDP)	25.2	1.8	-8.6	19.7	11.0

Source: Bangladesh Economic Survey 2022, Ministry of Finance, Government of the People's Republic of Bangladesh.

Table 3 presents the macroeconomic indicators from 2014 to 2018. Over the past of years, GDP per capita has been increasing; the economic growth rate has also been increasing; the inflation rate has been decreasing. The current account balance showed a fluctuating trend. The population of the country has been increasing with time. Over the years, imports have been more than exports, which has imbued the attraction of Foreign Direct Investment (FDI). The macroeconomic indicators point out that the economy of Bangladesh has started growing increasingly as the Government of the People's Republic of Bangladesh started following a liberalization policy to attract FDI to create a competitive environment in trade and commerce in the country.

VI. FACTORS FOR ECONOMIC DEVELOPMENT

Economic Development in Bangladesh is the function of the Government's plans, policies, and timely implementation. To prepare plans and policies, there are many impediments in the process of economic development that are to be traced. Though Table 3 shows an increasing

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trend of economic growth in Bangladesh, its economy has been facing poverty, unemployment, illiteracy, resource constraints, adverse balance of payments, etc. Presently, about 20.5% of people are living below the poverty line in Bangladesh, the unemployment rate is 4.5% and the illiteracy rate is about 28% (www. Google.com, Bangladesh Economy data 2019). The economic activities are interrelated to one another in any economy; thus, the whole economy is interlinked with each other's activities. So, the economy of Bangladesh confronting the problems is to be addressed simultaneously in the national priority plans to accelerate economic development. Using human and material resources in terms of productivity is considered to be a precondition for economic development. There is a positive relationship between productivity and optimum job opportunities. Moreover, productivity is linked with the cost of living, per capita income, GDP growth rate, education, technological development, know-how, resource generation, etc. Therefore, the low productivity of any economy hurts the aforementioned indicators adversely.

To keep the economy progressing, a pragmatic plan would be considered important for exploiting human and material resources in terms of productivity. So, there is a necessity for huge investments in the form of equity capital, developed technology, know-how, managerial skills, and so on. Bangladesh as a developing country, has continuous resource constraints, underdeveloped technology and technology, inadequate managerial skills, and so on. FDI may be supplemented for the required factors of production in the domestic economy, considering economies of scale and economies of scope.

VII. GOVERNMENT POLICY TOWARDS FOREIGN DIRECT INVESTMENT

The Government policy in the case of Foreign Direct Investment (FDI) in Bangladesh may be classified in two phases, viz., the first phase during 1971-79 and the second phase during 1980 onwards.

Government Policy during 1971-79

Since her independence, the Government of Bangladesh has planned to establish socialism as one of the state principles. Accordingly, the Government formed a planning commission for the preparation of a policy plan for economic development. Based on the social, economic, and political situation of the country, a radical change in the modern capitalistic sector was formed to prevent the concentration of resources in the hands of the upper class. The Government of Bangladesh proclaimed a nationalization policy in February 1972. As per policy, the enterprise with fixed assets amounting to over US$0.040 million (US$1 Bangladesh Taka 36.596) was nationalized, thus 86% of total industrial assets were brought under Government control [12].

For the development of Bangladesh, the Government launched the First Five-Year Plan (1973-78), giving much emphasis on the public sector. Public sector allocation was 89 % while private sector allocation was 11% in the plan. In 1974, the Government revised industrial policy with little change in private sector investment, boosting up the ceiling to US$0.068 million (US$ $ = BDT 36.596) fixed earlier with the provision of increasing the investment up to US$0.096 million (US BDT 1= 36.596 through the investment of profits. In 1976, the Government started encouraging private investment with the change of industrial policy. For the planned development, the Government undertook a two-year plan (1978-80). The allocations of funds were 84% for the public sector and 16% for the private sector.

During the two plan periods, the financial performance of the public sector was not satisfactory. During 1974-80, sector corporations incurred losses except in 1979-80 (Third Five-Year Plan, 1985-1990). Emphasis was given by the government on the private sector for economic growth and development since 1976. At the embryonic stage of development, domestic private entrepreneurs are not in a position to invest huge amounts of funds because of their inability to manage the funds, uncertainty of profits, or profits at low rates. At the nascent stage of the development of domestic entrepreneurs, the Government of Bangladesh started attracting foreign investors to invest in the country to create a competitive environment in business.

Government Policy during 1980 Onwards

The government of the People's Republic of Bangladesh promulgated the Foreign Private Investment Act in 1980. To boost the private sector to be more active in economic growth and development, along with foreign investment, the Government started revising the industrial policy in 1982, 1986, and 1991, respectively. The Government also opened all kinds of industries open for the private sector, withdrawing ceilings except for defense goods, nuclear energy, mechanized forest extraction, as well as printing and minting etc. Since 1980, five plans, viz., Second Five-Year Plan (1980-85), Third Five-Year Plan (1985-90), Fourth Five-Year Plan (1990-95), Fifth Five-Year Plan, and Sixth Five-Year Plan have been completed. Allocations of funds provided for the private sector were 35.5 % for the Second Five-Year Plan, 35.2% for the Third Five-Year Plan and 39.4% for the Fourth Five-Year Plan, 40% for the Fifth Five-Year Plan, and 77.2% for the Sixth Five-Year Plan. The Seventh Five-Year Plan is going on.. 78%of the fund is earmarked for the Seventh Five-Year Plan.

The Government also realized that domestic entrepreneurs would not do well in the industrial sector because of resource constraints, underdeveloped technology and know-how, and inadequate managerial skills etc. To make the domestic entrepreneurs competitive, the Government has allowed free access of foreign investors into the Bangladesh economy. The provisions made for foreign investments are (Bangladesh: A New Horizon for Investment-1994) [11]:

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i) No approval or permission, or no objection certificate is required for establishing an industry in the free sectors with its own source of financing.
ii) No approval is also required either for credit or for projects involving foreign loans or credit in which the effective rate of interest is within the London Interbank Offer Rate (LIBOR) plus 4%, the down payment is less than 10% and repayment periods exceed 7 years.
iii) There will be no limitation in respect of foreign equity holding.
iv) A unit has to be registered with its sponsoring agencies to avail of institutional and infrastructural services and for monitoring.
v) Several agencies have to be created with specific promotional roles for foreign investors. The agencies are Bangladesh Small and Cottage Industries Corporation (BSCIC), Bangladesh Export Processing Zones Authority (BEPZA), and the Board of Investment (BOI).

Considering the present needs of the economy, the Government has identified some priority sectors where foreign investments can be made with 100 percent ownership, as well as joint ventures with local private sponsors or with the public sector. The areas are (Bangladesh: A New Horizon for Investment-1994)[12]

i) Export-oriented industries
ii) Industries in the export processing zones
iii) High-technology products that are either import substitutes or export-oriented
iv) Undertakings in which a more diversified use of indigenous natural resources is possible
v) Basic industries depending mainly on local raw materials
vi) Investment towards improvements in the quality and marketing of goods manufactured and/or increase in production capabilities of the existing industries and
vii) Labor-intensive, technology incentive, and capital-intensive industries, etc.

To increase foreign investment in Bangladesh, the Government announced some incentives as expediting approvals for industrial licensing or investment or collaboration; tax holidays for 5-12 years, concessionary rate of import duty on machinery, import of machinery under supplier's credit or pay as you earn scheme, liberalized export policy, repatriation of profits, dividends, capital gain, royalties and salaries, tax exemption, tax rebate, financing facilities, and residence facilities to foreign investors.

The Government has announced special incentives to encourage non-resident Bangladeshis to invest in Bangladesh. which are considered equal to the facilities being offered to foreign investors. Moreover, non-resident Bangladeshis can enjoy buying newly issued shares and debentures of Bangladeshi companies. Besides, they can maintain foreign currency deposits in the Non-resident Foreign Currency Deposit (NFCD) Account for up to 5 years (Bangladesh- A new Horizon for Investment-1994). Besides, export processing zones (EPZs) offer some additional facilities to foreign investors in setting up industries in the country. The facilities are free from national import policy restrictions, offshore banking facilities, back-to-back letter of credit facilities, equal treatment of foreigners with indigenous investors, one-stop service to investors, and all customs formalities within EPZs (Bangladesh- A New Horizon for Investment-1994)

To ensure available manpower for employment in the industrial sector, the Government of Bangladesh has been trying to develop human resources by setting up institutions, Viz, universities, vocational and technical training centers, apprenticeship and workers education, etc. Workers' wages are generally fixed through a collective bargaining process, but in the absence of a collective bargaining process, wages would, however, be fixed by the minimum wages board (Bangladesh -A New Horizon for Investment-1994)[10]

The Government of Bangladesh ensured legal protection to foreign investment in the country against nationalization and expropriation. The Government also protected intellectual property rights, viz., patents, designs, trademarks, and copyrights. For this, some investment treaties have also been made between Bangladesh and other countries. The countries are the USA, the UK, Romania, Belgium, the Republic of Korea, Thailand, Turkey, France, and Italy. Besides, Bangladesh is a signatory to some multilateral agencies by which foreign investors can be ensured protection for their investments. The agencies are the Multinational Investment Guarantee Agency (MIGA), Overseas Private Investment Corporation (OPIC), and International Centre for Settlement of Investment Disputes (ICSID) (Bangladesh- A New Horizon for Investment-1994).

VIII. FOREIGN DIRECT INVESTMENT IN BANGLADESH

It is clarified that the Government of Bangladesh has liberalized its investment policy for foreign investors. Following the liberalization policy, foreign investors started coming to Bangladesh with investment proposals. The investments made by foreign investors during 2014-2018 are presented in Table 4.

Table 4

Foreign Direct Investment (FDI) in Bangladesh during 2014-2018

years	US $ Billion
2016	233
2017	215
2018	242
2019	1.91
2020	1.53

Source:https://www.macrotrends.net>countries>BGD>foreign

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Table 4 shows the yearly FDI inflows into Bangladesh for the period of 2014-2018. The table presented the fluctuations of FDI inflows into Bangladesh. It is clarified in the table that the highest investment of FDI inflows was US$283 in 2015, and the lowest was US$215 in 2017. Many reasons might be attributed to these fluctuations. The reasons are inadequate incentives to investors, political volatility, red tape, and capital-intensive and labor-intensive projects. Among the reasons, political volatility may be considered the dominant factor for the fluctuation of FDI inflows into Bangladesh.

IX.CONCLUDING REMARKS

As stated earlier, globalization refers to the process of making the world economy increasingly integrated. During globalization, emerging economies have developed tremendously, as seen earlier. Following the development, the Government of the People's Republic of Bangladesh has liberalized investment policy, fiscal policy, and reformed financial institutions to attract foreign direct investment into the country. Consequently, many foreign investors started coming to Bangladesh with investments in Bangladesh. The economy of Bangladesh has been accelerating day by day as there is a competitive environment between domestic and foreign investors.

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Cox's Bazar & the Blue Flag Standard: A Study on Coastal Tourism Sustainability

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Abstract **- Cox's Bazar, the world's longest sandy sea beach, is key to Bangladesh's coastal tourism. However, it faces increasing pressures from pollution, unplanned urban growth, and climate change. To ensure its sustainability, it is essential to follow global standards like the Blue Flag Standard. This eco-label certifies beaches based on strict criteria for water quality, waste management, safety, and environmental education. This study looks at how well the Blue Flag framework can apply to Cox's Bazar by examining current tourism practices, policies, and views from stakeholders. The findings highlight significant gaps in infrastructure, enforcement, and community awareness that hinder sustainable management. Introducing the Blue Flag system could boost conservation efforts, draw eco-minded tourists, and improve the global standing of Cox's Bazar. In the end, this research suggests that eco-certification provides a practical way to balance environmental health with socio-economic growth in Bangladesh's coastal tourism sector.**
Keywords: **Cox's Bazar, Blue Flag, Coastal tourism, Sustainability**

I. INTRODUCTION

Cox's Bazar, the world's longest sandy beach, plays a key role in Bangladesh's tourism economy. However, it faces threats from pollution, poor waste management, and climate change[2][18]. These issues put both the environment and the long-term viability of tourism at risk. The Blue Flag Standard is an international eco-label for beaches. It focuses on water quality, safety, waste management, and environmental awareness.[20][7] This study looks at how the Blue Flag framework could be used in Cox's Bazar to improve management protect natural resources and set the beach as an example for sustainable coastal tourism in Bangladesh [1][4].

II. LITERATURE REVIEW

Cox's Bazar highlights the significant potential and the challenges of achieving sustainable coastal tourism in Bangladesh. Studies on tourist perceptions and environmentally responsible behavior show that people are becoming more aware of ecological issues. However, they also point to problems like inadequate infrastructure, pollution, and poor management practices. Research on sustainable tourism in disaster-prone coastal areas stresses the need for integrated planning to balance economic benefits with environmental resilience. Meanwhile, marine litter surveys expose severe waste management issues along the beaches. Although the Blue Flag program is known internationally as a standard for clean, safe, and well-managed beaches, there is little research connecting its criteria to Cox's Bazar. Most studies view Blue Flag as a policy goal instead of a tested framework in Bangladesh. This creates a gap for research that examines its feasibility, local adaptation, and potential to turn Cox's Bazar into a model for sustainable coastal tourism. [5], [3], [12], [14].

III. METHODOLOGY

This study uses multi modal approaches to mitigate noise through biodegradable composite materials. The method includes the following steps:

Research Design: A descriptive digital survey design was used to explore stakeholders' views on tourism sustainability in Cox's Bazar and the possible adoption of the Blue Flag Standard. A structured questionnaire was given both online and offline through QR code scanning. It targeted tourists, residents, business owners, and students from related fields.

Data Collection: The survey included questions about awareness of coastal pollution, perceptions of environmental management, views on the importance of international certification (Blue Flag), willingness to support eco-friendly initiatives, and expectations for sustainable tourism. The questions were presented as multiple-choice and Likert-scale responses to capture attitudes and the strength of opinions.

Data Analysis: Microsoft Excel and Python were used for quantitative analysis. Frequency counts and percentages were calculated for each survey item. The results were compared with existing studies on coastal sustainability and global Blue Flag practices to find similarities, gaps, and potential strategies that could benefit Bangladesh's tourism sector.

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IV. RESULTS

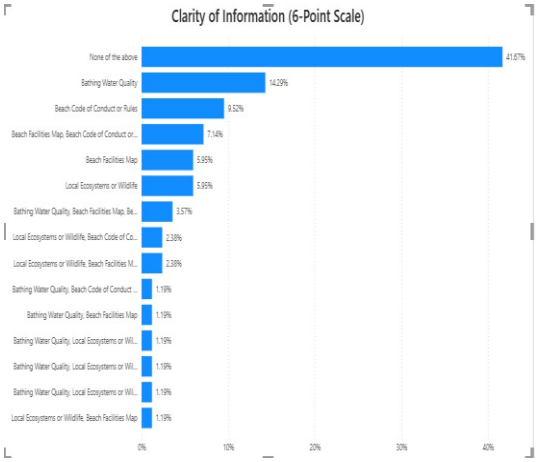


Fig 1: Clarity of Information

Respondents pointed out which parts of beach information are communicated the best. "None of the above" was chosen by 41.67%, showing a general lack of clarity. Among the specific aspects, bathing water quality was noted by 14.49%, and the beach code of conduct/rules by 9.52%. Other areas, such as beach facilities at 8.14% and 5.95%, local ecosystems at 5.95%, and extra bathing water information at 3.57%, received less attention. This suggests that the current information on environmental and management features of Cox's Bazar is limited or not consistently shared with stakeholders.

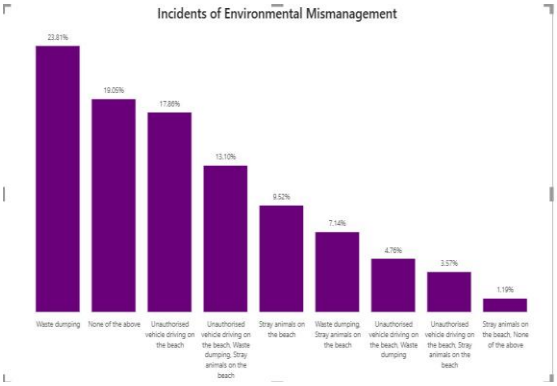


Fig 2: Incidents of Environmental Mismanagement

Respondents identified key issues affecting the beach environment in Cox's Bazar. Waste dumping was the most reported problem at 23.81%. This was followed by no issues observed at 19.05%, unauthorized vehicle driving on the beach at 17.86%, and stray animals on the beach at 13.01%. These findings highlight significant management challenges, especially in waste control and enforcement of regulations, which could affect both environmental quality and visitor experience.

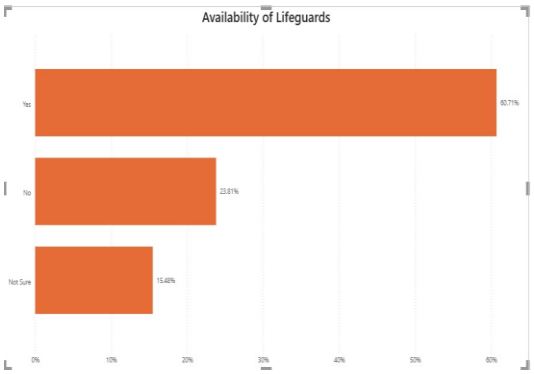


Fig 3: Availability of Guards

Among respondents, 60.71% reported that beach guards are available. 23.81% stated there were no guards present, and 15.48% were unsure. This indicates that while most people notice some level of supervision, a significant number of visitors feel there are safety gaps at Cox's Bazar.

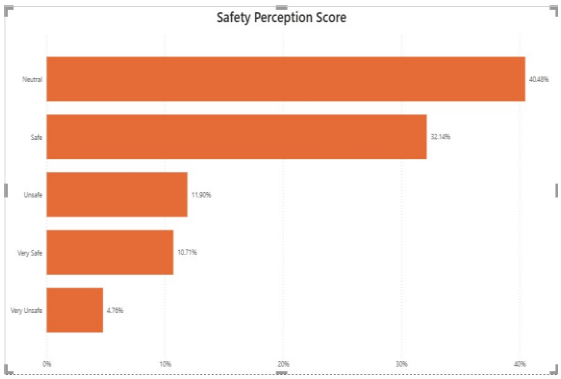


Fig 4: Safety Perception Score

Respondents' views on beach safety indicate that 40.48% feel neutral, 32.14% see it as safe, and 10.71% feel very safe. A smaller group perceives risks, with 11.90% feeling unsafe and 4.76% feeling very unsafe. Overall, most visitors have a neutral to positive opinion of safety, although a notable minority still has concerns.

V. DISCUSSION

The survey shows that information clarity at Cox's Bazar is limited. The largest group of respondents chose "None of the above," indicating that many visitors feel there is little clear guidance. Only a small number noticed specific details like bathing water quality or beach rules. Key management issues include waste dumping and unauthorized vehicle use. Most respondents saw beach guards, but some noted a lack of supervision. Overall, safety perceptions were mostly neutral or safe, but a significant minority felt unsafe. The findings indicate that while some measures are in place, there are still significant gaps in environmental management, information sharing, and visitor awareness. This highlights the possible benefits of implementing standards like the Blue Flag for sustainable coastal tourism.

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VI. CONCLUSION AND FUTURE OUTLOOK

The study shows that Cox's Bazar has issues with environmental management, clear information, and visitor safety. Some measures are in place, like beach guards and basic facilities, but there are still major gaps in waste management, illegal activities, and public awareness. Most respondents feel neutral to safety, but a few express concerns. This highlights the need for better supervision and education. Adopting international standards like the Blue Flag could improve environmental sustainability, safety, and the beach's global reputation. It would help balance tourism growth with environmental protection. Good planning, enforcement, and community involvement are vital for making Cox's Bazar a model for sustainable coastal tourism in Bangladesh.

The road ahead for Cox's Bazar coastal tourism sustainability is assessing Blue Flag accreditation viability, optimizing waste and marine debris management, and promoting green infrastructure. Strengthened community engagement, climate adaptability, and policy reform will be instrumental in aligning local practice with global standards. Comparative experience from other Blue Flag beaches and long-term monitoring through data-based instruments can make Cox's Bazar a model for coastal tourism sustainability.

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How Female Student Migrants in Dhaka Adapt to the Urban Economy through Money Management Apps

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Abstract: **Many students migrate from rural areas to urban centers for education, and a significant portion are female. Many rural female students in Dhaka have limited financial literacy as they previously had little involvement in household budgeting, making money management challenging. This study explores how smartphone financial apps, particularly Wallet and Money Manager, assist these students in handling their finances. Based on the Technology Acceptance Model (TAM), the research examines how perceived usefulness of these apps influences behavioral intention and actual use. Using qualitative methods, structured surveys were conducted with 100 female students from public and private universities in Dhaka. The study assessed participants' financial knowledge, budgeting habits, and views on mobile financial tools. Findings show that money management apps enhance financial competence. About one-fourth of participants used these apps, while one-third reported improved budgeting habits through expense tracking and personalized monthly planning. Most users adapted well to the apps' interfaces despite varying digital literacy levels. Additionally, many participants became better prepared for unexpected expenses without relying on family or informal loans. Overall, these apps promoted savings habits and reduced impulsive spending, demonstrating their potential to strengthen financial literacy and autonomy among rural female student migrants.**

I. INTRODUCTION

The transition from rural to urban life represents a significant milestone for many young women in Bangladesh. Each year, a growing number of female students migrate to Dhaka in pursuit of higher education and better opportunities. While this migration offers new prospects for personal and professional development, it also introduces complex challenges, particularly in managing personal finances. For many of these students, financial independence is an unfamiliar responsibility, as they often come from households where decision-making about money is traditionally dominated by parents or male family members. As a result, these students face not only the pressures of academic life but also the necessity of learning how to handle money effectively in an expensive and fast-paced urban environment. Financial literacy—defined by [4] as the possession of knowledge and skills necessary for effective money management—remains a critical yet often overlooked competency for this demographic. Lack of financial literacy can lead to poor budgeting, impulsive spending, and an inability to cope with unexpected expenses, all of which can exacerbate stress and limit the educational success of migrant students. In this context, digital technologies have emerged as potential solutions to bridge the knowledge gap. Mobile financial applications such as **Wallet** and **Money Manager** provide accessible platforms for budgeting, expense tracking, and planning. These tools promise to transform financial habits by fostering structured practices and offering real-time data visualization to enhance decision-making.

The adoption of such technologies, however, cannot be understood in isolation from the social and cultural context of the users. For rural female migrants, factors such as digital literacy, cultural norms around gender and finance, and perceptions of technology play significant roles in determining whether and how these tools are used. The **Technology Acceptance Model (TAM)** provides a useful theoretical lens to explore these dynamics, as it focuses on perceived usefulness and ease of use as primary determinants of technology adoption. While TAM has been extensively applied in quantitative research, this study employs a qualitative framework to capture the lived experiences, attitudes, and behavioral patterns of students as they engage with financial applications.

This paper aims to explore how financial management apps influence the budgeting habits, spending behaviors, and sense of financial control among rural female students living in Dhaka. By conducting focus group discussions (FGDs) and interviews with 100 participants from both public and private universities, the study seeks to uncover recurring themes that explain the role of technology in enhancing financial literacy and independence. Beyond documenting adoption patterns, this research also evaluates whether these tools act as instruments of empowerment by promoting resilience, reducing dependency on informal support networks, and encouraging disciplined financial behavior.

The significance of this inquiry lies in its contribution to an underexplored area of research at the intersection of gender, migration, and digital financial technology in a developing country context. While previous studies often prioritize urban populations or gender-neutral

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perspectives, this paper centers on an overlooked demographic—female rural migrants navigating the complexities of city life. Through a thematic analysis grounded in TAM, the study not only addresses a theoretical gap but also offers practical insights for educators, policymakers, and technology developers aiming to enhance financial inclusion and empowerment among marginalized groups.

II. BACKGROUND

In Bangladesh, many young women arrive every year in Dhaka to pursue their education as a means to a better future leaving behind their small towns and villages. Most of them see this journey a way of learning how to survive in an unfamiliar urban environment besides they also receive an education. The city offers opportunities to many of these student but most of these students are confronted with new responsibilities the most being financial. In the meantime, a new variety of opportunities has been enabled by the explosive growth of digital technology in Bangladesh. The broader scope of mobile programs available to students now allows them to control the way they manage their money more reasonably since smartphones have become so common. Such apps as Wallet and Money Manager are becoming more and more popular as assistants that help to plan expenses, save money, and monitor daily spending. These tools can also be helpful aids to young women who are getting their first introduction to financial management, as well as partial technological aids. The desire to have more academic and economic opportunities has caused many rural learners, especially female learners to be able to gain higher education opportunities in Dhaka, Bangladesh, as it has become increasingly an urbanized city. These female student migrants particularly face certain challenges, one being that of cultural and patriarchal restrictions that put constraints on their economic empowerment, and the other being that of poor financial literacy because of the lack of involvement in household economic decision making in their rural homes. The solution can be proposed by the increase of financial technology, most importantly, money management apps such as Wallet and Money Manager that offer readily available tools in terms of financial planning, budgeting, and expenses tracking. This study suggests that Mobile applications aid female migrant students in their adaptation to the Dhaka urban economy as it satisfies their economic management requirements dynamically and in many, often challenging, forms .

This paper, which draws on the Technology Acceptance Model (TAM), explores the influence of perceived utility and usability on the adoption of these apps as well as perceived risk, perceived financial control and social impact to female students. The role of Fintech in improving financial inclusion in Bangladesh has been pointed out in previous studies by [3,8] but female student migrants have had less emphasis. This paper aims to help fill in this gap by examining their experience and shedding light on how digital technologies can empower these students to overcome financial barriers, improve their personal budgeting habits, and emerge as more financially independent members of the urban population of Dhaka and, more broadly, on financial inclusion as well as gender equality.

This paper looks at the lives of female students who travel to Dhaka to study in colleges where they adapt to the requirements of the urban economy. This research papers elucidate the connection between the digital literacy, financial independence and empowerment of women as far as education mobility is concerned through their use of money management apps.

III. RESEARCH SIGNIFICANCE

This research holds significance at multiple levels—social, theoretical, and practical—by addressing the intersection of gender, migration, and digital financial technology in Bangladesh. From a **social perspective**, the study sheds light on an underexplored population: rural female students who migrate to Dhaka for higher education. These young women often arrive with limited financial literacy, as financial decision-making in rural households is typically dominated by parents or male figures. By documenting how this group adapts to financial independence through digital tools, the research contributes to a broader understanding of gendered financial inclusion. At a **theoretical level**, the study makes a unique contribution by situating the Technology Acceptance Model (TAM) within a qualitative framework. Traditionally, TAM has been applied quantitatively, focusing on measurable constructs such as perceived usefulness and ease of use. This research demonstrates how those constructs can be interpreted through lived experiences. For instance, perceived usefulness is reflected in participants' descriptions of improved budgeting and resilience, while perceived ease of use is revealed in their narratives about digital learning curves. By reinterpreting TAM qualitatively, the study enriches the model and opens pathways for more nuanced applications in future research.

Practically, the findings have implications for **universities, NGOs, and policymakers** who aim to promote financial literacy among marginalized groups. The evidence suggests that digital financial tools are not just convenient aids but **agents of empowerment** that can transform how female students engage with money, independence, and urban life. Tailored programs that combine digital literacy training with financial management education could amplify these benefits, particularly for rural women adapting to the challenges of migration. The significance of this study thus lies in its demonstration that financial management apps do more than record expenses—they reshape financial behavior, support resilience, and foster independence in ways that extend far beyond the immediate technical function of the applications.

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IV. LITERATURE REVIEW

Empowerment, technological adoption and economic integration among female student migrants in the developing world such as Dhaka, Bangladesh is a complicated problem. In this literature review, the existing knowledge on women empowerment, the adoption of fintech and mobile financial services (MFS) as well as rural-urban migration in Bangladesh have been summarized. It also demonstrates how online tools like money management apps facilitate economic flexibility alongside citing the studies on the aspects affecting fintech adoption, particularly with regards to fragile groups such as women, young undergraduate students and migrants.

Rapid urban growth has been witnessed in Bangladesh; by 1991, over 40 percent of rural in-migrants were attracted into Dhaka, a tendency that persists into the 2020s [6]. The economic promise attracts people to start migrating in rural-urban directions, yet the migrants with poor and female backgrounds are mostly impacted by it because they often have problems with finding apartments, jobs, and incorporating financially. [6] explores the physical and geographical adaptability of female migrants in Dhaka, which has to do with their migration to urban slums and squatter settlements after living their home places in rural areas. The migrants are introduced to the familial networks initially as their first homes and therefore they are oftentimes narrow and they lack basic amenities. The longer such stays last, the better housing conditions and the greater locational mobility are achieved, which characterizes some slow adaptation to urban life. In a system of sex segregation, however, women lack the independent economic power of financial networks and are limited by being dependent upon male networks.

This change also impacts economic sectors because immigrants have to bargain with the labor and monetary markets in the city. Based on their findings on low-income internal migrant workers in Dhaka, [2] determine that the adoption of MFS is related to the age, profession, and education level. Migrant workers enhance economic resilience and transparency by making use of mobile money to make everyday purchases and remittances. Nonetheless, barriers such as limited access and computer skills are still present, particularly access to women in low-paid occupations. Even though they focus more on the low-income migrants as a whole instead of students or women in particular, their results demonstrate the validness of digital technologies in narrowing rural-urban discrepancies.

With fintech, which consists of e-wallets, money management apps, and mobile banking, financial inclusion in Bangladesh has been transformed since the 2010s. [4] utilizes the Technology Acceptance Model (TAM) to learn the factors that affect the fintech adoption, including perceived utility, ease of use, risks, trust in the brand and governmental support. Based on the results of Structural Equation Modeling (SEM) on 160 respondents, the present study concludes that brand image, perceived risk, and trust are the key determinants of behavioral intentions to use fintech services, including mobile financial services (e.g., bKash, Rocket). This fits in with even bigger efforts to put the economy on a legal footing, since technology makes cash and unrecorded exchanges less necessary (particularly in urban areas).

It is facilitated by [4] who examine the intention to adopt mobile fintech services in the developing market in Bangladesh. Findings support the importance of social influence, trust, perceived benefit and conducive conditions as adoption drivers as proposed in their study of 218 respondents using SEM. The number of mobile customers facilitated services expanded by 3.08 per cent per month after the COVID-19 because of 178.61 million mobile customers initiated services such as bill payments, remittances. However, rural and urban areas still differ and urban users benefit more of digital literacy and agent networks. The research favors the user-centric designs to enhance happiness and financial inclusion.

[8] utilize a revised Unified Theory of Acceptance and Use of Technology (UTAUT) model covering 375 respondents where the focus is laid on undergraduates. The intentions to adopt fintech are influenced positively by performance expectancy, effort expectancy, and enabling conditions, whereas the social influence and individual inventiveness does not affect them. It means that young and highly educated clients ascribe greater importance to such practical benefits as efficiency and cost savings. These apps may facilitate budgeting and remittances among the student migrants, however, there is some resistance due to the challenge of security concerns.

Digital finance is the key to the empowerment of women in patriarchal societies in countries like Bangladesh where mobility and financial autonomy of women are restricted by gender norms. [1] employ fully-revised OLS and canonical co-integration on the data of 20112023 to investigate the impact on poverty alleviation and entrepreneurship of women through the support of mobile and agent banking. At 5 %, mobile banking leads to drastic employment and empowerment of women who can take independent decisions on behalf of their families. To fully bring out their potential the report recommends national digital programs and this is particularly true in the metropolitan areas where those women who migrate have new opportunities.

Based on the findings made by Financial Inclusion Insights Survey, 2017, [7] build a relationship between mobile phone use among women and their empowerment. They observe that the mobile phones enhance household decision on non-housewives better than limited women (e.g., housewives) via the regression specifications of OLS, ordered logit, and

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multinomial logit. It is the heads of the family and spouses who benefit most under the patriarchal systems and that under ICT alone, constrained women may not be empowered unless literacy and the knowledge of rights are addressed. Whereas adoption varies by family circumstances, evidence indicates that gender roles of migrating women can be transformed through mobile applications.

In the study by [5], Business Model Canvas is implemented as a qualitative method to explore the idea of financial inclusion of the marginal agricultural peoples through MFS. Although the story is solely about the rural farmers of the country, it highlights the problems of MFS in less privileged areas, such as limited agent networks and complex procedures. In step with the transformations of urban migrants, suggestions cover products specifically developed to meet agricultural requirements, whereby fintech is incorporated in value chains.

The capability of Fintech to support urban economic adaptation is the enhancement of financial access and empowerment, which is evidenced by the results of the existing research [1,3,4]. A female-specific research reports on the barriers to the women empowerment in patriarchal environments [7], whereas an effort on migrants reflects geographical relocation and patronage of MFS [6,7]. However, these two aspects are rarely put together: there is not much research on female student migrants in Dhaka, and money management applications have not been considered in the context of adaption aid. Students and often youthful and tech-savvy can use budgeting, remittances, and entrepreneurship apps. But, female specific problems such as digital inequalities and less mobility are not fully understood.

On a theoretical premise based on TAM/UTAUT frameworks addressing the determinants of adoption, this gap warrants a special study on how migrant women students use applications to access the urban economy of Dhaka. Understanding the disadvantages (such as security threat) and advantages (such as empowerment) can facilitate more inclusive designs that will aid in the achievement of the sustainable development goals that include financial access and gender equality. The literature encourages fintech to act as a facilitator toward migrant assimilation and women empowerment in Bangladesh, but it has not been very specific concerning female students. To address this, the paper examines the app-mediated integration of economy in Dhaka.

Literature Gap:

There is a lot of literature on empowerment of women, adoption of fintech and rural-urban migration in Bangladesh, yet nothing much is known about how female student migrants into Dhaka adapt to urban economy by using money management applications. Studies such as [2], investigate the way in which low-income migrants access mobile financial services (MFS) to transfer money to the homeland and [4] focuses on spatiotemporal issues such as how female migrants settle in urban areas. Students (especially female students) are not given a separate identity in these works. This is comparable to the findings of fintech, as seen in the works of Hasan [3,4,8], who also report the reasons why women and young clients use mobile banking and cite such factors as its practical usefulness, trust, and convenience. Individuals scarcely ever connect sex and education and migration from a village to a large modern city like Dhaka. Mobile technology is found to grow independence and entrepreneurship among women as evident in the research pieces by Alom et al. [1,7].

Nonetheless, these studies do not directly answer the question of the on-the-move female students and the use of apps to address financial burdens in a patriarchal society. Still, the case of rural farmers covered by [4] does not include the experiences of urban students, with particular emphasis on women. No specific concern to female student migrants with money management apps in the context of budgeting, sending payments, or even about creating small businesses is provided, although a brief study of up-to-date academic literature (as of August 18, 2025) reveals related descriptions, including topics about mobile banking gender disparities or rural student strains in urban areas. This disparity necessitates a more thorough examination of how these applications can assist young women in overcoming obstacles like restricted mobility or a lack of digital literacy while opening doors to advantages like financial independence, opening the door for more inclusive tools and policies that promote economic inclusion and gender equality.

V. OBJECTIVES

Relying on their role to expose people to financial literacy and economic integration, the current study aims to examine the consumption of the money management applications, specifically Wallet and Money Manager, in the context of urban financial adaptation among female student migrants in Dhaka. The objectives are to learn how these apps can support financial literacy and financial competence among female students, who will have transferred to the city of Dhaka, and to determine the effects of such other variables as the perceived financial control (PFC), the perceived risk (PR), and the social influence (SI) and their influences on their behavioral intention and actual use of these apps. The Technology Acceptance Model (TAM) also explains the relationship between the perceived usefulness (PU) and the perceived ease of use (PEOU) and adoption of these apps in the management of finances. Make recommendations to develop user friendly applications that will facilitate financial inclusion and empowerment. Name the disadvantages and advantages of using these apps to adapt to the

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economy, including barriers to digital literacy, and financial independence. The purpose of the study is to determine whether female student migrants consider money management apps useful in moving around the urban economy of Dhaka. So far, the preliminary findings suggest that these apps can be useful in improving budgeting and limiting the impulsivity of spending, yet there are questions about digital literacy and fears over security.

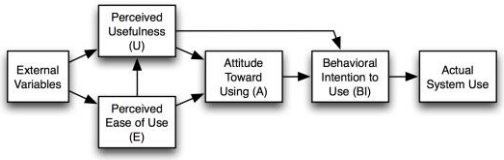
VII. RESEARCH QUESTIONS

Most of the rural female students are unable to take care of their own money as they leave portraits to Dhaka to continue their studies. It is quite difficult to cope with urbanization whereby an individual has no financial planning and budgetary skills. Money management applications such as Wallet and Money Manager might also come in handy in this scenario, and can help students learn how to use their money to budget, save and spend their money wisely. The following research questions guide the study to obtain a better insight regarding this.

- How do they influence the budgeting behavior and financial literacy of these rural female student migrants in Dhaka, Bangladesh via money management apps such as Wallet and Money Manager?
- What is the extent to which adoption and use of such different apps amongst female student migrants are related to the perceived utility and usability (measured by the Technology Acceptance Model)?
- How do these apps help female students to be financially independent and independently cope with unexpected expenses in the urban area?

VI. THEORETICAL FRAMEWORK

This study is aimed at understanding how female student migrants can use a money management app including Wallet and Money Manager to adapt to the urban economy. The aims of investigating how these apps contribute to greater financial literacy and competence among the female students who moved to urban Dhaka and how these other perceived factors, perceived financial control (PFC), perceived risk (PR) and social influence (SI) influence their behavioral intention and actual use of the apps. Also, the Technology Acceptance Model (TAM) can be used to determine the influence of the perceived usefulness (PU) and perceived ease of use (PEOU) of the adoption of these apps in financial management. Provide recommendations on developing user-focused applications which can facilitate financial inclusion and empowerment. Name the pros and cons of the use of these apps in the context of economic adaptation, including barriers connected to digital literacy, and benefits, including gaining financial independence.



The research question of the study is whether money management applications have helped fact migrants (female students in Dhaka) to navigate through urban economy. Early findings suggest that these applications can successfully improve the budget and help participants reduce impulsive purchases, but some problems such as digital literacy and safety concerns still persist.

VIII. RESEARCH METHODOLOGY

Research Design

This study adopted a qualitative research design to explore how rural female student migrants in Dhaka adapt to urban financial life through the use of money management applications, specifically Wallet and Money Manager. A qualitative approach was chosen to capture the depth and richness of participants' lived experiences, which could not be adequately understood through surveys or numerical data alone.

Sampling

A purposive sampling strategy was used to select participants who met specific criteria: (a) female students, (b) originally from rural areas, (c) currently studying in universities in Dhaka, and (d) engaged in managing their own finances. The final sample comprised 100 participants drawn from both public and private universities to ensure diversity in socioeconomic background and exposure.

The rationale for focusing on this group was twofold: first, rural female migrants represent a demographic often excluded from mainstream financial inclusion studies; and second, their transition from dependent financial roles in rural households to independent financial management in urban contexts makes them an ideal case for exploring digital adaptation.

Data Collection

Data were collected through two primary qualitative techniques:

- Focus Group Discussions (FGDs): Multiple group discussions were conducted, each comprising 6–8 participants. These sessions captured collective experiences, peer influences, and shared challenges related to financial literacy and app usage. The group format also facilitated the identification of common themes and differences across participants.
- In-depth Semi-Structured Interviews: To complement FGDs, individual interviews were carried out with 25 participants. These allowed for a more detailed exploration of

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personal narratives, including budgeting strategies, saving behaviors, and individual experiences of adopting (or rejecting) financial applications. The semi-structured format provided flexibility, enabling participants to reflect on their own terms while ensuring that key research questions were addressed.

All FGDs and interviews were conducted in Bangla to ensure comfort and authenticity in participants' responses. Sessions were audio-recorded with consent and transcribed for analysis.

Data Analysis

Thematic analysis was employed to interpret the data. The process began with open coding of transcripts, highlighting key phrases, patterns, and observations. These codes were then grouped into categories that reflected broader dimensions of experience. Finally, these categories were synthesized into the five major themes presented in the findings section.

The **Technology Acceptance Model (TAM)** served as a guiding theoretical framework. Its constructs of perceived usefulness and perceived ease of use were employed not as rigid variables but as interpretive lenses to understand how participants' experiences aligned with or challenged expectations about digital adoption.

Ethical Considerations

Ethical approval was secured from the relevant institutional review board. Participants were briefed about the purpose of the study, and informed consent was obtained prior to data collection. Confidentiality was maintained by anonymizing personal identifiers in transcripts and findings.

Trustworthiness of Data

To ensure rigor, the study incorporated several strategies:

- **Triangulation:** Combining FGDs and interviews allowed for cross-validation of findings.
- **Member Checking:** Summaries of findings were shared with a small group of participants to confirm accuracy.
- **Thick Description:** Detailed narratives were preserved to capture the complexity of experiences.

Research Findings (Thematic Analysis)

The narratives collected from the focus group discussions (FGDs) and in-depth interviews revealed a set of recurring themes that illustrate the unique ways in which rural female student migrants in Dhaka perceive, negotiate, and ultimately engage with financial management mobile applications. These findings not only highlight the practical role of technology in shaping financial behavior but also uncover the deeper psychological and cultural dimensions of using such tools within a context of migration, gendered expectations, and urban adaptation.

Theme 1: Selective Adoption of Financial Applications

Not every participant in the study adopted mobile applications such as Wallet or Money Manager. In fact, only about one fourth of the sample reported that they actively used these apps as part of their daily financial management. This selective adoption demonstrates that while the presence and awareness of financial technology is expanding in Dhaka, its penetration among rural female migrants remains uneven.

For some participants, the apps quickly became indispensable tools that they integrated into their everyday routines. They would record expenditures daily, compare their spending across weeks, and check how much of their budget remained available. Others, however, expressed hesitancy in adoption. The reasons for this varied. Several cited limited exposure to financial technologies before moving to Dhaka. Coming from rural households where financial transactions were often handled in cash and budgeting was informal, these students had little prior experience with structured financial management. Others admitted to lacking confidence in their digital skills, describing the apps as "confusing at first" or "too complicated to understand without help."

One participant put it this way:

"In my village, my father used to handle all expenses. I never thought about writing down where the money went. When I first came to Dhaka, I was spending randomly. My roommate showed me Money Manager, but at the beginning, I did not understand the categories. It felt like too much work."

This variation in adoption underscores that financial applications cannot be assumed to automatically reach all users equally. Their uptake is mediated by prior exposure, peer networks, and levels of digital literacy.

Theme 2: Budgeting as a Learned Skill

Approximately one third of participants reported noticeable improvements in their budgeting practices after using financial applications. What stood out in their narratives was not just the practical use of apps for recording expenses but the **transformational learning process** that budgeting represented.

Many participants reflected on how budgeting was initially an unfamiliar concept. Before using the apps, they described managing money in vague terms—such as keeping "mental notes" or simply reacting to financial shortages when they arose. However, through the features of the apps—monthly planning, expense categorization, and reminders—they began to see budgeting as a skill to be practiced, refined, and internalized.

One student shared:

"I used to finish my allowance within the first 15 days. Then I would call home for extra money. After I started using Wallet, I could see exactly where my money was going—mostly on snacks and online shopping. Slowly, I started to cut down and plan for the whole month. Now I even keep a small amount aside for emergencies."

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Budgeting thus became more than a functional activity; it became an empowering practice that enabled participants to exert greater control over their lives in the city. Several emphasized how budgeting reduced their anxiety at the end of the month, as they were no longer forced to depend on borrowing from friends or calling their families for additional remittances.

Theme 3: Financial Resilience and Independence

The majority of participants explained that financial applications strengthened their ability to handle unexpected costs, including medical emergencies, travel expenses, and academic needs. For many, this represented the first time they felt confident about managing crises without immediate dependence on their families.

Students highlighted how the apps helped them plan "emergency funds," even in small amounts, that later proved useful. One participant described how she was able to cover a sudden health expense without calling her parents:

"When I got sick last semester, I had to buy medicine and go to the clinic. Earlier I would have called my father to send money, but this time I had enough saved because the app kept reminding me about saving. It felt good to solve my problem on my own."

This kind of financial resilience is critical for young women who are navigating not only the academic pressures of higher education but also the social and cultural expectations of independence in an urban environment. The apps functioned not only as technical aids but as psychological tools that reassured participants of their financial capacity. For many, the ability to handle emergencies without outside help reinforced a sense of **independence**—something that was new to them as migrants transitioning from rural family structures to urban individual responsibility.

Theme 4: Shifting Spending Behavior and Saving Habits

Another prominent theme was the gradual change in participants' approach to spending and saving. By visualizing their expenses in different categories—such as food, transport, tuition, or leisure—students became more conscious of how they were allocating money. This awareness discouraged unnecessary or impulsive purchases, a behavior that several admitted had been common before they started using the apps.

One participant explained:

"I used to buy fast food almost every day after class. When I saw in the app that half of my money was going there, I was shocked. Now I limit it to twice a week and save the rest."

Over time, these adjustments accumulated into stronger saving habits. Students described feeling proud of their ability to save small amounts, which they could then put toward personal goals such as buying books, contributing to tuition fees, or planning short trips. The apps, in their view, served as "silent motivators" that nudged them toward more deliberate financial behavior.

This shift highlights an important pattern: the role of financial technology not only in managing existing resources but in **re-shaping attitudes toward money**. For many participants, saving was previously viewed as unnecessary or impossible given their limited allowances. With structured tracking, however, saving became a realistic and meaningful goal.

Theme 5: Negotiating Digital Literacy

While digital confidence varied across the sample, the majority of participants eventually adapted successfully to the interfaces of Wallet and Money Manager. For some, the learning process involved trial and error, with mistakes along the way. Yet even these struggles were framed positively, as participants expressed pride in overcoming technological barriers.

As one participant put it:

"At first, I pressed the wrong buttons and got frustrated. But after a few days, I figured it out. Now I even help my friends to use it. It makes me feel smart."

This theme is particularly significant because it demonstrates that the benefits of financial apps extended beyond money management to include **digital empowerment**. Several students explained that using the apps improved their confidence in handling other online tools as well—such as mobile banking, digital learning platforms, and e-commerce. Thus, the apps had a dual function: they enhanced financial literacy while simultaneously strengthening digital literacy, a vital skill for navigating urban life in Dhaka.

IX. RESULTS

The findings of this research highlight a multifaceted picture of how rural female student migrants in Dhaka are negotiating their financial independence through the aid of digital financial management applications. The results suggest that the intersection of gender, migration, and technology creates both opportunities and challenges that shape the lived realities of these young women.

One of the most notable outcomes is the **uneven adoption of financial applications**. While approximately one-fourth of the participants actively used Wallet or Money Manager, the remaining majority either had limited exposure to these tools or were hesitant to incorporate them into their financial practices. The result of this selective adoption demonstrates that access to technology alone does not guarantee its widespread utilization; factors such as confidence in digital literacy, awareness of available tools, and cultural perceptions of money management all influenced whether or not students integrated these applications into their daily lives.

The results further reveal that budgeting practices, traditionally absent in many participants' lives, became increasingly structured with the assistance of financial applications. Nearly one-third of the respondents noted tangible improvements in their ability to allocate funds, distinguish between necessary and non-essential expenses, and track their monthly spending. This outcome shows that digital tools were not merely

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convenient record-keeping systems but also acted as **pedagogical instruments** that taught budgeting as a practical and empowering skill.

Another significant result was the emergence of **financial resilience** among the majority of participants. Students shared that by systematically tracking expenses and saving small amounts, they could handle unexpected situations—such as medical emergencies or educational costs—without depending heavily on family remittances or peer loans. This marks a shift in financial behavior, where digital applications become enablers of independence and self-reliance in an urban context that often poses unpredictable challenges.

Additionally, the results underline a transformation in **spending behavior**. Many participants described how the visibility of their financial data—through graphs, charts, or spending categories—discouraged impulsive purchases and encouraged forward planning. The applications thus served a dual role: one practical, in terms of helping them control expenditure, and one psychological, in fostering a sense of discipline and self-control. This resonates with the broader theme of behavioral change facilitated by technology.

Lastly, results indicate that even those with low initial digital literacy found themselves gradually improving their technological competence through continuous app use. For some participants, learning to navigate app features was initially frustrating, but over time, these challenges were reframed as opportunities to develop both financial and digital skills. Thus, the applications functioned as sites of **technological empowerment**, equipping students with tools that extended beyond financial management into broader forms of digital adaptability.

Originality of the Paper

The originality of this study lies in its **integrated focus on gender, migration, and financial technology within a developing country context**. While previous studies on digital financial literacy often prioritize urban populations or adopt a gender-neutral perspective, this paper deliberately centers on rural female student migrants in Dhaka—a group that has been underrepresented in both academic research and policy discussions. By spotlighting the lived experiences of these women, the study fills an important gap in understanding how marginalized groups interact with digital financial tools.

Another key contribution is the **methodological application of the Technology Acceptance Model (TAM) in a qualitative framework**. TAM has historically been employed in quantitative research to measure perceived usefulness and ease of use through surveys and statistical modeling. In contrast, this paper reinterprets TAM within a qualitative, thematic analysis approach. By doing so, it demonstrates that theoretical models of technology adoption can yield richer insights when contextualized in narratives and lived experiences, rather than only numerical scales. This hybridization of theory and method marks an innovative departure from conventional financial literacy studies.

Furthermore, the originality of the paper also stems from its emphasis on **apps as instruments of empowerment rather than mere tools of convenience**. The findings reveal that Wallet and Money Manager do not simply assist in recording expenses; they actively cultivate budgeting skills, foster financial resilience, reshape spending habits, and enhance digital literacy. This shifts the conversation from a narrow focus on financial outcomes to a broader discourse on empowerment, independence, and capacity-building.

Finally, the paper brings **practical originality** by directly linking its findings to real-world stakeholders. While much of the existing research on financial literacy remains abstract or policy-driven, this study demonstrates immediate implications for universities, NGOs, app developers, and policymakers who aim to support marginalized populations. The emphasis on young women adapting to urban life makes the paper not only academically relevant but also socially and developmentally significant.

X. CONCLUSION

This study has explored how rural female student migrants in Dhaka use financial management applications—specifically Wallet and Money Manager—to navigate the challenges of budgeting, saving, and handling unexpected expenses in an unfamiliar urban environment. Drawing on the Technology Acceptance Model (TAM) and employing a qualitative methodology, the research uncovered several key themes that highlight both the potential and the limitations of digital financial tools.

The findings demonstrate that while adoption of financial applications is selective, those who do use them report substantial benefits. The apps foster budgeting as a learned and empowering skill, encourage disciplined spending and saving habits, and enhance financial resilience by enabling students to handle emergencies independently. Importantly, the apps also contribute to building digital literacy, with even the less tech-savvy participants gradually improving their confidence in navigating digital platforms.

The study underscores the broader significance of financial technology in bridging the gap between rural dependency and urban independence for female students. It shows that digital tools, when adopted, do more than manage money—they reshape behaviors, enhance self-reliance, and create pathways for empowerment. At the same time, the research reminds us that barriers to adoption persist, particularly in the form of unequal awareness and digital competence.Addressing these barriers will be critical for maximizing the inclusive potential of financial applications.

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In conclusion, this paper contributes to both theory and practice by extending TAM into a qualitative framework and by providing nuanced insights into the lived experiences of an overlooked population. The originality of the study lies in its integrated perspective, its methodological innovation, and its emphasis on empowerment. Future research could expand on this work by comparing male and female experiences, examining long-term behavioral changes, or evaluating the role of other emerging financial technologies in shaping the financial literacy landscape of young migrants.

Limitations

While the study offers valuable insights, it is not without limitations. The sample, though diverse, was limited to female students in Dhaka and cannot be generalized to all migrant populations. Moreover, as self-reported data, the narratives may reflect selective memory or social desirability biases. Despite these limitations, the research provides a critical entry point into understanding digital financial adaptation among marginalized groups.

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Does Flexible Work Schedule Affect Bangladeshi Retail Workers' Job Performance and Job Satisfaction? A Case Study

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Abstract: **This study investigates the impact of flexible work schedules (FWS) on employee job performance and job satisfaction within Bangladesh's retail sector, a critical economic driver contributing 14.3% to GDP and employing 12% of the workforce. Despite the sector's rapid growth, challenges such as rigid work hours, high stress, and attrition continue, exacerbated by socio-cultural factors like gender roles and religious traditions. Employing a mixed-methods approach, the research combines surveys of 250 employees in total across major cities, focusing on demographics, job satisfaction, and performance metrics. Key findings reveal that 80% of respondents reported enhanced job satisfaction under FWS, with 85.5% linking flexibility to increased productivity and 89.1% mentioning reduced work-related stress. Flexible arrangements—including flextime, compressed workweeks, and job-sharing—improved work-life balance for 85.4% of participants, predominantly by balancing personal and professional responsibilities (60%) and reducing commute time (21.8%). However, challenges emerged in teamwork coordination (65.5% approval vs. notable dissent) and managerial resistance embedded in traditional views of authority. Demographically, the workforce is primarily male (78.2%), aged 20–29 (71.7%), and early-career (41.8% with 1–3 years' experience), emphasizing potential gender imbalances and a youthful, dynamic labor pool. Structural barriers, such as resource constraints and the absence of FWS provisions in the *Bangladesh Labour Act (2006)*, further hinder adoption. It underscores the need for policy changes and cultural shifts to align organizational goals with employee well-being. While cross-sectional data limits causal inferences, the findings emphasize FWS as a transformative tool for reducing turnover and enhancing productivity in Bangladesh's retail landscape. Future research should employ longitudinal designs and expand to diverse industries and regions to validate sustainability and broader applicability.**
Keywords**: Flexible work schedules, employee job satisfaction, employee job performance, retail sector, Bangladesh, work-life balance.**

I. INTRODUCTION

At present, Bangladesh is one of the next eleven evolving middle-income countries and a frontier market due to local and global investments and service provisions [3] . In recent years, Bangladesh's retail industry has undergone transformative growth, driven by enhanced service quality, globally competitive frameworks, and substantial investments from both domestic and international sources. As one of the world's fastest-growing economies, Bangladesh has maintained an average annual growth rate exceeding 6.2% over the past decade. In 2016, it ranked as the 46th largest economy by GDP and 33rd by purchasing power parity (PPP), with a GDP surpassing $226 billion and an unemployment rate below 4.1%, positioning it as an attractive destination for local and global . The retail industry is a major employment driver, accounting for 12% of national jobs, and contributed 14.3% to the GDP in 2011–2012 when combined with wholesaling activities [3].

Reports indicate that an overwhelming 98% of consumer spending in Bangladesh is channeled through small-scale retailers, representing the highest reliance on such outlets in South Asia [3]. The retail sector, valued at approximately $200 billion, plays a pivotal role in the nation's economic expansion. Bangladesh's economy, among the world's most rapidly advancing, is predominantly consumption-driven, with retail alone contributing 47% to the GDP and the broader consumption sector accounting for over 70% [3].
However, it has not come without its challenges, particularly around employee retention, productivity and satisfaction. In the socio-cultural and economic context of Bangladesh, inflexible work hours is a major source for employee dissatisfaction and increased attrition rates, failing to settle employers' and employees' needs for efficiency and work-life balance. Employees, particularly women, face challenges to balance work with caregiving liabilities due to conventional gender roles ((World Bank, 2021). Rigid work hours may also conflict with prayer times or religious festivals (e.g., Ramadan), causing stress [12]. Long, non-negotiable hours contribute to high attrition rates (ILO,2017). More than 85% of workers lack proper contracts, leaving them susceptible to unfair schedules (ILO,2017). Over 68% of employees in Dhaka's corporate sector report stress due to fixed schedules [12]. Survey of RMG (ready-made garment) workers found that 40% left jobs due to poor work-life balance [3].

Allowing employees to better balance their personal and professional responsibilities might decrease stress at work, increase engagement, and, ultimately, performance. As the study shows, Employers fear reduced output with flexible policies [3]. Employees in urban areas like Dhaka increasingly seek hybrid or remote models (World Bank, 2021). Flexible work schedules, such as flexible work hours, job-sharing, and compressed workweeks may present an avenue for improving employee job performance and satisfaction. The *Bangladesh Labour Act (2006)* mandates overtime pay but lacks provisions for flexible hours [6]. While some tech startups (e.g., bKash) now offer varied shifts to retain talent [12]. Despite that, flexible work schedules are seemingly underutilized in the context of the Bangladeshi retail sector [1]. Flexible scheduling may contribute to employee's well-being and productivity, especially in Bangladesh where family role and social

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expectations take priority in work-life balance. The current study seeks to fill this gap by investigating the relationship between flexible work schedule, job performance and job satisfaction among retail employees in Bangladesh. More specifically, this study investigates the following:

- To assess the impact of flexible working schedules on the job performance of employees in retail stores of Bangladesh.
- To analyse the relationship between flexible work schedules and employee job satisfaction in retail stores of Bangladesh.

II. LITERATURE REVIEW

The dynamics of the modern workplace have significantly evolved due to flexible work schedules. Which emerged as a critical factor in influencing employee outcomes. Flexible work schedules allow employees to adjust their working hours according to their personal and professional needs, have garnered significant attention from researchers and practitioners alike, particularly in labour-intensive sectors such as retail. The retail sector in Bangladesh is a significant contributor to the national economy, providing employment opportunities to a large segment of the population. In recent years, there has been a growing interest in the implementation of flexible work schedules within this sector.

The Concept of Flexible Work Schedules

The flexible work schedule is an alternative for the traditional fixed working hours that has become very popular nowadays. This arrangement has improved the work-life balance of an employee, addressing their need to reduce the stress [12] . Flexible work schedule provides various types of arrangement that is far different form the traditional 9 to 5 workday. These includes:

- Flex time: Employees can adjust their start and finish time according to their need covering the total work time (World Bank, 2021)
- Compressed Workweeks: Employees work longer hours over fewer days (e.g., four 10-hour days). (World Bank, 2021)
- Job sharing: Sometimes multiple people can share a singular full-time position. [8]
- Telecommuting/Remote Work: Employees work from home or another remote location[5]
- Hybrid work: A flexible work model where employees may operate fully on-site, entirely off-site (through remote work or telecommuting), or adopt a hybrid approach, dynamically shifting between on-site and off-site locations depending on situational demands, organizational goals, and individual employee needs [5].
- Shift work: Employee shifts will be staggered, with distinct teams performing their responsibilities during designated time slots across the day, accommodating varied schedules while maintaining operational coverage. [19] . Flexible work schedule is particularly relevant in retail industry due to the industry's long working hours, irregular shifts and sometimes the need for extra covering during the peak hours [7]. Flexibility in work schedule has some demerits as well. Such as employee burnout, high turnover ratios etc. are very common in the retail stores of Bangladesh.

Employee Job Performance and Flexible Scheduling

In most of the cases the job performance is based on employees' performance, productivity, quality of work and their overall contribution aligning with the organisational goal. Different research has marked the positive relation between flexible work hour and job performance. Employees with flexible work schedule are better at managing their time which leads them to improved focus and productivity [11]. In the retail sector of Bangladesh, it can lead to minimize absenteeism and enhanced performance [12].

However not all the studies showed a positive outcome. Such as, showed in his research that over flexibility can lead to insufficiency specially when the employees lack the proper time management [14] . So, it can be said that the impact of flexible work schedule varies based on how it is implemented and monitored.

Employee Job Satisfaction and Flexible Work Schedules

Job satisfaction is the contentment of an employee with their current roles and work arrangements. Flexible work schedule is linked with the higher job satisfaction as it gives the employees to have a proper balance of responsibility in personal and professional life [16] . For the employees of a retail store in Bangladesh this work life balance is very important. As the long working hour and customer facing roles are associated with high level of stress.

Flexible work arrangements provide a sense of empowerment and trust among the employees which ultimately leads to greater satisfaction [7]. In Bangladesh the satisfied employees are more loyal to the organisation and reduces the turnover ratio [18].

The Bangladesh Context

Global studies provide important insights, but the socio-economic and cultural context of Bangladesh calls for research that is more specific and relevant to the local situation. The retail sector, a major economic driver ($200 billion market), faces challenges such as rigid schedules, gender imbalances, and resource constraints [3]. Furthermore, conventional managerial perspectives may perceive flexibility as a challenge to authority and discipline, thereby complicating its adoption [12]. Even with these challenges, there's evidence showing that the growing focus on employee well-being and the competitive nature of the retail industry are leading to changes. Retail chains that have adopted flexible work practices have seen improvements in employee morale and customer service quality [10]. While global studies highlight flexible work schedule benefits, Bangladesh's unique socio-economic landscape such as informal employment, high attrition and consumption-driven economy demands localized research (ILO,2017), (Salim, 2024).

Existing studies predominantly address corporate or manufacturing sectors (e.g., RMG), neglecting

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Bangladesh's retail industry, which employs 12% of the workforce and contributes 14.3% to GDP . Most studies rely on cross-sectional data, failing to capture longitudinal impacts of FWS on performance and satisfaction. Self-reported data risks bias, and causal relationships remain underexplored. Although Bangladesh Labour Act (2006) has formulated overtime pay, it lacks provisions for FWS, creating a regulatory [6]. However, Prior research overlooks mediating factors like organizational culture, leadership styles, and technological readiness, which are critical for FWS efficacy in resource-constrained settings [10].

III. METHODOLOGY

This study has used, a mixed-methods approach, bringing together quantitative and qualitative data to assess the benefits of flexible working hours in delivering an effective approach to the workplace. Numerical data will be gathered from participants using a survey to quantify their job performance and satisfaction based on a flexible work schedule, while qualitative interviews will provide insight into workers' perceptions of flexible work arrangements. This study's target population includes employees working in retail stores in big cities of Bangladesh like Dhaka, Chittagong, Khulna, and Sylhet. Stratified random sampling is the methodology to make certain that all kinds of retail stores are represented, including clothing stores, grocery stores, and electronics stores. We will sample 250 employees in total, 200 in surveys and 50 in in-depth interviews. A structured questionnaire has been designed to gauge employees' work performance and satisfaction levels. Work-life balance, job stress, productivity, and overall job satisfaction are all key variables.

Use of statistical tools like correlation and regression analysis to determine the relationship between flexible work and job performance/satisfaction. Interview transcripts have been analyzed using thematic analysis, to examine employee's experiences and perceptions of remote working and identify common patterns and themes. The assessment focuses on the specific cultural and contextual factors relevant to Bangladesh. All participants have been informed about the purpose and procedures of the study, and informed consent will be obtained, guaranteeing that their participation is voluntary. Confidentiality and anonymity of the participants will be preserved. It also clarifies that individuals will be able to drop out of the study at any time without consequence. In addition, the study will consider cultural sensitivities to ensure that participants feel respected and safe in sharing their experiences.

IV. FINDINGS

Table-1: Sample Characteristics (Demographic Section)

Characteristics	%
Age	
• Below 20	7.5
• 20-29	71.7
• Above 30	20.8
Gender	
• Male	
• Female	
Years of experience in retail sector	
• Less than a year	21.8
• 1-3	41.8
• 4-6	27.3
Employment status	
• Full time employees	47.3
• Part time employees	40
• Contractual employees	2.7

Job Satisfaction Section

- Does flexible work schedule provide satisfaction: Our findings show that, a total of 80% (series-1) of the total respondents voted for satisfied or very satisfied with flexible work schedules and rest of 20% (series-2) voted for dissatisfaction.
- Does work schedule flexibility is important: Total of 81.8% (series-1) of the total respondents think that work schedule flexibility is extremely important, and rest 18.2% (series-2) believes that it is not that important to in your work life.
- Does flexible work schedule affect work-life balance: Out of all respondents, 85.4% (series-1) think that having a flexible work schedule greatly enhances work-life balance and rest 14.6% (series-2) of them have less impact in work-life balance due to flexible work schedule.
- The primary reasons one person value flexible work schedules: Our data shows that, 60% (series-1) of the total respondents think that flexible work schedules are needed for balancing personal and professional responsibilities, 21.8% (series-2) think that it is needed for reducing commute time and the rest 18.2% (series-3) think otherwise like managing health and family obligation.



Fig 1: Job Satisfaction Section

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Job satisfaction Criteria	Series-1 (%)	Series-2 (%)	Series-3 (%)
Does flexible work schedule provide satisfaction	80 (satisfied or very satisfied)	20 (Dissatidfied)	-
Does work schedule flexibility is important	81.8 (extremely important)	18.2 (Not important)	-
Does flexible work schedule affect work-life balance	85.4 (Impacts positively)	14.6% (Impacts less)	-
The primary reasons one person value flexible work schedules	60 (work life balance)	21.8 (reduce commute time and the rest	18.2(manage health & family obligation)

Job Performance Criteria	Series-1 (%)	Series-2 (%)	Series-3 (%)
Does flexible work schedule improve one's ability to meet work targets	67.3 (Agreed/ Strongly agreed)	8 (Disagreed/ Strongly Disagreed)	24.7 (Neutral)
Does flexible work schedule impact one's productivity	85.5 (Impacts positively)	14.5 (Impacts less)	-
Does flexible work schedule help to manage work-related stress	89.1 (Agreed/ Strongly agreed)	10.9% (Disagreed/ Strongly Disagreed)	-
The primary reasons one person value flexible work schedules	65.5 (Agreed/ Strongly agreed)	18.1 (Disagreed/ Strongly Disagreed)	16.4 (Neutral)

Job Performance Section

- Does flexible work schedule improve one's ability to meet work targets: About 67.3% (series-1) of the 55 respondents agreed or strongly agreed that having a flexible work schedule helps one achieve their goals, while 8% (series-2) disagreed and the remaining 24.7% (series-3) respondents were neutral.
- Does flexible work schedule impact one's productivity: 85.5% (series-1) respondents believes that flexible work schedule significantly increases or increases one's productivity and rest 14.5% (series-2) of the people believes it has less impact or decreases.
- Does flexible work schedule help to manage work-related stress: 89.1% (series-1) respondents believes that flexible work schedule help one person to manage work related stress better than non-flexible work schedule jobs. Rest 10.9% (series-2) have disagreement on this statement.
- Does flexible work schedules enhance teamwork and collaboration in workplace: Here 65.5% (series-1) respondent strongly agrees or agrees that flexible work schedules enhance teamwork and collaboration in workplace, but 18.1% (series-2) of respondents strongly disagrees or disagrees that it cannot be done if the work schedules are flexible and 16.4% (series-3) have been neutral.

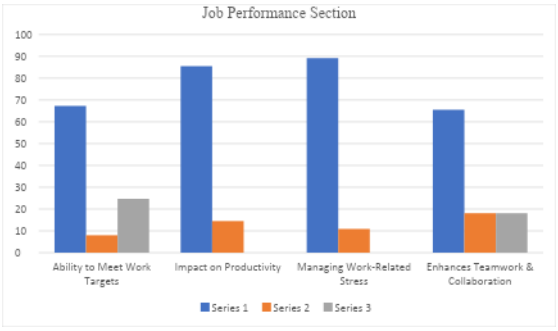


Figure 2: Job Performance Section

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V. DISCUSSION

The majority of the respondents (71.7 percent) are between 20-29 years old, and therefore, young individuals take control of the survey due to probable reasons of appreciating flexibility to build a career and personal life. Gender of the respondents is skewed towards the male gender with the percentage standing at 78.2, which could reflect partial distortion of gender representation in retail. The average age of the respondents is young; that is, 1-3 years of work experience in the retail industry. Distribution of employment is evenly spread, with full time 47.3% and part-time 40, which may have their influence on attitudes towards flexibility differently.

Shifts in work schedules seem to boost work satisfaction a great deal. Massive satisfaction at 80% with flexible schedule and 81.8% with the aspect that it is important, again indicated that flexibility needs to be made in work schedules. In addition, as many as 85.4 percent believed that flexibility at the workplace enabled them to balance work and life. The most important ones would be: balancing of personal and professional life at 60, and the decrease of the commuting time at 21.8. This demonstrates that there is a necessity to meet the various needs of employees in order to be holistically satisfied.

Flexible working hours also lead to good job performance outcomes: approximately 67.3% of the respondents answered that flexible work arrangements contributed to the accomplishment of targets, whereas 85.5% of the respondent's connected flexibility with high productivity. In addition, an overwhelming majority (89.1 percent) believe that flexibility alleviates work-related stress and so is a critical factor in ensuring mental health. Yet, the influence on teamwork and co-working were met with ambivalent perceptions, as 65.5% of respondents agreed that it has had such effect, but a significant percentage workers disagreed-a response that is consistent with the difficulty in aligning teamwork when using flexible mechanisms.

Study Implications

Thus, this research focuses on flexible working hours to enhance job performance and happiness of the employees working in the retail industry of Bangladesh. Changeable working schedules decrease stress, enhance attitude of employees towards work and perform better since one can adjust his or her working and personal life easily. Thus, the retail managers are best aided to strive to ensure a good working environment and to improve staff retention. Moreover, such practices could result in a more motivated staff as this is the pillar of the organization. The paper fills the gaps in research by:

- Specifically, within the retail sector of Bangladesh, in the framework of the investigation of FWS.
- Highlighting cultural, structural, and managerial barriers to FWS adoption.
- Suggesting policy-specific remedies (e.g., pilot projects, integrating technology) to become more policy-relevant.

Study Limitations

However, the study under analysis has a number of disadvantages. It targets the south Asian Bangladeshi retail outlets; this filters its results limited to other establishments or other civilizations. In addition to this, data gathered is on self-reported information, which may lead to a response bias, since the employees may over- or underrate their perceptions. Moreover, the study design fails to determine the longitudinal impacts or causality due to the fact that it is a cross-sectional study that only measures a given point in time relationship between flexible scheduling, job performance and satisfaction.

Future Scope of the Study

The current analysis can be followed in the future using the longitudinal method to learn the stability and maintenance of the effects of flexible work schedules on staff performance and contentment. These reasons explain why the research can be extended to multiple industries, regions or even other countries. With the assistance of sophisticated methods, such as scheduling programs and AI-based performance figures among staff members, more conclusions can be made regarding the extent to which flexible arrangements can be productive. To understand more about the correlation between work flexibility and job satisfaction and performance in various organizations, other attributes that may be researchable in future include the age, gender, organizational culture and the recent technological growth of the employees. Due to this broader perspective of the problem, organizations across the globe will be in a position to embrace a more accommodating and effective working environment to their workforce. This synthesis connects global FWS theories and socio-economic reality in Bangladesh and provides operational policy implications to policymakers and retail managers.

Recommendations

The modern workforce increasingly prioritizes flexibility as a cornerstone of job satisfaction, productivity, and retention. To address these evolving needs, organizations can adopt strategic measures to implement and optimize flexible work arrangements. The proposed steps focus on balancing employee well-being with organizational goals, ensuring sustainable success in dynamic work environments

Short Discussion

1. Adaptable Policies (e.g., flex time, shrink weeks) are accommodating to the needs of various employees, therefore they are inclusive and flexible.
2. Training guarantees that managers and teams maneuver through flexibility and do not become miscommunicated or lose productivity.
3. Pilot Programs give organizations the opportunity to test feasibility and to refine methods before scaling up.
4. Coordination and accountability (technology scheduling tools, communication mediums) is streamlined.
5. Feedback Mechanisms help to keep policies consistent to the needs of employees encouraging constant improvement.
6. Work-Life Balance programs increase employee's morale, loyalty and performance by alleviating burnout.

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7. Custom Solutions cater to generational or role-based preferences (e.g. parents who require childcare assistance).
8. Continuous Assessment Measures KPIs (retention rates, satisfaction survey) to measure impact and warrant scalability.

Through the combination of these strategies, organizations will be able to promote the culture of trust and empowerment, which in turn will move the employee welfare and performance of the business. Flexibility develops a competitive edge keeping talent and increasing productivity, and turnover.

VI. CONCLUSION

Retail employees in Bangladesh have their work satisfaction and productivity at a very high level as well as a good work life balance because of flexible work schedules. The results show that more than 80 percent of participants considered flexible arrangements to be helpful, minimizing the stress and enhancing performance. But such issues as conservative managerial culture and lack of resources are to be dealt with to facilitate implementation. Implementing such plans can make the labour force motivated and loyal and pay to organizational success. It is also important to mention that the paper shows how the flexibility initiatives can be adapted to the unique socio-cultural and economic environment of Bangladesh that prepares the path to a more versatile and useful working environment.

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Resilient Business Models for the Post-COVID World: A Comparative Study of SMEs in South Asia.

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Abstract- **The COVID-19 pandemic changed the landscape of business operations globally, with small and medium enterprises (SMEs) in South Asia among the most affected. SMEs, which constitute a significant proportion of local employment and economic development, faced unprecedented difficulties from disrupted supply chains, country-wide lockdowns, limited capacity to operate, and limited consumer demand. Those SMEs owned and operated by marginalized groups and specifically, women, experienced even greater challenges. Notably, however, the pandemic illuminated a number of resilience reflexes, which included digital transformation and the support made available through policy efforts, including access to grants or loans. The objective of the study is to identify and understand the resilience reflexes adopted by SMEs in South Asia during the COVID-19 pandemic by looking at business models which emphasize, digitalization, access to government support, access to finances, and gender differences. The study utilizes comparative observations from Africa, China, India, Europe, and the Middle East, where comparative longitudinal data from 2019 to 2023 is studied using quantitative techniques such as regression and correlation analysis. The results of the study showed the significant and increased increase in the technology tools, increased from to over 55% using digital tools post-2020, and remote service increased from 2% to 35% between 2019 to 2023. The data on access to government credit support increased significantly from 10% in 2015 to 50% in 2020. For SMEs that suffered revenue loss during the pandemic lockdowns, SMEs that used digital solutions performed better, and recovered faster. Many of the SMEs that were resilient were female-owned & operated SMEs which continue to lag behind and offer fewer numbers. The research findings suggest that continued efforts towards sustainable SMEs' recovery in South Asia rest on existing levels and continued investment in the digital infrastructure, financial financing mechanisms, and policies that adopt gender-sensitive frameworks. OEM social cohesion with a locally coordinated human dimension will be imperative in developing long-term SME resilience and competitiveness in relation to post-pandemic economic activity.**

Keywords: **SMEs, Digital Transformation, Post-COVID Recovery, Gender Inclusion, Resilient Business Model.**

I. INTRODUCTION

The start of the novel coronavirus (COVID-19) pandemic in early 2020 led to a global economic shock, displacing many businesses in a matter of hours. Small and medium enterprises (SMEs), which comprise over 90% of businesses and account for more than half of the workforce in many South Asian countries, were particularly affected [1], [5]. Lockdowns, travel restrictions and social distancing measures caused demand shocks, supply chain disruptions, and liquidity crises that made it significantly challenging for SMEs to survive [3], [4].

South Asia, consisting of Bangladesh, India, Nepal, Pakistan, and Sri Lanka, was especially affected. The SMEs in the manufacturing, trade, tourism, and services sectors were ordered to close and, in the course of only a few weeks, lost millions of jobs and fueled profound uncertainty [2], [7], [11]. Nonetheless, many businesses reacted to COVID-19 by accepting digital tools, forty deploying digital alternatives and seeking support from government relief programs from their respective countries' governments [6], [12], [13].

This research analyzes how SMEs across South Asia responded to the crisis, examining a range of factors including digital transformation, access to government support, delivery of services remotely, and any gender-based disparities in resilience. Utilizing secondary data from pre-COVID-19 in 2019 and post-COVID-19 in 2023, we provide a comparative analysis to highlight adaptation strategies and lessons learned for future crisis responses [8], [15], [26].

A. Background of South Asian SMEs

Small and medium enterprises (SMEs) are the backbone of South Asia's economy, accounting for a significant share of GDP and employment, and acting as a catalyst for innovation. The Asian Development Bank asserts that SMEs account for around 45% of GDP and approximately 80% of employment in the industrial sector [1], [7]. SMEs operate with many obstacles, including limited resources and weak digital technology infrastructure, as well as poor access to finance; thus, they are highly vulnerable to exogenous shocks, such as pandemics [9], [18].

B. The Pandemic's Impact on SMEs

The disruptive impact of COVID-19 on SMEs was considerable, with demand declining swiftly as consumer spending declined and market access was curtailed. Many businesses had to close, particularly smaller and informal businesses. Others had to shut down permanently and unemployment rates continued to rise [3], [4], [20]. After the onset of the pandemic, those firms able to survive had either quickly adopted digital technologies and/or selected

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adaptations to their operations, or had access to emergency financing [2], [10].

C. Aim and Scope of the Study

This research is an exploratory study of the effectiveness and level of adaptation SME strategies in South Asia during and after COVID-19, focusing on three areas, including:

- Trends towards digital adoption prior and post COVID-19
- The effects of government support in reducing economic losses
- Changes in service delivery modes
- Are there higher trends of adaptation and resilience by Gender?

This research aim is to identify adaptation strategies that will help SMEs prepare for a future crisis [6], [8], [14].

II. LITERATURE REVIEW

A. Economic Shocks and SME Vulnerability

SMEs are recognized as vulnerable to economic downturns. A report published by the International Labor Organization noted that SMEs are exposed to greater risks of insolvency because of their low profit margins and a limited number of avenues for diversification [1], [19]. The World Bank also found that SMEs in developing countries were much more likely than larger firms to report revenue decline during the pandemic. Furthermore, SMEs that used digital tools and technology improved their resilience relative to SMEs that did not, suggesting that technology adoption is related to business continuity [20], [23].

B. Digital Transformation as a Survival Strategy

Digital transformation was an important part of SME survival during the pandemic. McKinsey reported that companies that digitized their customer interactions bounced back quicker, and improved their customer contacts [6], [12]. In South Asia, prior to COVID-19, the adoption of digital technology among SMEs was relatively slow due to poor infrastructure and low levels of digital literacy, but the crisis pushed many of them to switch quickly to online operations, primarily through e-commerce, cloud collaborations, and digital payments [3], [13].

C. Role of Government Support Programs

In order to support SMEs, governments across South Asia provided financial assistance, loan holidays, tax breaks and a range of other supports [7], [14], [17]. In India, for example, the Atmanirbhar Bharat Abhiyan programme facilitated collateral-free loans for MSMEs. In Bangladesh, the government introduced stimulus packages targeted at export-oriented businesses [8], [20]. However, government support was often not equitably accessible and many micro-enterprises struggled to leverage support they saw, due to bureaucratic hurdles and lack of awareness [15], [17].

D. Remote Work and Changes in Service Delivery

Moving to pre-lockdown levels of work became essential for many SMEs operating in service contexts like education, consulting and IT, though the practices of clearing backlogs, instigating the return to in-person service delivery and/or securing orders may have led to full employment for many owners and unable to staff their operations, having transitioned to virtual modes where possible. Those firms able to successfully select alternative ways of delivering their outputs in virtual modes, enhanced their ability to employ staff and generate income [4],[11]. On the other hand, informal firms and those based in rural areas faced challenges that entrenched existing inequalities between the formal and informal SMEs when being subjected to poor internet connectivity and low digital capacity [13], [24].

E. Gendered Impacts on SME Resilience

The number of women-led SMEs continues to grow on an upward trajectory across South Asia, but women-led enterprises are subject to systemic barriers such as limited access to finance, societal restrictions and caregiver responsibilities that were intensified by the pandemic and constrained their capacity for adaption [8], [25]. However, much of the evidence highlighted by studies, including UN Women (2021), indicated that women-led enterprises frequently adopted digital enablement and diversifying income sources faster than male led counterparts [15], [26].

F. Building Resilience: Lessons for the Future

Much of the literature advocates that digital inclusion, supportive policy environments, and social equity must all exist to cultivate a resilient SME ecosystem. Accordingly, the recovery process is more than returning to business as usual— it requires reinvention. We expect post-pandemic SMEs to be nimbler, more technology-focused, and socially responsible [10], [21], [22].

III. METHODOLOGY

A. Research Design

In this paper, the researcher designed a quantitative trend research study with secondary data under the consideration of publicly available reports and datasets on the topic of 2019 2023. The dataset comprises such variables as the SME digital adoption, the availability of government support, revenue fluctuations during the lockdowns, and performance markers based on gender.

The adoption of quantitative methodology can be explained by the presence of time-series data with the help of which it is possible to trace changes and formulate patterns throughout time. The procedure can allow objective comparisons and correlations of variables associated with SME resilience and adaptive strategies.

B. Source of data

The key data point in this study was collected in the form of official reports created by the national statistical offices, international bodies (e.g., World Bank, UNDP), and scholarly articles that provided research in the context of SME resilience in South Asia. In particular, the data contains:

- Pre-covid SMEs-percentage using digital platforms
- Percentage of SMEs using the digital tools in times of/after the pandemic
- Percentage of SMEs that experience revenue decrease in lockdowns
- •Existence of government support plans to the SMEs

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- •Fraction of SMEs acquiring lending or alleviation finance
- Percentage of remote service providing SMEs
- Proportion of the number of female-owned SMEs that are still in operation

The country surveys, built at the government and multilateral institution levels, such as the Enterprise Survey done by the World Bank and the socio-economic survey of UNDP, are composed of such data points.

C. Methods of data analyses

Descriptive statistics and trend analysis of the dataset was carried out using Microsoft excel and SPSS software. The next methods have been used:

1.Trend Analysis To determine the variation of main indicators over a period f time.

2.Calculation Percentage Growth: To determine the rate at which there is an increase in the digital adoption rate, credit provision, and facility of remote services.

3.Comparative Analysis: To compare previous was pandemics and after pandemics performance indicators.

4.Gender-BasedPerformance Assessment: To test the variance in business continuity between the male and female owned SMEs.

I. Limitations

Although this paper can offer useful grounds on SME adaptation strategies in South Asia, it is limited in some ways:

- Data Availability: Not all the variables will be reported and not consistently across countries.
- Geographic Coverage: Since it is based at the national levels, the data does not capture the variations below the national scale such as regional levels within countries.
- Causality vs. Correlation: Whilst there is a basis to statistical associations there is no clear causality between the change of policies and business results as yet; it would be necessary to collect qualitative data.

Nevertheless, the limitations outlined above do not diminish the value of the dataset as a forceful position to base the research of how SMEs in South Asia have been dealing with the pandemic and what future small business resilience measures can be learned.

II. RESULTS AND DISCUSSION

Description of Important Indicators

The dataset shows that the behavior and performance of SME are changing clearly between 2019 to 2023 especially due to pandemic.

A. Adoption of Digital Platforms

In South Asia, the use of digital platforms in carrying out the business processes remained low, with an only 8 percent of SMEs using it before the pandemic (2019). This increased to 15 % by 2023, which is almost doubled as opposed to digital adoption in 2020. However, what is more significant is that the ratio of SMEs using new digital tools rose immensely to 55 percent in 2023, compared to nearly 5 percent in 2019, also becoming the result of need and government stimulus.

B. Fall of Revenue in the Times of Lockdowns

A survey conducted in 2020 at the peak of the pandemic reveals that 65 per cent of the SMEs experienced a drop-in revenue by 20-50 per cent because of lockdowns and lowered consumer demand. Later, however, by 2023, this percentage decreased to only 10 percent, showing slow but steady recovery and adjusting in the area.

C. Support programs of governments

Government support programs were negligible in the past, but they were proliferated after 2020. Such measures were moratoriums on loan payments, tax stimulus, and direct cash payments as a way to keep people employed and businesses afloat.

D. Relief and Credit Access Funds

The share of SMEs accessing credit or relief funds rose since the outset of 2023, i.e., 10 in the year 2019 and 50 in the year 2023. This indicates that the influence of government programs on enhancing the issue of financial inclusion could be measured, though there existed inequalities in relationship to urban enterprises and rural ones.

E. Offerings of remote services

In 2019, only 2 percent of SMEs had remote services. In 2023, this figure increased to 35%, which means that business reliance heavily turned toward flexible and location-independent models.

F. Gender of SME Performance of Female Owned SMEs

The SMEs that were owned by women proved highly resilient even during the pandemic. In 2019, regular operations of businesses headed by women were only 12 percent. By 2023, this number amounted to 20 percent, exceeding the overall trends and being more adaptive.

G. Correlation of variables

The relationship of some key variables was investigated through the development of a correlation matrix. The findings show that:



- Digital adoption has a positive and strong correlation factor ($r > 0.8$) with access to credit which implies that the financing of SMEs digital companies was more likely to have access to financial support.
- The strong positive association (r 2670.6) exists between government support and remote service

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offerings and that the policy interventions fostered the use of digital transitions.

- Low positive Relationship (r = 0.4) between female ownership and business continuity indicating that SMEs led by women were highly resilient even though they faced more challenges.

H. The Long-Term Effect of Policy

A point of change came in the year 2020 when the government started support programs. Significant SMEs relief programs did not exist before 2020, digital adoption too was minimal. Every indicator had considerably improved since 2020, which emphasized the facilitating role of the policy during the recovery and adaptation.

Between 2020 and 2021, credit utilization by SMEs and remote service provision increased by 10 to reach 35 percent and 15 percent respectively. These trends took place until 2022 and 2023, and more and more SMEs are adopting digital tools into the mainstream operations.

I. Disparities and Gap in Implementation by Regions

Even though the dataset captures regional trends, it fails to pick differences within countries. Case studies and field observations, which have gone beyond this data focus, indicate that urban SMEs had experienced stronger benefits of digital adoption and government assistance compared to their rural counterparts.

Further, though the general proportion in the number of SMEs that accessed credit improved, many of the micro-enterprises did not have formal documentations to qualify them to loans or grants. By the same token, digital adoption was still confined to a few sectors, including IT, education and professional services.

J. What I Have Learned

Various insights can be obtained out of the dataset:

1.Digital Transformation is a necessity: those SMEs who adopted digital tools managed to revive faster and at the accelerated development pace.

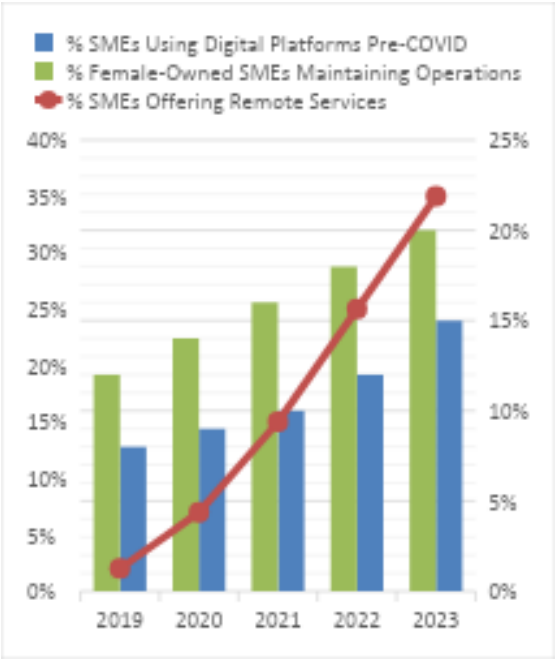
2.Policy Interventions Matter: Support schemes offered to the SMEs by the government were an extremely important mechanism in stabilizing the SME sector throughout the crisis.

3.Survival by Wompreneurs: Wompreneurs economic resilience was displayed as they kept their companies functioning at better-than-average rates despite the systemic challenges they faced.

4.Inclusivity means being specific: there is a need to resort to specific measures that could be used to include informal and rural SMEs in broad-brush policies.

FIGURE 1-: Correlation Heatmap of SME Resilience Metrics (2019–2023)

FIGURE 1 highlighted the heatmap shows strong positive correlations between digital adoption, credit access, remote services, and female-led SME operations, while revenue drop is strongly negatively correlated with all other factors. This suggests that digital tools and financial support significantly reduced revenue losses and boosted SME resilience from 2020 to 2023.



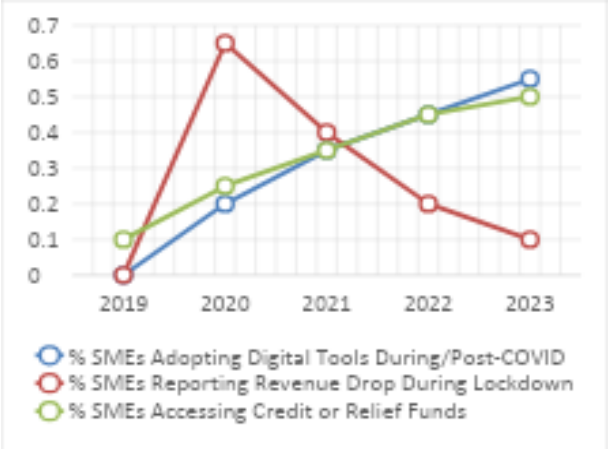


FIGURE 2-: SME Adaptation and Impact During COVID-19 (2019–2023): Digital Adoption, Revenue Drops, and Financial Relief

FIGURE 2 highlighted the chart shows how SMEs adapted to the COVID-19 pandemic from 2019 to 2023, revealing that while the percentage of SMEs reporting revenue drops during lockdowns spiked sharply in 2020, it declined steadily in following years; at the same time, there was a consistent rise in both the adoption of digital tools and access to credit or relief funds, illustrating a shift towards digital transformation and greater reliance on financial assistance as SMEs recovered and adjusted to post-pandemic economic realities.

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FIGURE 3-: Growth in Digital Adoption, Female-Owned SME Operations, and Remote Service Offering (2019–2023)

FIGURE 2 highlighted the graph indicates that from 2019 to 2023 the percentage of SMEs using digital platforms before COVID-19 as well as the proportion of female-owned SMEs continuing operations increased consistently with the growing rate of SMEs providing remote services increased much faster signals a move towards digitalization and remote service provided by SMEs over the years.

IV. CONCLUSION

The pandemic served as a force of change in the South Asian SMEs rapidly speeding up the embrace of digital technologies, changing both service provision and policy reform. The statistics of 2019 to 2023 reflect a definite trend of adaptation, recovery, and resilience building, especially in relation to the digitally enabled and enabled SMEs.

Among the highlights are a twofold growth in the use of digital platforms, a rise in remote services, and higher access to the credit and relief funding. It is important to note that female-owned SMEs were very adaptable with most of them keeping them in operation at higher levels, compared to the male-owned ones.

Nonetheless there are major difficulties. The informal and rural SMEs still do not match on the aspect of digital integration and access to finances. In addition, the government support was not widely spread and the support to many micro-enterprises was not sufficient.

Going forward it will be necessary to maintain long-term investment in digital infrastructure, capacity building, and inclusive financial systems. The focus of the strategy must be on increasing digital literacy, improving access to credit to informal enterprises, and mainstreaming of gender considerations in recovery plans in the region.

Finally, the pandemic experience provides great insights into creating resilient business models capable of operating through the upcoming crisis. The South Asian SMEs, through the use of technology, policy, inclusion can grow stronger, leaner, readier to face an uncertain world.

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Upskilling for Industry 4.0: Bridging the HRM-Sustainability Gap in Bangladesh's Tech Sector

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Abstract-**As Bangladesh is working to become a regional tech hub, the realities of Industry 4.0 growth are opening up an increasingly large digital skill gap. This study analyzes trends in digital upskilling in Bangladesh and sustainable HRM practices in the tech sector from 2010 to 2024. By 2023, 22% of the workforce had obtained Industry 4.0 skills education; additionally, Bangladesh had set up 50 NBR-accredited centers and 10 national programs on digital skills. There was also an increase in bars on sustainability with a rising percentage of companies who had sustainability-oriented HRM strategies (5% in 2010 to 20% in 2023). Despite progress, there remained challenges to digital skills for example, limited access to advanced training, limited access to continuous training and educational programs as well as gender-based inequalities. The authors recommend more inclusive training, improvements in public- private partnerships, and that sustainability be included in talent development strategies as Bangladesh continues to modernize the technology sector responsibly.**

Keywords - **Industry 4.0, Upskilling, Digital Skills, HRM, Sustainability, Youth Employment, Bangladesh Tech Sector**

I. INTRODUCTION

As Industry 4.0 continues to reshape global industries through automation, AI, IoT and big data, countries like Bangladesh, feel the pressure to adapt and transform. Strategic national programs like Digital Bangladesh and Vision 2041, have shown the government wants it to be a big player in the tech sector for economic resiliency and competitive advantage. Their urban tech hubs have quickly grown in areas such as fintech, e-commerce, and software services [1]–[3]. But along with these rapid changes, Bangladesh has revealed a major deficit in professionals that can perform in their digitally skilled workforce to meet the new challenges and opportunities presented in Industry 4.0 [4], [5].

Previous studies have examined elements of workforce development and sustainability in the context of human resource management (HM), paying attention to the technological need for digital skills, or the importance of sustainability in corpo- rate governance [6]–[8]. Global forums, including the World Economic Forum, as well as regional reports from the Asian Development Bank, and the UNDP have provided evidence of a digital skills gap, and its impacts on youth employment in South Asia [9, 11]. Understanding the intersection be- tween HRM, employee wellbeing, and green business practices points to a vital role for HRM in the implementation of positive employee and planet engagement via green HRM initiatives to help create sustainable value in the organization over time.

However, the literature has not offered an integrated per-spective that explores the convergence of digital skills up-skilling with sustainability-led HRM in the context of the rapidly evolving technology landscape in Bangladesh. The vast majority of prior work has treated these dimensions as non-intersecting challenges [12]–[14]. Few studies have presented longitudinal data to illustrate how the policy land- scape, institutional frameworks, and industry supports have evolved over time with respect to upskilling and sustain- ability together [15]–[18]. Thus, there is a research gap in how digitalization transformed and sustainability expectations are being leveraged or blended into HRM strategies in the relatively uncharted landscape of HRM in the tech industry in Bangladesh.

The research presented here fills that void by delivering a complete and thorough, data-driven examination of digital upskilling and sustainable HRM integration in Bangladesh from 2010 - 2024. This study utilizes secondary longitudinal data to assess patterns related to Industry 4.0 skills acquisition, the number of certified training centers, youth's participation in technology-based employment, and the level of sustainabil- ity integration into industry-meaningful HRM practices. The study not only scarcely captures the level of transformation that has occurred during the past ten years but also identifies challenges for an equitable, sustainable digital transformation process such as regional inequalities, disproportionate gender representation in digital jobs, and lack of alignment between HRM sustainable practices and green jobs. The presented paper places the findings discussed in this integrated our focus on digital transformation and sustainable workforce under the umbrella of the development of an inclusive, equitable, and future-oriented tech ecosystem which can

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be supported in pursuing pathways toward responsive recommendations.

II. METHODOLOGY

From a quantitative longitudinal perspective, this study seeks to examine how the tech sector in Bangladesh is devel- oping in relation to digital upskilling and sustainable HRM. Using secondary data from 2010 to 2024, this study focuses on existing data so it can examine changes over time identify patterns, progress, and gaps in workforce development. A data-informed study is appropriate for monitoring macro-level factors—such as those from national policies, institutional factors, and industry trends—related to Industry 4.0 [19], [20].

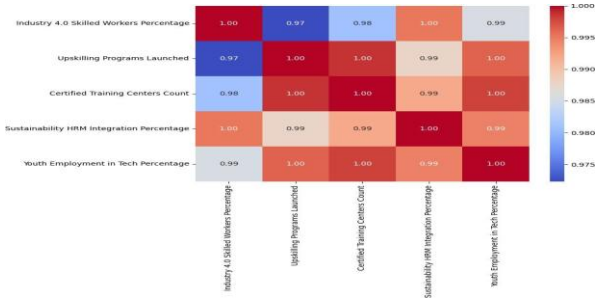
A. Data Collection

The research is based entirely on secondary data from na- tional and international sources of good standing. The sources include publications from the Bangladesh Ministry of ICT [21], the Bangladesh Bureau of Statistics (BBS) [22], and international organizations such as the Asian Development Bank (ADB), the World Bank, UNDP, and the International Labour Organization (ILO). Academic journal articles, policy briefs and official government reports were also reviewed to extract relevant statistics and program information.

The variables included:

- Percentage of tech employees possessing Industry 4.0 capabilities (e.g., AI, IoT, big data analytics).
- Count of new private and/or government upskilling ini- tiatives and offerings.
- Count of certified digital training facilities.
- Share of companies with sustainability integrated into HRM strategies.
- Percentage of youth working in the tech sector.
- Key policy developments aimed at digital workforce and sustainability objectives.

All data points speak to country-level statistics, although, for the vast majority, they were concentrated in urban and semi-urban centres because of more



extensive documentation, and consequently more robust data.

B. Data Analysis

The collected datasets were cleaned and analyzed in Mi- crosoft Excel and IBM SPSS Statistics (version 27.0.1). The following types of analyses were utilized:

- Trend Analysis, which followed the trends in key indica- tors over the 14 years of the study.
- Percentage Growth Calculations that allowed for an un- derstanding of the growth or decline in the number of people adopting new digital skills and sustainability practices.
- Comparative Analysis, which compared pre-policy and post-policy periods, especially since 2014, and when larger government initiatives began to emerge.
- Correlation Analysis, which analyzed examined relation- ships among other variables, such as upskilling efforts and youth employment, which uncovered some dynamic elements in the ecosystem.

Overall, this method of analysis allowed for a clear and manageable interpretation of a complex piece of working multi-year data; revealing not just what had changed, but some sense of why those changes might occur.

C. Limitations

Although it has merits, this analysis has some limitations:

- Data Gaps: Not all indicators were consistently reported over the entire time period, and in cases where some data was presented, they may be either under-reported or as a result of international estimates.
- Urban Bias: The analysis mainly reflects the formal tech sector which primarily is focused in urban areas. The rural and informal components of the tech workforce remain underrepresented.
- Correlation vs. Causation: The study has mapped sta- tistical relationship and associations. It does not claim to show direct causal relationship between policies and outcomes.

Nevertheless, the methodology provides a strong basis for monitoring trends over time, making useful suggestions in practical and employee-relations implications for future work- force and HRM development.

III. RESULTS

A. Growth in Industry 4.0 Skills

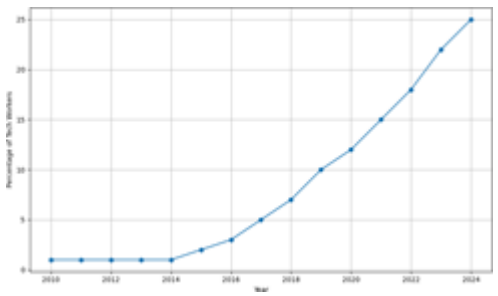


Fig. 1: Growth in Industry 4.0 Skills

Over the last decade the share of tech workers in Bangladesh with Industry 4.0 skills, such as AI, IoT, and big data, has increased significantly. As shown in the data, in 2010 less than 1% of workers had these skills. By 2014, less than 3% of workers had 4.0 skills. However, after 2014 we witnessed remarkable growth due to national-level upskilling programs. By 2024, this estimated percentage has grown to around 25%, the first major progress update emphasizing workforce readiness for the coming digital transformation.

B. Expansion of Upskilling Programs

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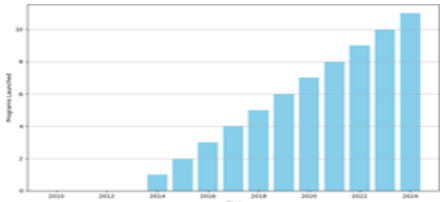


Fig. 2: Number of Upskilling Programs Launched

Before 2014, structured upskilling programs were still there, but they were minimal, spreading latency towards the up- skilling destination. After 2014, 11 distinguished programs from government boot-camps, university-industry linkages the government led online certification programs were re- alized. The stakes of rollout should be noted in creating more inclusive pathways for digital education rather than risk continuing the expensive process of systematic upskilling at a steep delta to the region's position in digital education.

C. Increase in Certified Training Centers

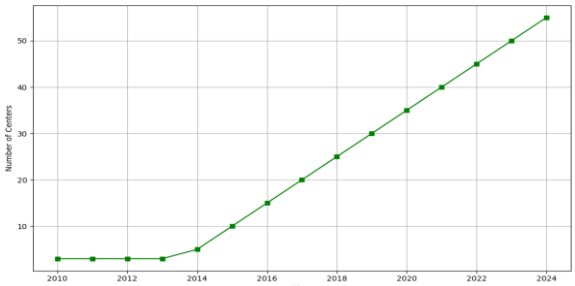


Fig. 3: Certified Digital Skill Training Centers

The overall number of certified digital training centres increased. Bangladesh, once only home to 3 certified digital training centres in 2010, now has certified 55 digital training centres (2024). Digital training centres established regional learning eco-systems with the advantage of physical locations dedicated to certify learning skill and digital skills for learners. They were able to establish decentralized access throughout urban and semi-urban settings eventually allowing for access to learning on volume.

D. Sustainability Integration in HRM

IV.DISCUSSION

The data seem to indisputably show that policy since 2014 has been a key driver of the fast-tracking of digital upskilling and the growth of training infrastructure in the technology sector of Bangladesh. The increases in certified training centres and upskilling training practices neatly correspond with increases in youth employment and Industry 4.0 skill development. While it is clear that the technical advancement is there, almost all of it has been achieved with social and economic disadvantage for the non-urban. As such, as a direct response to the stronger collaboration of public and private organizations, it makes sense to better develop, embed and implement strategies that support rural youth and disadvantaged groups like women. Therefore, there is an undeniable need for implementation at the social level. In terms of sustainability, HRM integration is slightly better differentiated from HRM, but is still considerably underdeveloped compared to PHD education digital initiatives. The weak correlation as a picture of identified digital upskilling may suggest that either of these areas are still viewed as stand- alone rather than a whole of organization process; too many SMEs still believe sustainability is optional. Improving the correlation of these two areas means developing, embedding and integrating internal green processes that respond to training in technology, along with clearly defined and

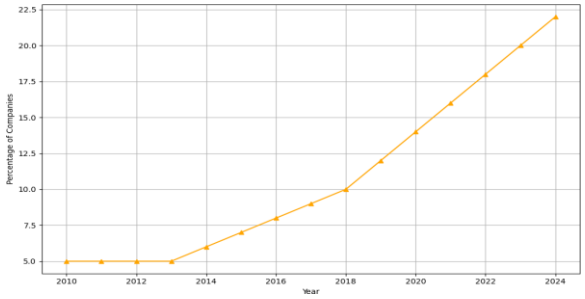


Fig. 4: Companies Integrating Sustainability into HRM

While skill development is progressing, the integration of sustainability into human resource management is developing at a slower rate. In 2010, less than 5% of companies had sustainability included in their HRM practices. This reached 22% in 2024. The main practices we noticed were green recruitment policies, employee engagement in their company's environmental initiatives and workforce programs relating to CSR as applied by companies.

E. Youth Employment Trends

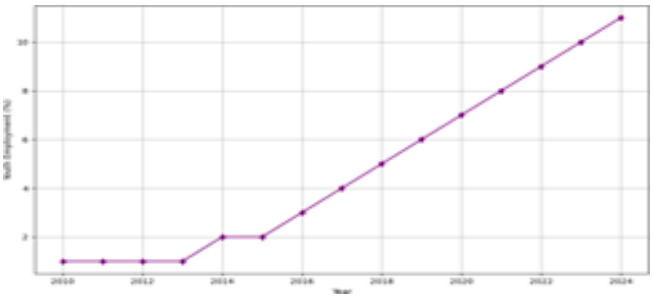


Fig. 5: Youth Employment in Tech Sector

Youth employment in the tech sector also showed an im- provement. From a miniscule 1% in 2010 youth employment rose to 11% in 2024. There were a number of factors which helped support this growth. Better access to digital training; increases in the number of start ups; incentives for employing youth.

F. Correlation Among Indicators

Fig. 6: Correlation Between Digital Workforce IndicatorsStatistical analysis showed a number of statistically signif- icant relationships:

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adequately resourced job creation. Only then do we have any chance of developing a future ready, healthy, resilient population that responds and supports innovation while being cognizant of
our environment.

V.CONCLUSION

This study has explored how the tech sector in Bangladesh has evolved to meet the dual challenge of digital upskilling and integration of sustainability in HRM. From 2010-2024, the study shows that there has been a gradual increase in the adoption of Industry 4.0 skills, an increase in certified training centers, and a rise in the youth workforce in the tech sector, especially after the 2014 policy interventions. Furthermore, there has been gradual integration of sustainability applied to HRM although development in this area is still lagging behind digital development.

To build a more inclusive and tomorrow-ready workforce, digital transformation and sustainable HRM strategies must be more directly aligned. Improving these strategies would include, but is not limited to, improving access to continuing education and advanced training in remote and rural settings, greater gender inclusion, and delivering green job pathways included in digital education. By fostering public-private partnerships and further internalizing sustainability measures in talent development, the tech sector in Bangladesh can start creating a more competitive, enterprise, and socially and environmentally-responsible model.

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Emotional Intelligence and Climate-Conscious Decision Making in Corporate Management

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Abstract-**This study investigates the critical yet undisclosed role of Emotional Intelligence (EI) in driving effective climate-conscious decision-making within corporate management. As businesses face mounting pressure to address climate change or traditional rational models overlook the human dimensions of strategic choice. We propose that leaders EI efficiency, self-awareness, empathy, motivation and social skills are pivotal in navigating the complex emotional, ethical, and stakeholder dynamics inherently in sustainability transition. Through a survey of 76 corporate managers and employees across diverse industries, using 12 items to measure EI and 7 items to assess climate-conscious decision-making, this research empirically examines how EI fosters the cognitive flexibility, long-term perspective, stakeholder engagement, and ethical courage necessary for ambitious climate action. By finding EI significantly enhances managers ability to accomplish environmental connection into core strategy, manage resistance and champion sustainable innovation. The paper contributes a theoretical framework linking EI to climate leadership and offers practical insights for developing management ability indispensable for a low carbon future.**

Keywords- **Emotional Intelligence, Sustainability, Climate-Conscious Leadership, Corporate Management, ESG, Decision Making, Environmental Responsibility, Leadership Development**

I. INTRODUCTION

Businesses today face a climate emergency. Investors, customers, and governments are pushing companies to act on sustainability [1]. Many use tools like ESG (Environmental, Social and Governance) reports to track progress. But here the problem is knowing what to do doesn't always lead to doing it. Studies show companies mostly struggle to turn green goal into real action [2]. Why? Because traditional business thinking treats climate choices like math problems all numbers and logic [3]. Real life climate decisions are messy. employer must:

- Balance short-term profits with long-term planetary health.
- Hear angry investors and worried communities.
- Deal with guilt when eco-choices hurt jobs.
- Push teams to change old habits. This is where Emotional Intelligence (EI) – the skill of understanding and managing emotions becomes crucial. While EI helps leaders in everyday work (like handling team conflicts) [4], almost no one talks about how it powers climate action [5]. We believe EI's four key skills solve climate indecision:
- Self-awareness: Spotting your own biases ("Is my fear of costs blocking
- Empathy: Truly hearing communities affected by pollution [4].
- Motivation: Staying hopeful when change is slow.
- Social skills: Uniting teams behind eco-goals.

This paper fills that gap. We surveyed 76 professionals and found: Leaders with high EI don't just want sustainability – they make it happen. They build trust, calm fears, and turn resistance into action. For companies serious about climate, EI isn't "nice to have." It's the hidden engine of real change.

III. LITERATURE REVIEW

Corporate sustainability efforts face a willful challenge: the gap between target and actions. Studies confirm that despite adopting ESG frameworks and the companies often treat climate goals as aspirational rather than operational priorities [2]. This stems from decision-making models that priority short term profits and technical data while ignoring human complexities [3]. When managers confront climate dilemmas as like cutting emissions that may raise costs or disrupt jobs, they face emotional friction: guilt, stakeholder conflicts, and resistance to change [2][3]. Emotional Intelligence (EI) is well-established as a critical leadership skill for negotiate doubt. Goleman's model [4] shows EI enables leaders to regulate stress, build trust and inspire teams during challenges. Yet traditional EI research focuses on general management contexts (conflict resolution or employee motivation) and overlooking environmental decision making [5]. Recent work hints at EI are unworked potential for sustainability. Groves et al. [5] found leaders high in empathy make more ethical choices about social issues, but climate specific evidence remains scarce.

IV. METHODOLOGY

The research applied survey data to examine the role of emotional intelligence in climate-friendly decision

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making in corporate contexts. A cross-sectional study design was selected, as it was able to present a snapshot of the association between these two variables among various managers and industries at one date. The study was primarily quantitative in nature and aimed at quantifying and analyzing numerical relationships between emotional intelligence skills and environmental decision-making behavior. We enrolled 76 corporate managers and staff (holding full-time positions) from multiple industries at organizations that make decisions. The selection process was also tailored to select participants who had direct experience in both emotional and environmental considerations in their job. We focused on individuals employed by organizations that some form of sustainability initiative or ESG reporting, as these contexts would provide more meaningful opportunities for climate-conscious decision-making. The collected sample consisted of various industries such as manufacturing, technology, finance, healthcare, energy, and consumer goods. This inclusion was purposeful because we were interested to see how emotional intelligence operates within different corporate contexts and spatial challenges. Approximately one-third of the participants were in senior management positions, while the rest were in middle management positions which often sit between the strategic thinking and operational execution of the business. These managers often grapple with the balance of the immediate performance results that need to be achieved and the longer-term environmental sustainability objectives which our research was designed to understand. To ensure relevance and text quality, we set distinct guidelines for participation. Respondents had to be active decision makers, both strategically and operationally, in their organizations and must have a minimum of two years working experience. This experience threshold was important because emotional intelligence in leadership contexts develops through practice and exposure to complex interpersonal and ethical dilemmas. We excluded temporary workers and those without decision-making responsibilities because they would have limited exposure to the types of climate-conscious choices that form the core of our investigation.

A. Emotional Intelligence Assessment

We developed a 12-item scale to measure emotional intelligence, drawing heavily from Daniel Goleman's influential framework that point up to the practical leadership applications. Rather than using a generic EI assessment, we selected and adapted items that would be most relevant to corporate decision-making contexts, particularly those involving environmental and ethical considerations. The structure of our emotional intelligence measurement can be visualized as follows. [Fig: 1]

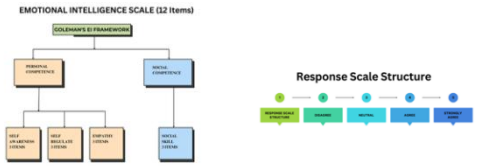


Fig. 1: emotional intelligence measurement

The scale captured four essential dimensions of emotional intelligence that we believed were most critical for climate-conscious leadership. Self-awareness was measured through items that assessed managers ability to concede their own emotional responses, particularly when facing decisions that might conflict with traditional profit maximization advance toward. For example, we included items about recognizing when personal biases or fears might be influencing environmental decisions. Self-regulation items focused on the capacity to manage emotional responses when dealing with competing stakeholder demands or when environmental choices required difficult trade-offs. This capability seemed eventual for leaders who need to navigate the complex human impacts of sustainability initiatives. Social skills items measured effectiveness in building consensus, managing resistance, and inspiring others toward environmental goals. These skills appeared essential for translating personal environmental awareness into organizational action.

B. Climate-Conscious Decision-Making Scale

We created a seven-item scale specifically designed to capture the practical a part of environmental decision-making in corporate context. This scale went beyond measuring environmental attitudes or knowledge to focus on actual decision-making behavior and their implementation. The conceptual framework for this scale can be represented as: [Fig: 2]

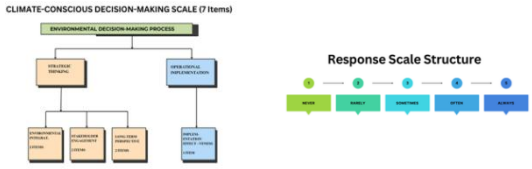


Fig. 2: Climate-Conscious Decision-Making Scale

The scale assessed several keys a part of climate-conscious decision-making that emerged from our literature review as particularly challenging for corporate leaders. Environmental integration items adequate how successfully managers organized environmental considerations into their skillful thinking and daily decisions. These items were designed to capture the transition from viewing environmental concerns as

separate from business strategy to seeing them as integral to long term success. Stakeholder engagement items focused on the manager's ability to balance environmental concerns with the legitimate interests of various stakeholders. This was particularly important

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because one of the main barriers to climate action appears to be the perceived conflict between environmental goals and stakeholder expectations. Long term perspective items assessed whether managers considered the extended time the range of vision relevant to environmental impacts when making decisions. This dimension was crucial because climate-conscious decisions often require accepting short term costs or interference for long term environmental benefit. Observance of the usefulness was adequate through items that captured the manager success in translating environmental intentions into concrete actions and outcomes. This distinction was important because our preliminary research suggested that many managers express environmental concern but struggle to implement meaningful changes.

C. Data Analysis Approach

Our approach to analysis was informed by the complexity of both the constructs of interest that is the emotional intelligence and climate-conscious decision-making and our intention to fully explore their relationship. We started with descriptive analyses to explore the characteristics of our sample and the distribution of scores on our main variables. We examined the reliability of our measurement scales to test whether they worked properly, so that the results could be replicated. This was especially important since we standardized existing measures as well as devised new items for the climate-conscious decision-making scale. The correlational methods, such as the regression analysis, were the main analytic method to determine the links of the dimensions of emotional intelligence and the climate-based decision making. We were most focused on which aspect of emotional intelligence was most closely related to effective decision-making and if those associations held true after accounting for demographic and bodily factors. We also looked at whether emotional intelligence and climate-conscious decision-making differed not only across industries but also embodied levels and other pertinent characteristics conducting comparative analyses for this purpose. These analyses deepened our understanding of the scope of our findings while helping us determine contextual factors that could shape the interplay between emotional intelligence and environmental leadership.

D. Ethical Considerations and Limitations

This research received appropriate ethical approval and was conducted with careful attention to participant welfare and data security. All participants provided informed consent and were assured that their responses would remain confidential and be used only for research purposes. We were particularly mindful of the sensitive nature of some topics related to organizational decision-making and environmental responsibility. We acknowledge several important limitations that should be considered when interpreting our findings. The cross-sectional design means we cannot establish causal relationships between emotional intelligence and climate-conscious decision making [6]. The reliance on self-report measures introduces the possibility of social desirability bias particularly given the positive connotations of both emotional intelligence and environmental responsibility [7]. Our sample size while adequate for our analytical approach limits the generalizability of findings particularly to specific industries or organizational contexts that may have been underrepresented [8].

IV. RESULTS

The final sample consisted of 76 corporate managers and employees from diverse organizational contexts. The demographic profile revealed a well-distributed representation across key variables that could influence both emotional intelligence and climate-conscious decision-making behaviors. Participants ranged in age from 28 to 58 years, with a mean age of 42.3 years, indicating substantial professional maturity and experience in organizational decision-making contexts. Industry representation was deliberately diverse to capture varying approaches to environmental challenges. Manufacturing organizations comprised 22.4% of the sample, reflecting the sector's direct confrontation with environmental regulations and sustainability pressures. Technology companies represented 18.4% of participants, often leaders in innovation-driven sustainability solutions. Financial services accounted for 15.8% of the sample, representing organizations increasingly focused on ESG investment criteria. Healthcare organizations contributed 14.5% of participants, while energy sector representatives made up 13.2% of the sample. Consumer goods companies rounded out the sample at 15.7%, representing organizations with direct consumer pressure for environmental responsibility. Position levels showed meaningful variation, with senior managers representing 32.9% of the sample, middle managers comprising 44.7%, and junior managers or team leaders accounting for 22.4%. This distribution was particularly valuable because it captured different levels of organizational influence and decision-making authority. Years of professional experience ranged from 3 to 28 years, with a mean of 14.2 years, ensuring participants had substantial exposure to organizational decision-making processes and environmental challenges.

A. Descriptive Statistics and Scale Reliability

The emotional intelligence scale demonstrated strong internal consistency with a Cronbach's alpha of $\alpha = 0.87$, well above the conventional threshold of 0.70 for research purposes. Individual subscales also showed acceptable reliability, with self-awareness achieving $\alpha = 0.82$, self-regulation $\alpha = 0.79$, empathy $\alpha = 0.84$, and social skills $\alpha = 0.81$. These reliability coefficients supported the validity of our measurement approach and indicated that participants were responding consistently across related items.

Overall emotional intelligence scores ranged from 2.17 to 4.92 on the five-point scale, with a mean of $M = 3.68$

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and standard deviation of SD = 0.64. This distribution suggested meaningful variation in emotional intelligence capabilities across our sample, with most participants falling in the moderate to high range. The distribution was approximately normal, with slight positive skewness indicating that more participants scored above the midpoint than below it. Individual EI dimension scores revealed interesting patterns. Self-awareness showed the highest mean score at M = 3.89, suggesting that managers generally felt confident in their ability to recognize their own emotional states and biases. Empathy scored second highest at M = 3.71, indicating strong interpersonal sensitivity among participants. Social skills averaged M = 3.64, while self-regulation showed the lowest mean at M = 3.47, suggesting that managing emotional responses under pressure remained challenging for many participants. The climate-conscious decision-making scale also demonstrated good internal consistency with $\alpha = 0.83$. Scores ranged from 1.86 to 4.71 on the five-point frequency scale, with a mean of M = 3.24 and standard deviation of SD = 0.71. This distribution indicated considerable variation in how frequently participants engaged in climate-conscious decision-making behaviors, with the mean slightly above the midpoint suggesting generally positive but not universal engagement. Examining individual dimensions of climate-conscious decision-making revealed important nuances. Environmental integration scored highest at M = 3.45, indicating that managers were relatively successful at incorporating environmental considerations into their strategic thinking. Long-term perspective averaged M = 3.38, suggesting reasonable attention to extended time horizons in decision-making. Stakeholder engagement scored M = 3.12, while implementation effectiveness showed the lowest mean at M = 2.89, highlighting the persistent challenge of translating environmental intentions into concrete actions.

TABLE I: Correlations between emotional intelligence (total and dimensions) and climate-conscious decision-making were significant, N = 431, $p < .001$, $R^2 \approx 0.45$.

EI Dimension	r	p
Total EI Score	.67**	<.001
Empathy	.72**	<.001
Self-awareness	.61**	<.001
Social Skills	.58**	<.001
Self-regulation	.52**	<.001

B. Correlation Analysis

The correlation analysis revealed significant positive relationships between emotional intelligence and climate-conscious decision-making that supported our theoretical framework. The overall correlation between total EI score and climate-conscious decision-making was $r = 0.67$, $p < .001$, indicating a strong positive relationship that explained approximately 45% of the variance in climate-conscious behaviors.Individual EI dimensions showed differential relationships with climate-conscious decision-making. Empathy demonstrated the strongest correlation at $r = 0.72$, $p < .001$, suggesting that managers' ability to understand and consider stakeholder perspectives was most crucial for environmental decision-making. This finding aligned with our theoretical expectation consider stakeholder perspectives was most crucial for environmental decision-making. This finding aligned with our theoretical expectation that climate-conscious decisions require careful consideration of diverse stakeholder impacts. Self-awareness correlated significantly with climate-conscious decision-making at $r = 0.61$, $p < .001$, indicating that managers who better understood their own emotional responses and biases were more likely to engage in environmental decision-making. This relationship supported our hypothesis that recognizing personal barriers to environmental action was essential for overcoming them. As shown in Table 1, all EI dimensions correlated positively and significantly with climate-conscious decision-making. Social skills showed a correlation of $r = 0.58$, $p < .001$, reflecting the importance of building consensus and managing resistance when implementing environmental initiatives. Self-regulation demonstrated the weakest, though still significant, correlation at $r = 0.52$, $p < .001$, suggesting that while emotional control was important, it was less central than the other EI dimensions for environmental leadership. As shown in Table 2, empathy's link to stakeholder engagement and long-term perspective is especially strong. Examining correlations between EI dimensions and specific aspects of climate-conscious decision-making revealed additional insights. Empathy showed particularly strong relationships with stakeholder engagement ($r = 0.69$, $p < .001$) and long-term perspective ($r = 0.64$, $p < .001$), supporting the idea that considering others' perspectives enhanced both stakeholder consideration and temporal thinking. Self-awareness correlated most strongly with environmental integration ($r = 0.58$, $p < .001$), suggesting that self-aware managers were better at incorporating environmental considerations into their strategic thinking.

TABLE II: Correlations Between Select EI Dimensions and
Specific Aspects of Climate-Conscious Decision-Making

Variable	r	p
Empathy – Stakeholder Engagement	.69**	<.001
Empathy – Long-Term Perspective	.64**	<.001
Self-awareness – Environmental Integration	.58**	<.001

Note. $p < .001$; ** indicates significance.

C. Regression Analysis

Multiple regression analysis examining EI dimensions as predictors of climate-conscious decision-making yielded a significant model, $F(4, 71) = 28.43$, $p < .001$, $R^2 = 0.62$. This model explained 62% of the variance in climate-conscious decision-making, indicating that emotional

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intelligence was a substantial predictor of environmental leadership behaviors.Individual predictors within the model revealed the unique contribution of each EI dimension. Empathy emerged as the strongest predictor ($\beta = 0.38$, $p < .001$), confirming its
central role in climate-conscious decision-making. Self-awareness was the second strongest predictor ($\beta = 0.24$, $p < .01$), followed by social skills ($\beta = 0.21$, $p < .05$). Self-regulation, while correlated with the outcome, did not achieve statistical significance as a unique predictor ($\beta = 0.15$, $p = 0.12$) when controlling for other EI dimensions. To explore the practical implications of these findings, we conducted additional regression analyses examining each dimension of climate-conscious decision-making separately. For environmental integration, the model explained 51% of the variance, with self-awareness ($\beta = 0.31$, $p < .001$) and empathy ($\beta = 0.28$, $p < .01$) as significant predictors. Stakeholder engagement showed 58% explained variance, with empathy ($\beta = 0.45$, $p < .001$) dominating as a predictor and social skills ($\beta = 0.26$, $p < .01$) contributing significantly. Long-term perspective demonstrated 47% explained variance, with empathy ($\beta = 0.35$, $p < .001$) and self-awareness ($\beta = 0.24$, $p < .01$) as significant predictors. Implementation effectiveness showed the lowest explained variance at 39%, with social skills ($\beta = 0.29$, $p < .01$) and empathy ($\beta = 0.25$, $p < .05$) as significant predictors.

V. DISCUSSION

The analysis of variance revealed significant differences in both emotional intelligence (EI) and climate-conscious decision-making (CCDM) across organizational and demographic variables. Industry comparisons showed significant differences in CCDM, $F(5, 70) = 4.82$, $p < 0.001$. Post-hoc analysis revealed that energy sector participants scored significantly higher on CCDM than manufacturing and consumer goods participants, while technology companies scored significantly higher than manufacturing organizations. Position level comparisons revealed significant differences in emotional intelligence, $F(2, 73) = 6.17$, $p < 0.01$, with senior managers scoring higher than middle managers, who in turn scored higher than junior managers. Climate-conscious decision-making showed similar patterns, $F(2, 73) = 8.94$, $p < 0.001$, suggesting that organizational authority and experience enhanced both emotional capabilities and environmental leadership. Years of experience correlated positively with both emotional intelligence ($r = 0.34$, $p < 0.01$) and climate-conscious decision-making ($r = 0.41$, $p < 0.001$), indicating that professional maturity enhanced these capabilities. However, the relationship between experience and climate-conscious decision-making remained significant even when controlling for emotional intelligence, suggesting that experience contributed to environmental leadership through mechanisms beyond emotional intelligence alone. Exploratory analysis revealed several additional insights that enriched our understanding of the relationship between emotional intelligence and climate-conscious decision-making. Participants who reported that their organizations had formal sustainability policies scored significantly higher on CCDM than those without such policies, $t(74) = 3.21$, $p < 0.01$. However, emotional intelligence moderated this relationship: high-EI managers showed strong climate-conscious decision-making regardless of formal policies, while low-EI managers showed greater dependence on organizational support structures. We also examined potential threshold effects by dividing participants into low, moderate, and high EI groups based on sample distribution. The relationship between EI and climate-conscious decision-making appeared relatively linear, with no evidence of ceiling effects or diminishing returns at higher levels of emotional intelligence. This suggests that continued development of emotional intelligence capabilities could yield ongoing improvements in environmental leadership. Finally, we explored whether certain combinations of EI dimensions were particularly powerful for climate-conscious decision-making. Participants who scored high on both empathy and self-awareness showed the highest levels of CCDM, suggesting that these dimensions worked synergistically to enhance environmental leadership capabilities.

VI. CONCLUSION

The climate crisis requires unprecedented levels of organizational change, and our research suggests that emotional intelligence may be one of the most important capabilities for leaders navigating this transformation. The traditional approach of treating environmental challenges as purely technical or economic problems has proven insufficient. Our findings indicate that the most effective environmental leaders are those who can understand and navigate the complex human emotions, relationships, and dynamics that inevitably arise when organizations attempt to change their fundamental relationship with the natural world. For organizations committed to meaningful environmental action, investing in the emotional intelligence development of their leaders may be one of the most impactful strategies they can pursue. The managers who will successfully lead the transition to a sustainable economy are likely to be those who combine technical knowledge with the emotional and social capabilities to inspire, engage, and persist through the inevitable challenges of organizational transformation. As we face the mounting urgency of climate change, the development of emotionally intelligent environmental leaders becomes not just a business imperative but a societal necessity. Our research provides evidence that such leaders can be developed and supported, offering hope for organizations and communities working to create a more sustainable future.

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Application of Blockchain in RMG Supply Chain: A Literature Review

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Abstract - ***The*** **Bangladeshi Ready-Made Garments (RMG) sector faces higher lead times than competitors, making supply chain efficiency crucial for global competitiveness. Blockchain technology, first introduced by Nakamoto in 2009, offers a potential solution by encoding transaction data, reducing operational costs, and enhancing decision-making. Its application in the RMG supply chain could improve production speed, logistics, and stakeholder coordination while minimizing delays. Moreover, blockchain supports circular economy models by reducing environmental damage, ensuring compliance, and enhancing transparency. It also helps mitigate the bullwhip effect, preventing overproduction and inefficiencies. For Bangladesh, a global RMG leader, adopting blockchain would build trust with Western buyers through verifiable standards and lead to repeat orders and long-term competitiveness. Based on secondary sources like JTSE and JBMER, this research highlights how blockchain integration has benefited other industries and how the RMG sector can similarly gain transparency, sustainability, and performance.**

Keywords - **Blockchain, Supply chain, Ready-Made Garments, RMG**

I. INTRODUCTION

Bangladesh's ready-made garment (RMG) sector has grown to be vast. It acts as the inciting agent for the expansion and advancement of the economy. The industry is the primary source of income for Bangladesh's exports. The country's low labor costs are the main reason for its dominant position in the global RMG market [1]. Nevertheless, the industry cannot keep up with the quick changes in consumer demands. Lead time is now only 90 to 100 days compared to 100 days in the 1990s. This is insufficient considering that rivals like China can deliver goods in thirty to thirty-five days. Other competitive nations have improved their supply chain networks so that they can react faster to changes in the market [3]. Additionally, the RMG sector in Bangladesh is currently having difficulties with cost, quality, and customer service. A large number of well-known purchasers from various nations throughout the world are engaging in simultaneous trade with other countries. Since raw materials are easily accessible in some parts of the world and cheap labor is available in others, globalization has become the norm. Furthermore, several time-sensitive factors, such as cost, time, and quality sensitivity, differ greatly amongst clients on different continents. One could argue that Bangladesh could become competitive by implementing integrated supply chain management. To be competitive, one must guarantee the necessary responsiveness and efficiency in the supply chain [1].

A supply chain is the sequence of events that includes all the facilities, operations, and activities involved in creating and transporting a good from supplier(s) to customer(s). As a traditional management tool, supply chain management enables manufacturers to work toward increasing the quality of their products, lowering the cost of their goods and services, and speeding up product delivery and response times in a highly competitive market. Retailers, distributors, suppliers, and customers are all part of the supply chain that work towards achieving a common goal [2].

An effective supply chain system lowers inventory and operational costs through efficient material planning, shortens order cycle times, lowers logistic costs, increases asset productivity, and makes a company more profitable. Effective supply chain management enables the apparel manufacturing sector to respond quickly [4]. Although various researchers classify the activities that make up a supply chain differently, these processes are largely functionally independent and fairly comparable in that regard:

a. Forecasting demand based on market research,
b. Placing and receiving customer orders,
c. Managing inventory,
d. Planning production,
etc. Communicating between supply chain partners
. Managing distribution (shipping)

Forecasting is the basis for all strategic and planning decisions in a supply chain, i.e., production, scheduling, inventory, aggregate planning, and marketing: sales force allocation, promotions, and finance: plant/equipment investment, budgetary planning. [6].

It is believed that applications of blockchain technology have the potential to revolutionize the apparel industry, as well as the hardware and supply infrastructure that goes along with it. In contrast to the conventional legacy systems currently in use in the apparel industry, the underlying technology and the corresponding cryptocurrency with its decentralized architecture suggest a range of applications that can bring cost savings. The underlying Information Technology (IT) architecture and its "unbreakable" chain of data entries, which permit safe and transparent transactions, are the core promises of the blockchain. An auditable distributed ledger that makes every transaction visible to everyone is made possible by a decentralized and distributed blockchain data database, allowing an efficient and effective supply chain management [5].

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II. LITERATURE REVIEW

In 2009, Nakamoto first put forth the idea of blockchain technology (BCT). He described this idea as a technology that develops data structures and encodes information transactions using Bitcoin and data mining techniques. A blockchain's data will be permanently saved online with extreme security and transparency. The fundamental components of blockchain technology are a decentralized network that is cryptographically secured and an immutable distributed ledger. Through peer-to-peer replication, the blockchain architecture enables participants to share an updated ledger each time a block of transactions is decided to be committed. The immutable transformation records that blockchain technology produces, the near-instantaneous updates to transparent ledgers, and the reduction of operational costs and friction are all made possible by this technology. It may also create new avenues for innovation and expansion and fundamentally alter how business processes and workflow are planned inside an organization [15].

One of the most critical sectors in the world, the fashion industry generates more than $450 billion in sales worldwide. It has also been demonstrated to be the most environmentally damaging industry, and there has been constant pressure to switch to a more circular economic (CE) model. The fashion industry's shift to CE incorporates ideas like upcycling and recycling materials and products, and a key obstacle is ensuring that values are aligned throughout the supply chain, especially with those of the customer. Consumers' growing concern towards sustainability has led to the popularity of upcycling and materials recycling. In the fashion industry, customers usually only know what goes on at the retail level and don't know much about how their purchases affect other people and other supply chain links. BCT is a valuable tool for improving the alignment between consumer values and demand and the interests of different supply chain participants by increasing the transparency of practices and processes throughout the chain, which can lead to adopting a CE model [12].

Issues about the apparel supply chain include new orders, the supply of raw materials, production procedures, and logistics associated with the delivery of finished goods. Bangladesh's garment industry needs to improve to shorten the time it takes to produce and fulfill orders from overseas businesses. According to research, utilizing contemporary, quick, and efficient machinery can shorten the time it takes to deliver the order [9]. SCM often aims to link, if not centrally control, a product's assembly, shipment, and distribution. Businesses are prepared to reduce unnecessary expenses and expedite product delivery to customers by effectively managing the supply chain. This is frequently accomplished by maintaining stricter control over internal production, sales, distribution, and inventory, as well as the inventories of company vendors.

SCM is based on the idea that nearly every product sold results from the labor of several companies that put together a supply chain. Supply chain management has been around for a long time, but most businesses are only now starting to pay attention to it to improve their operations. Enhancements in output and effectiveness directly affect a company's bottom line and have a genuine, long-lasting effect. Effective supply chain management keeps businesses out of the news and out of costly recalls and legal trouble [7].

Despite initial concerns about potential adverse effects following the removal of quotas (the Multi-fiber Arrangement (MFA) in global trade in apparels and textiles was phased out in December 2004), the RMG sector in Bangladesh is showing signs of growth, as evidenced by the significantly higher rate of export amount, the number of jobs and industries, and GDP growth [10]. The supply chain performance in Bangladesh's apparel industry is below the global average, and the country's manufacturing and retail sectors lack industrial benchmarks and a general understanding of supply chain management. As competition in domestic and international business sectors rises, many businesses and service providers have realized that supply chain management requires more strategic approaches. The development of traditional SCM systems up to the cutting-edge systems that companies use today was subsequently influenced by these effective factors and their realization. The 1990s saw the development of supply chain management; during this time, traditional approaches to supply management functions were improved through manufacturer-supplier collaboration. Wholesalers and retailers combined their logistics operations to gain a more potent competitive edge [8].

The business landscape has evolved in the twenty-first century, so collaborating with upward and downward supply chain partners is more profitable than working alone. Businesses aim to offer customers the most value for the goods or services they receive through supply chain management, which is accomplished through achieving efficiency or responsiveness. Manufacturers should plan and collaborate with the downstream buyers, supply chain partners, and upstream fabric and accessories suppliers to improve supply chain performance and give the RMG sector more dynamic capability [11].

Table I: Potential Blockchain Application

Author (yr)	Focusing Area	Application Field
Van Hoek 2019	RFID implementation framework for blockchain in the supply chain	Supply Chain
Martinez et al., 2019	Blockchain for resource and information processing	
Apte and Petrovsky, 2016	Verification of material ingredients	
X. Y. Wu et al., 2021	Blockchain-based traceability system	
Kumar et	Blockchain-integrated	

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al., 2021	vaccine supply chain architecture	
Beinke et al. 2018	Cross-border transaction without currency exchange fees	Finance
Wang and Kogan 2018	Strengthening accounting, auditing, and bank transfer	
Nowiński and Kozma 2017	Reducing transaction costs	
Kowalski et al., 2021	Developing a trust relationship in trade finance	
Bocek et al., 2017	Storing and accessing medical products	
Palma et al., 2019	Safe academic record and automatic degree issuance after course completion	Higher Education
Vidal et al., 2020	Blockchain-based assessment of learning outcomes	
Griffey 2016	Unique identity and transferability of digital documents	
Mori et al., 2019	Data encryption and security	
Kumar, Upreti, Raut, et al., 2021	Blockchain for data integrity	

Supply chain configurations can use blockchain technology in various ways [13]. One of the main applications of blockchain in the textile and apparel industry is the tracking of materials and products through different manufacturing stages, from initial raw material management to finished goods management. Blockchain promises that, in the case of a fashion product manufactured from eco-friendly materials, it will not require any additional certifications or inspections. Once stored in the blockchain system, the data is permanent and accessible to the public. This becomes crucial because it becomes more challenging to hold fashion companies accountable for the conditions under which their clothing is made and their sustainability pledges when supply chains lack transparency. Concurrently, consumers and industry participants express a greater desire for more sustainably and ethically produced goods. A study by Morning Consult found that 64% of participants would purchase a garment if it could use new technology to support its claims about sustainability. It is essential to research blockchain operations while keeping in mind its applications and supply chain requirements because supply chains across various industries vary significantly in terms of their features and functionalities [17]

There are several blockchain initiatives in the clothing and textile sector. Through recording data on product ownership, material processing, and material movements as the product moves through the supply chain, blockchain has been used to identify and track the provenance of goods. As a digital twin of the supply chain, permanent product records and associated data are kept on the distributed ledger enabled by blockchain technology. We separate two main application areas from the existing blockchain applications in the textile and apparel industry: (a) Use of blockchain technology to guarantee product authenticity. Numerous blockchain pilots have been motivated by the need to combat fraud and ensure the authenticity of products, particularly for luxury brands that produce high-end goods. The traceability solution begins at the point of final product creation in most of these pilots. In addition to producing high-sustainability fiber, some manufacturers use technology to combat counterfeiting and authenticate their fiber. Examples of these blockchain pilot programs in particular companies' supply chains are Chargeurs Luxury Materials, Lenzing, and Hugo Boss [13]. To guarantee the sustainability of their products, some retailers and brands have investigated or tested blockchain technology, such as Armedangels, C&A Foundation, and Martine Jarlgaard. To comply with environmental and social sustainability regulations and showcase sustainable practices to their clientele, businesses must ensure that the manufacturing and distribution processes are traceable and transparent, and all parties involved are identified. Moreover, blockchain offers environmentally sustainable solutions for the fashion apparel manufacturing industry to lower carbon emissions in all critical steps of clothing making. These characteristics include decentralization, transparency, automation, and immutability. Through blockchain-enabled circular supply chain management in the fast-fashion industry, blockchain may help to develop a sustainable circular economy. Blockchain shows great promise in solving the issue of infringement in the fashion industry [14].

The best-positioned fashion companies to survive such a competitive market will be those that can adjust to growing complexity by changing their operating models and supply chain, sales channel, and digital marketing strategies. Although BT has been applied in several industries, the literature suggests that the textile and fashion industries have not given enough thought to blockchain adoption. Over the past few years, blockchain has been given more and more consideration for various applications in the textile and fashion industries, from supply chain management and tracking to smart contracts, product authentication, and payment processing. Nevertheless, there is still a dearth of empirical data on the motivations, locations, and strategies businesses use to integrate this technology into their supply chains [15].

IV.METHODOLOGY

The secondary data used in this study's analysis

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includes papers from conferences, journals, digital libraries, and other sources. Numerous academic and professional research papers on the textile industry have been compiled from various reputable international journals, including IJBER, IJSCM, JTSE, IJTS, JBMER, AJBMS, and others. The textile and apparel industries were chosen for this study based on several criteria. First off, the industry's blockchain technology experimentation is progressing quickly. Second, this industry differs significantly in terms of supply chain configuration, product attributes, and business process characteristics, as well as in the regulatory frameworks and market conditions in which it operates. Thirdly, because there are so many social and environmental problems, sustainable development is one of the most challenging sectors. Production, shipping, and logistics are essential for managing material flows across intricate and international supply chains. They are also highly fragmented and globalized and must adhere to several rules, business procedures, and management requirements.

V.DISCUSSION

A recent investigation into the potential impact of blockchain technology on supply chain practices and policies identified the primary drivers of blockchain deployment within supply chains and the areas in which this emerging technology may offer the most outstanding value for supply chain management. A noteworthy finding regarding blockchain endeavors is that most technology companies utilize permissioned blockchain solutions. This is not surprising considering how sensitive supply chain information is—it is not a good idea to divulge confidential information to unidentified parties at any stage of the supply chain, including demand, capacities, orders, and prices. Additionally, permissioned blockchains are better at maintaining the consistency and integrity of data appended to the blockchain—a crucial feature for making decisions. In a blockchain-based supply chain network, there usually is a network orchestrator— possibly one of the funding members—who helps the various stakeholders coordinate and work together. This orchestrator is essential to the creation, appropriation, and distribution of value among network participants in the future. Specific consortia aim for more than just socioeconomic benefits. The blockchain facilitates transactions between various supply chain participants without needing an intermediary. As a result, it appears to work best when a problem affects several parties and solving it will benefit each of them. Participated members are motivated to collaborate and encouraged by this shared value [18].

Sustainable solutions are desperately needed in many industries, but the textile sector is one of the most urgent. Increasing traceability and transparency is a necessary first step towards implementing sustainable solutions, and blockchain technology can help with this. Through proactive system design, blockchain can improve traceability, sustainability, and transparency, allowing all parties involved in the supply chain to assess the effects of their actions over their entire life cycle and make more intelligent, strategic procurement decisions that are proactive rather than reactive. Concurrently, barriers for secondary markets are being lowered, and consumers can embrace better consumption, maintenance, and disposal practices by using blockchain technology. It makes it possible for the sector to more effectively and expeditiously comply with current and upcoming regulations. The textile sector requires a proactive approach to handle present and upcoming regulatory obligations.

Early adoption of blockchain technology by textile retailers will make them more resilient to disruptions in the industry, allowing them to track their entire supply chain and guarantee compliance at all levels. Policy makers will pressure organizations to address data security and traceability; those that do not act quickly to implement solutions risk noncompliance or expulsion from the market. Additionally, customers will want assurance that their clothing is made in more environmentally and socially friendly ways, and they might not be willing to pay for items that do not meet higher standards in the future due to the increased information transparency and credibility afforded by blockchain. Therefore, implementing traceability solutions immediately is in everyone's best interest. Blockchain is the most outstanding technology for safely tracking and managing every variable in this intricate supply chain. Governments can proactively mitigate environmental risks when foreign practices contradict domestic policies [19].

Overproduction can be decreased by using blockchain technology. There is a bullwhip effect because the fast-fashion supply chain is linear (design-manufacturing-sale-disposal). Due to the linear structure, information about end-customer demand must be distorted (primarily amplified for buffer consideration) when going upstream to suppliers, as only two adjacent nodes have the proximity to share information in part. As a result, the linear system produces significant waste due to transit inventory and overproduction. To lessen the bullwhip effect, a conventional approach has been to look for centralized information on consumer demand; however, this necessitates open communication among supply chain participants. However, this is challenging in a system beset by "lacks," such as a lack of mutual trust, a lack of a common goal among supply chain participants, and incomplete information sharing in multi-tier supply chains. In addition to that, supplier management and supplier selection using blockchain technology can help address the challenge of environmental and social responsibility. One of the most crucial choices in the pre-production phase for attaining sustainable supply chain management (SCM) is the assessment and choice of sustainable suppliers. Fast fashion companies must locate dependable and trustworthy suppliers, particularly those with sustainability certifications, as many of their production activities have been outsourced to low-wage nations. In the past, fashion outsourcing companies have independently developed a multi-criteria selection process that may or may not take social and environmental sustainability into account. The recycle/reuse/reduce option is the most critical factor in environmental protection when choosing and evaluating suppliers. In the meantime, child/forced labor, health and

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safety, freedom of association, discrimination, disciplinary procedures, working hours, compensation, and management systems are all covered by the Social Accountability 8000 (SA8000) standard certification (Social Accountability International, 2014). To receive certification, suppliers must fulfill all of these prerequisites (Witkowska, 2016). As a result, evaluating and selecting suppliers is intricate and time-consuming, involving numerous actors, procedures, and pieces of data.

Blockchain technology may offer a more advantageous choice when assessing and choosing the best suppliers. Before a prospective supplier is allowed to access the blockchain, it must be validated. Blockchains can be programmed to automatically trigger actions (including supplier certification) once specific conditions are met, and they can accelerate the flow of data between nodes due to the inherent characteristics of automation. As a result, all blockchain nodes can quickly conduct, record, and access the verification. Consequently, a blockchain-driven supplier selection procedure will be simpler, faster, and more reliable to ensure a successful launch of CSCM during the pre-production phase. Blockchains can precisely record, trace, and monitor peer-to-peer asset transactions. As a result, the blockchain record and traceability system can assist in promoting the three pillars of sustainability by tracking and monitoring environmental and social responsibilities in real-time.

In addition to auditing manufacturing from biological sources and technical fibers derived from non-renewable chemical resources, it can, for instance, audit the quality and safety of using chemicals, water, and land during the fashion production. Gathering information about the light, humidity, temperature, and working hours at the workplace can also determine the status of the workforce and the working conditions. These data can be used to analyze, assess/reassess, and certify/recertify whether the suppliers have complied with the obligations and moral standards to treat their workers fairly during manufacturing. Many fast-fashion items are currently regarded as waste and thrown away in the post-production phase, even though they are still in reusable condition, after being worn a few times or never even being sold. Blockchain technology can make recycling and reusing these fashion items easier in the right contexts. The production and usage history of items can be easily tracked and authenticated since the blockchain has verified and recorded information about the fashion product (such as brand, model, manufacturer, components, processing technology, purchasing date) and even the consumer. These used goods can be given away, rented out, or sold again after being cleaned and sanitized to increase their useful life. Depending on where the clothes are reused, buying 100 secondhand clothes could prevent the production of 60–85 new ones. This shows how blockchain technology applications can benefit CSCM in the fashion industry. Furthermore, materials from products acknowledged to be nearing the end of their useful lives can be recycled into new products via blockchain verification and authentication. For instance, post-consumer textile waste can be used to create purses, hang tags made of polyester, and bow ties. Particle boards, decorative bowls and vases, and other sustainable composites can be made from the blended fabrics. As a result, blockchain technology can reduce the quantity of textile waste dumped in landfills and save resources needed to create products and production lines [12].

While taking the example of Lenzing (which produces wood-based viscose fibers, modal fibers, lyocell fibers, and filament yarn, which are used in the textile industry — in clothing, home textiles, and technical textiles — as well as in the nonwovens industry), it fights counterfeiting. Utilizing the blockchain solution guarantees the authenticity of their sustainable fibers in the finished clothing. Lenzing's downstream complex supply chain has made identifying and tracking fiber easier through blockchain technology and embedded tracers. In addition, the blockchain-based platform facilitates safe information exchange between the geographically separated supply chain partners. It offers a single data source from which participants can obtain, exchange, and verify their sustainability certifications and supply chain data. Lenzing can ensure its sustainable fibers are used sustainably by exchanging certifications and sustainability-related data. This also holds significance for retailers and end brands, as they can utilize the blockchain platform to ascertain the sustainability credentials of every supplier within their network. To guarantee the authenticity of the traceability data and to confirm the connection between the real and virtual worlds, it is still essential to employ a third-party auditing company to validate the data collected on the blockchain platform throughout the supply chain. We contend that future strategies and standards to enable supply chain traceability through blockchain technology will heavily incorporate external audits [13].

Moreover, it is demonstrated that behavioral intentions and purchase behavior are significantly correlated. In addition, the intention to purchase an online product is predicted substantially by attitude, perceived usefulness, and ease of use. The most crucial role of technology is to foster a positive attitude toward its adoption. Marketers should promote this attitude through deep product knowledge, a strong brand image, and enhanced customer communication. Marketers ought to inform customers about blockchain technology's positive effects on the environment and how it can improve both their own and future generations' lives. Generations to tackle the COVID-19 issues. Research verified that perceived utility and perceived usability play a significant role in influencing behavioral intentions to use blockchain-enabled online ordering systems, consistent with earlier theories of TAM. Additionally, the results validate the perspective that consumers value blockchain's use in an online system for product purchases. Creating new styles and adapting to the rapidly shifting needs of customers are not the only two challenges COVID-19 has brought about for the world's apparel industry.

"Counterfeiting" is a significant issue undermining the luxury clothing and fashion sectors. The most prominent players in the market invest millions of dollars in starting a

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new trend. Still, when it comes to making money, dishonest manufacturers and traders enter the fray and steal a significant portion of the earnings by providing low-cost replicas of clothing and accessories. While there are several ways to stop someone from leaving a store with stolen clothing, counterfeiting is another animal. The underlying data, which shows that counterfeit goods cost the clothing and fashion industries more than $1000 billion annually, illustrates the seriousness of the situation. The alarming aspect is that counterfeiting has worsened, even with stringent government laws. Imagine how simple it would be to trace clothing from the material used to make it to when it was purchased online or in a store. For consumers, what would that mean? Using smartphones, consumers can verify the legitimacy of a product before purchasing by scanning the barcode on a shirt, pair of pants, or another item. Transparency and traceability will result from having access to information about where it was made, which raw material was used, and other details. Customers will confidently choose the product they want to purchase on their own.

Because a blockchain will allow brands to hold and control the data they provide to their employees and the outside world while adhering to necessary ethical standards, there will be no room for copying and creating duplicate goods. After COVID-19, using blockchain will improve customer relations and increase revenues. Additionally, thanks to this, customers can comprehend the intricacy of bringing a product to market. This may change the way they view purchasing comparable but less expensive goods. Rather than restricting themselves to disposable items and concentrating solely on cost-cutting measures, the apparel and fashion industry can now emphasize quality and sustainability without compromising margins and revenues, thanks to increased buying and sales figures [14].

V. CONCLUSION

The discourse on the ready-made garment (RMG) sector in Bangladesh and its intersection with supply chain management and blockchain technology is a comprehensive exploration of the challenges and opportunities faced by this vital sector. The RMG industry, a cornerstone of Bangladesh's economy, has witnessed significant growth, primarily fueled by the country's low labor costs. It faces challenges such as inadequate responsiveness to changing consumer demands, extended lead times compared to global competitors, and price, quality, and customer service issues. Effective supply chain management (SCM) is an essential strategic imperative for the RMG sector.

There is an urgent need for sustainable solutions in the textile industry and blockchain to be positioned as a catalyst for traceability, transparency, and environmentally conscious practices. The paper forecasts the potential for blockchain to mitigate overproduction through decentralized and transparent systems and its role in supplier management, selection, and addressing environmental and social responsibilities.

Blockchain technology has the potential to integrate with the infrastructure of the textile RMG supply chain and disrupt the industry for the betterment. Blockchain's decentralized architecture, cryptographic security, and immutable distributed ledger position it as a disruptive force capable of addressing critical issues such as counterfeiting, traceability, and transparency within the textile and apparel supply chain. Blockchain integration is presented to align consumer values with sustainable and ethical practices, fostering a more transparent and accountable industry.

We envision blockchain technology as a game-changer for the apparel industry, offering operational efficiencies and a paradigm shift towards sustainable and ethical practices. The adoption of blockchain is portrayed as a strategic move to meet evolving consumer expectations, navigate regulatory obligations, and ultimately enhance the resilience and competitiveness of the RMG sector in Bangladesh and the broader global fashion industry.

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Application of Blockchain in Ready-Made Garments Supply Chain: A Conceptual Model

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Abstract - **The global apparel industry is highly competitive, demanding innovation and cost-effective production models. Bangladesh, a leading textile exporter, struggles with long lead times (90–100 days) compared to rivals like China and Pakistan. Relying only on cheap labor makes it difficult to sustain market leadership, especially as Cambodia and Vietnam rise. The COVID-19 crisis accelerated blockchain adoption worldwide, particularly in apparel, where it enhances transparency, authentication, and efficiency, strengthening brand image and profits. Blockchain, introduced by Satoshi Nakamoto, offers secure, decentralized data sharing, preventing breaches and fostering trust. For Bangladesh, integrating blockchain into the RMG supply chain could reduce costs, improve stakeholder collaboration, and ensure competitiveness. Research highlights that traditional supply chains depend heavily on labor and contractors, but blockchain's distributed ledger can streamline information flow among stakeholders. To maintain dominance in the digitized 21st century, Bangladesh must embrace blockchain, ensuring sustainability, customer satisfaction, and global relevance.**

Keywords- **Blockchain, Supply chain, Ready-Made Garments, RMG**

I. INTRODUCTION

The apparel and textile industries fundamentally influence the global economy and society. Access to markets, capital, skilled labor, and natural resources is insufficient for any apparel company seeking a competitive edge in a global economy. Furthermore, to meet the ever-changing needs of its clientele, the global textile manufacturing industry must adopt cost-effective production techniques as part of a "Gandhian Engineering" based economy. In this sense, the future of the worldwide apparel manufacturing industry is presently being shaped by a significant globalization effect. Like any transformation effect, there are many growth opportunities, but there are also many challenges. Since apparel manufacturing companies are not individually self-sufficient, this globalization and competitive environment direct business activities through supply chain networks, or more recently, collaborative networks of business partners. To fulfill the business partners' overall goals and strategic objectives, clothing manufacturing companies that comprise these operational chains or networks must be integrated and coordinate their business processes to become more efficient. All things considered, research and operational process automation greatly enhance the design of the supply chain network for the apparel manufacturing industry and improve its performance [2].

The textile and apparel (T&A) supply chain is an intricate web of suppliers and partners at every stage of production, as well as a variety of materials and complicated procedures. T&A products have a short shelf life with multiple styles and collections every season because of trend-based consumerism and changing and varied consumer choices. The first link in a traditional T&A supply chain is a fiber producer, either a natural fiber or an industry that produces chemical fibers derived from petroleum. The yarn-manufacturing units then spin these fibers into yarn, which is turned into fabric through nonwoven, knitted, or weaving techniques. These fabrics are then sent to factories that make clothing, sewn into clothes, accessories, or furniture. Subcontractors and sub suppliers that offer trimmings and value-added items (such as buttons, threads, chemical treatment, embroidery, etc.) are also a part of the supply chain.

In the T&A supply chain, fashion brands—typically retailers—are the focal firms. Based on several variables, such as low-cost production location, suppliers' track record, and consumer market, they drive the supply chain configuration by buying finished textile products from upstream suppliers and selling them to end consumers. Due mainly to globalization, the manufacturing of T&A has been offshored and outsourced to regions with more lenient labor laws, lower labor costs, and greater supply availability. This has reduced risk by eliminating the need to own manufacturing facilities and increasing supply chain flexibility. As a result, the supply chain comprises a dispersed manufacturing network with numerous intricate processes within each. However, effective information sharing has become essential due to the institutional and geographic distances between various partners, and insufficient information sharing impedes the T&A supply chain's ability to operate flexibly and synchronously [10].
Bangladesh is one of the top exporting nations for apparel and RMG in the global market. Beginning in Bangladesh in the late 1970s, this sector grew notably in the 1980s and experienced a boom in the 1990s. Using simpler technology, inexpensive labor, and simple-to-use sewing machines allowed the industry's rapid expansion. Look at the charts below, which show the export of RMG relative to Bangladesh's overall exports. Supply chain management systems shorten order cycle times, lower operating costs, boost asset productivity, and improve a company's ability to respond to the market. Aside from these advantages, effective supply chain management techniques allow the

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apparel industry to react quickly. "Quick response" refers to the cooperation and information exchange between distributors, suppliers, and manufacturers, enabling them to react to consumer needs more quickly [1].

One of the main problems facing the Bangladeshi ready-made clothing industry is order time management. Foreign buyers probably require a short lead time for clothing manufacturers. Because there is a seasonal demand for apparel. In response to requests from customers, buyers place orders. If the production is delayed, the buyer cannot catch up with the season. The lead time was 120–150 days at the start of the 1990s, but it was cut to 30–50 days in 2007, so it is currently 90–100 days. China only needs thirty days because of its facilities for textiles and other backward linkages and its export-friendly management and supportive policies. In Pakistan and India, it lasts 45–60 days (Nuruzzaman, 2008). Because of the unusually long lead time, it appears that the Bangladesh RMG industry will not be able to compete successfully in the global market under the current circumstances. This is the primary area of concern for current research [3].

Due to its potential to streamline business procedures, blockchain technology (BT) has recently gained more attention and generated excitement across various industries, including the textile and fashion sectors. A "blockchain," as the name implies, is essentially a decentralized database that stores data safely and encrypted in a distributed public ledger. It is made up of previously verified "blocks" of transactions. In an environment where security is not guaranteed, the practice of encoding data to prevent unauthorized access is known as cryptography. BT uses cryptography to safeguard the system's integrity by employing sophisticated cryptographic algorithms. All transactions are digitally signed and encrypted to ensure that no part of a transaction can be changed without the approval of other users in the blockchain. A chain of blocks is formed by adding blocks that, via a cryptographic signature, refer to the previous block.

This makes smart contracts or transactions unchangeable by guaranteeing their reliability. Blockchain technology is dependable because of its characteristics, which include the dispersion of data storage among several nodes and the application of consensus algorithms, which offer immutability and transparency and do away with the need for a central authority. Blockchain provides a safe and effective means of conducting international payments, improving capital markets, streamlining trade finance, enabling safe peer-to-peer transactions, and thwarting money laundering in the banking and finance industries. Researchers have noted the potential for blockchain applications in the supply chain of several industries, including fashion and textiles. Fashion brands that can adjust to growing complexity by updating their operational models and changing their digital marketing, supply chain, and sales channel strategies will be most equipped to survive in a market with this level of competition [4].

The benefits of blockchain technology for cryptocurrencies have increased its appeal, leading scholars to investigate and assess how it might be used in logistics and supply chain management. For instance, Walmart and IBM are well-known for their supply chain tracking projects utilizing blockchain technology. Every transaction and action in blockchain-based traceability systems is visible and can be tracked down and retrieved at any moment by numerous parties. One of the main applications of blockchain in T&A is tracking materials and products through different manufacturing stages, from initial raw material management to finished goods management. Blockchain promises that, in the case of a fashion product manufactured from eco-friendly materials, it will not require any additional certifications or inspections.

Once stored in the blockchain system, the data is permanent and accessible to the public. This becomes crucial because it becomes more challenging to hold fashion companies accountable for the conditions under which their clothing is made and their sustainability pledges when supply chains lack transparency. Concurrently, consumers and industry participants express a greater desire for more sustainably and ethically produced goods. A study by Morning Consult found that 64% of participants would purchase a garment if it could use new technology to support its claims about sustainability. Blockchain-SCM integration is an unexplored field with little research. It is essential to research blockchain operations while considering its applications and supply chain requirements because supply chains across various industries vary significantly in their features and functionalities (Umeh, 2016). To achieve this, we examine some case studies of blockchain applications in textile and apparel supply chains in the following section before moving on to the literature analysis [10].

II. LITERATURE REVIEW

Blockchain has become the new standard for technologically advanced business applications. Financial services, manufacturing, food, agriculture, pharmaceuticals, combating COVID-19, hotels, airlines, healthcare, government, and supply chain management are just a few industries using blockchain technology. Benefits of blockchain technology include traceability, visibility, authenticity, legitimacy, aggregation, automation, resiliency, accurate and prompt decisions, reduced costs, enhanced supply chain performance, and customer satisfaction [6].

Applications of blockchain technology have the potential to revolutionize how we currently use the apparel industry, as well as the hardware and software infrastructure that goes along with it. In contrast to the conventional legacy systems currently in the apparel industry, we contend that the underlying technology and the corresponding cryptocurrency with its decentralized architecture suggest a range of applications that can bring cost savings to the e-

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garments industry [5].

This technology can identify the various actors represented as network components in a company's production and distribution chain. The network tracks a product's journey from one actor to the next, making every transaction visible to the public. To comply with environmental and social sustainability regulations and showcase sustainable practices to their clientele, businesses must ensure that the manufacturing and distribution processes are traceable and transparent, and all parties involved are identified. Moreover, blockchain offers environmentally sustainable solutions for the fashion apparel manufacturing industry, including decentralization, transparency, automation, and immutability, lowering carbon emissions at every critical stage of clothing-making [6].

In 2009, Nakamoto first put forth the idea of BCT. He described this idea as a technology that develops data structures and encodes information transactions using Bitcoin and data mining techniques. A blockchain's data will be permanently saved online with extreme security and transparency. Some of the main features of BCT are decentralization, distrust, transparency, traceable and unforgeable transactions, anonymity, and credibility. Blockchain technology (BCT) can be utilized on various platforms: "Blockchain technology is not limited to capital markets and cryptocurrency."

In-depth training is also provided on smart contracts, privacy, and network security, among other platforms and applications. BCT can, first and foremost, facilitate information integration and sharing throughout the entire supply chain process. Consequently, there can be a seamless exchange of goods and materials. Furthermore, BCT provides better security for storing and handling data online. This quality can help to safeguard organizational intellectual property and stop the leakage of private information. Finally, more information about design, raw materials, and manufacturing processes can be swiftly accessed by all supply chain participants, but particularly by consumers. BCT can enhance integration and cooperation amongst supply chain participants by helping consumers comprehend the entire supply chain [7].

A distributed digital ledger is called a blockchain (Chen, 2018). Transactions are entered into the ledger in blocks. It is present in numerous copies dispersed throughout computers, called "nodes." Because every new block of transactions is connected to earlier blocks in a way that makes tampering nearly impossible, the ledger is secure. Because it is decentralized, it is not dependent on a single organization for storage, such as a bank. As new transactions are made, the ledger is updated and sent to the nodes connected to the blockchain network.

The "truth" about each transaction completed thus far in the blockchain can be found in the multiple copies of the ledger. To attempt a ledger fraud, one would need to time the falsification of the copies precisely. There is very little chance that this can be accomplished in blockchain networks of any practical size. Supply chains typically consist of procurement, production, storage, and distribution. It maintains relationships with suppliers, partners, subcontractors, and customers. Additionally, it is organized internally by department or function.

When operating in a silo, every department tracks goods and services using its own systems. This implies a decrease in transparency and an increase in friction. Supply chains can escape their silo mode with the aid of blockchain. Blockchain is a distributed, digital ledger that improves efficiency and transparency. Everyone may have access to the same transactional data. Subsequently, as software applications, smart contracts can be integrated with the blockchain. The smart contracts can take automatic action as events are recorded. The blockchain can help supply chain managers and their businesses in several ways, such as increased accountability and transparency among suppliers; almost instantaneous transactions using smart contracts; a tamper-proof ledger of manifests, departure and arrival times, and a general decrease in human error because of increased automation. The capacity to track and permanently record the flow of information and goods between participants in a supply chain is enhanced by blockchain technology, which substitutes a flexible, decentralized infrastructure for inflexible, centralized supply chain systems [8].

In addition, many additional intermediaries, traders, and logistics companies are engaged in the procurement, distribution, and transportation of textile and clothing goods throughout the primary value-adding operations and/or in the execution of processing tasks like fabric dyeing and finishing. While most product design and development occur in developed nations, many production activities, such as spinning, fabric manufacturing, cutting, sewing, and finishing, occur in developing nations. Leading clothing designers and manufacturers often take the lead in product development.

There are several ways to implement blockchain technology in supply chain configurations. Some well-known blockchain applications in the clothing and textile sector:

1. AURA Consortium: To spearhead and encourage industry-wide cooperation to investigate and implement blockchain technology for product traceability and authenticity, LVMH partnered with ConsenSys and Microsoft Azure to establish the AURA consortium. New members of the consortium include Prada and Cartier. AURA seeks to track products from the source of raw materials to the point of sale and demonstrate authenticity to consumers.
2. Arianee Consortium • The Arianee consortium is an industry-wide partnership that seeks to create guidelines for the blockchain-based Arianee protocol, which will be used to certify valuable assets digitally.
3. HUGO BOSS • The high-end apparel and fashion goods company Hugo Boss has partnered with ASTRATUM to

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create Tracey. This blockchain platform allows them to track products throughout their supply chain and guarantee their authenticity.

4. Chargeurs Luxury Materials is a top global provider of wool. To guarantee the quality of its fibers and facilitate traceability from the sheep to the retail customer, the company has created a label called Organica Precious Fibers using blockchain technology.
5. Martine Jarlgaard • A jumper Jarlgaard owned was the first clothing article to be tracked via blockchain technology. Through collaboration with Provenance and A Transparency, data regarding the product was tracked via a blockchain application as it moved through the supply chain.
6. C&A Foundation Bext360 is leading a blockchain pilot project to reach consumers eventually, which tracks organic cotton from the farm to the ginning stage. Blockchain was employed in the pilot as a safe data platform to integrate data along the supply chain.

The blockchain project's goal will determine how far product traceability in the supply chain can be extended. If the only goal is to guarantee the authenticity of the products, traceability can cover a range of upstream and downstream supply chain stages. For instance, the traceability system may begin at the garment manufacturing stage to authenticate an LVMH garment piece. However, suppose the goal is to guarantee that the garment is made of organic cotton. In that case, the scope of traceability may begin at the source of raw materials or the fiber producer. The upstream supply chain phases should be covered when the goal of traceability is to guarantee the sustainability of products. However, Supply chain traceability may be used in applications that seek to guarantee product authenticity and sustainability [9].

III. METHODOLOGY

The secondary data used in this study's analysis includes papers from conferences, journals, digital libraries, and other sources. Numerous academic and professional research papers on the textile industry have been compiled from various reputable international journals, including IJBER, IJSCM, JTSE, IJTS, JBMER, AJBMS, and others. The textile and apparel industries were chosen for this study based on several criteria. First off, the industry's blockchain technology experimentation is progressing quickly. Second, this industry differs significantly in supply chain configuration, product attributes, and business process characteristics, as well as in the regulatory frameworks and market conditions in which they function. Thirdly, because there are so many social and environmental problems, sustainable development is one of the most challenging sectors. Production, shipping, and logistics are important industries that manage material flows across intricate and international supply chains. They are also highly fragmented and globalized and must adhere to several rules, business procedures, and management requirements.

THEORETICAL MODEL

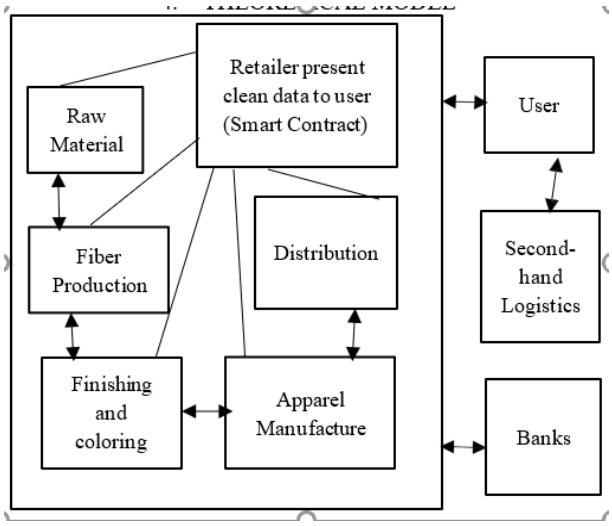


Figure 1: Textile retailer facilitating a blockchain ecosystem. Source: (Francisconi, 2017)

The following is how the transactions would happen in the event of a retail initiative and the presence of the necessary infrastructure: every stakeholder would be a distinct system user. When raw materials are converted into fibers, transactions are started by the fiber producer and verified by the yarn producer once received; yarn producers initiate another transaction to be confirmed by finishing and coloring agents; apparel manufacturers then start the unit-level authentication once they receive final fabrics. This process starts with a genesis transaction, which creates a hash value for future blocks to be built upon. The company harvesting and processing the raw materials initiates the transaction, and the recipient validates it. The clothing manufacturer imports the historical supply chain data by integrating a smart device into the garment, either the actual fabric or the garment label. Distributors use the blockchain network to record their activities as well. Customers can view provenance and impact data, which is verified by blockchain and curated by the retailer, by scanning a smart device embedded in the garment. When a user decides they no longer want a garment, data on the blockchain can help with responsible disposal by connecting the item with a buyer interested in used clothing. Because the blockchain transaction system deviates from centralized networks, which are prone to fraud and errors, its implications are revolutionary. Blockchain also changes the game by changing the script of traditional linear transactions from data push to data pull. Stakeholders can now pull verified, trustworthy, real-time information from the network instead of receiving data that may or may not be real. In contrast to traditional IT systems, blockchain systems can grant access to significant stakeholders not part of the direct network, like customers and banks, who depend on data being pushed out to them. Banks would be incorporated into the smart contract in a blockchain system to speed up clearings and other significant financial transactions. Clearing times are postponed, giving banks more time to verify transactions due to their growing concerns about fraud. This is an unneeded restriction in a blockchain system where transactions are validated automatically. An important departure from the status quo is that blockchain systems can give all stakeholders

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access to immutable, secure, authentic, verified, agile, and real-time data. Using digital components, second-hand logistics providers can automate clothing distribution to suitable second-hand markets, promoting a circular supply chain. Because of the financial benefits and the ability for all parties—from raw material producers to consumers—to fully understand the environmental and social implications of their decisions and utilize this knowledge as a springboard for investigating alternative procurement methods, such a system can support sustainable supply chain management [10].

IV. DISCUSSION

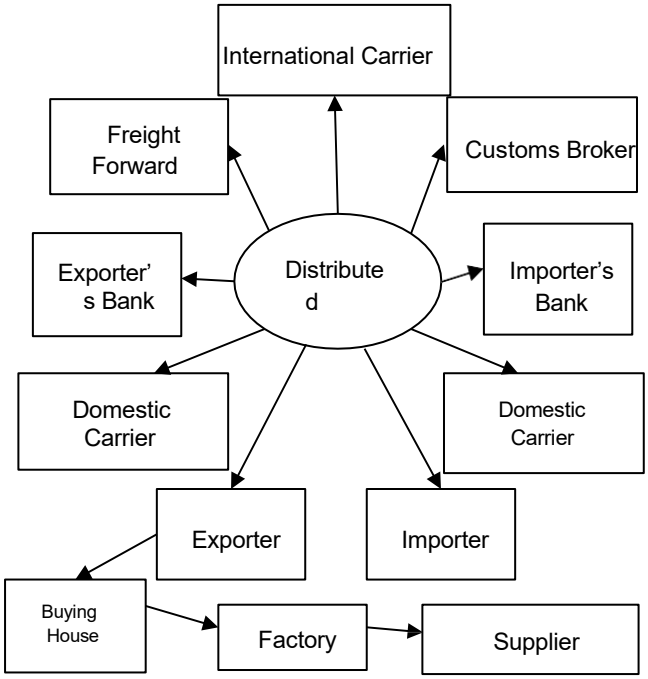


Figure 2: Proposed Model

Our proposed model is an application that will be controlled and updated centrally, known as the distributed ledger. The concerned parties, i.e., suppliers, manufacturers, retailers, consumers, logistic companies, banks, freight forwarders, etc., will have an ID and password to log in and check the shipment status. Moreover, they will also be able to update the information so that other members can check their dashboard, and all the concerned parties are updated via the distributed ledger. For example, a buying house brings an order from an American buyer and passes it on to the factory to manufacture the garment's product. Thus, the buying house will have a dashboard where the buyer will be able to see the update of the order; similarly, the factory will have a dashboard where the buying house will be able to see the update of the product. Each user will be separated by category so that the information does not overlap. The main aim of the model is to ensure transparency and accountability among the members. We believe such a ledger will help the industry stakeholders stay on the same page while sharing only the required information. This will lead to an efficient supply chain and will eventually lead to profit maximization.

IV. CONCLUSION

In conclusion, the global textile and apparel industries play a pivotal role in shaping the economic landscape, driven by the need for cost-effective production techniques and a responsive approach to changing consumer preferences. Globalization has led to complex supply chain networks, necessitating collaboration and integration among business partners to enhance efficiency. With its intricate web of suppliers and partners, the textile and apparel supply chain faces challenges such as short product shelf life and the demand for quick response to market trends. Bangladesh, a key player in the apparel and ready-made garment (RMG) export market, has experienced significant growth, propelled by factors like simple technology, inexpensive labor, and favorable policies. However, a significant concern for the Bangladesh RMG industry is order time management, with foreign buyers requiring shorter lead times. The industry's ability to compete globally is hindered by longer lead times than competitors in China, Pakistan, and India. Recognizing the need for innovation in supply chain management, the adoption of blockchain technology has gained attention. With its decentralized and transparent nature, blockchain offers a secure platform for tracking materials and products throughout the manufacturing stages. This technology addresses the challenges of accountability, sustainability, and transparency in the fashion industry. The potential applications of blockchain technology extend to enhancing traceability, visibility, authenticity, automation, and resiliency in supply chain management.

It highlights the diverse applications of blockchain technology across various industries, emphasizing its role in revolutionizing the apparel industry and associated hardware and software infrastructure. The benefits of blockchain include traceability, transparency, authenticity, reduced costs, enhanced supply chain performance, and improved customer satisfaction. Several case studies illustrate the implementation of blockchain in the textile and apparel supply chain, showcasing initiatives by major industry players like LVMH, HUGO BOSS, and Martine Jarlgaard. These initiatives aim to ensure traceability, authenticity, and sustainability throughout the supply chain, addressing the growing demand for ethically and sustainably produced goods. The integration of blockchain technology in the textile and apparel supply chain holds immense potential for addressing industry challenges, promoting sustainability, and meeting the evolving demands of consumers. As the industry embraces technological advancements, blockchain emerges as a transformative tool that can reshape global textile and apparel manufacturing dynamics.

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Evaluating Undergraduate Students' Employment Preferences: A Comparative Analysis of Salary, Work-Life Balance, and Organizational Sustainability

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Abstract- **Bangladeshi undergraduates' employment priorities have shifted markedly between 2010 and 2023. Using longitudinal survey data from over 75,000 final-year students at top universities, this study tracks trends in preferences for salary, work–life balance, and organizational sustainability. Descriptive statistics, time-series charts, and correlational/regression analyses are used to reveal these shifts. Results indicate a pronounced decline in the importance of salary and a dramatic rise in the emphasis on work–life balance, while interest in ethical or environmental factors remains minimal. Specifically, the share of students ranking salary as their top criterion fell from roughly 79% in 2010 to 33% in 2023, whereas the proportion prioritizing flexibility and life balance grew from about 12% to 58%. In contrast, preferences related to organizational sustainability hovered at only about 9–10% throughout this period. These trends align with motivation–hygiene theory and Maslow's hierarchy of needs, indicating that graduates are moving from extrinsic rewards toward intrinsic values and well-being. Correlation analysis uncovers an "ambition paradox": higher unemployment rates correlate strongly ($r \approx .90$) with factors such as intensive internship participation, high salary expectations, and desire for foreign jobs. Regression results show that moderate salary targets and clear sector preferences (government vs. private) predict lower unemployment risk, whereas internships alone did not guarantee employment. This implies that overly ambitious expectations may delay graduates' entry into the job market. Collectively, these findings suggest that contemporary Bangladeshi graduates now value work–life quality and purposeful employment more than before. This calls for universities, employers, and policymakers to adapt by integrating flexible work practices, mental-health support, and sustainability education into academic and workplace programs. Aligning training and recruitment with students' evolving values can help improve graduate employability and support Bangladesh's economic transition.**

Keywords- **Employment preferences, graduate expectations, higher education, job market trends, organizational sustainability, salary expectations, work-life balance, youth employment**

I.INTRODUCTION

The shift from university to the workplace has increasingly become intricate over the past decade due to new social norms, rapid technological advances, and global disruptors like the COVID pandemic. From a policy perspective, understanding the changing employability preferences of university graduates is important for strategic higher education planning, responsive labor markets, and policy frameworks. Youth employment and career choices incorporate economic factors alongside personal values, lifestyle goals, and perceptions of career longevity. With the increase in remote work, digital businesses, and ethical corporate branding, graduate students have begun prioritizing different factors when assessing prospective employers. Thus, employment opportunities for university students are no longer restricted to financial compensation alone. Contemporary graduates are increasingly influenced by work-life balance, ethics, organizational alignment, and personal growth. This has become more profound among Gen Z, who care less about traditional career yardsticks, and more about meaning, mobility, flexibility, and agile roles. Understanding this evolution helps reveal the alignment—or misalignment—between graduate aspirations and market trends.

Bangladesh exemplifies an interesting case for this transition. The future workforce of the country is disproportionately young, with a median population age of under 28 and currently over 4 million students enrolled in higher education. The competition that may still exist between these two sources of employment, the privately grown and government jobs is increasing as Bangladesh is constantly moving towards the mid-income states. Meanwhile, students receive more access to both social media, freelancing and digital nomadism. Such growth opens their eyes to a new perspective, where they could possibly start working in a foreign country or contribute to the culture of startups. Nevertheless, as the problem of graduate unemployment continues to be big, there is still a strong disconnect between the educational background needed and what is expected in the workplace.

The given research revolves around the main concern of graduates and those aspects that determine their choice of

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workplace: remuneration, work-life balance, and company sustainability. Although, pay is still extremely important, there is a drastic change to time freedom, psychological comfort, and morally upright employers. These aspects are consistent with the motivation-hygiene theory developed by Herzberg and these theories experience a distinction between extrinsic and intrinsic motivation that refer to salary and work-life balance and meaningful work respectively [1]. On the contrary, the impacts of sustainability to the decisions that are made by the graduates in Bangladesh are unknown. Such dimensions are addressed in international studies on employment preferences of graduates [2], yet little is known about what impact they have in Bangladesh.

To study the employment preferences changes in the undergraduate students in Bangladesh between 2010 to 2023, this paper relies on over 10-year of data. The focus of the research will be specifically on answering the following questions:

1. To what extent have students' priorities evolved regarding salary, work-life balance, and sustainability?
2. What are the contemporary trends regarding sector preference (government, private, startup)?
3. What determinants are linked to the inactivity of employment among graduates?

II. OBJECTIVES

The study aims to:

1. longitudinal shifts in employment Examine priorities among Bangladeshi undergraduates from 2010 to 2023, specifically regarding the relative valuation of salary, work-life balance, and sustainability considerations.

2.Survey the contemporary sectoral inclinations of final-year undergraduates, distinguishing between government, private enterprise, startup, and international employment trajectories.

3.Elucidate the statistical associations linking graduate unemployment to variables including internship engagement, anticipated starting salary, and aspirations for international career placements.

III. LITERATURE REVIEW

Recent global research indicates a sharp global shift in what young graduates desire from their careers. In contrast to earlier generations, who placed a premium on the virtues of stable yet high-paying jobs, the members of Generation Z now seem to largely favor purpose-driven, flexible careers that align with their personal values. Studies conducted in Western economies like the U.S. and U.K. have shown that young employees are gravitating toward roles that afford them not only freedom but also digital privacy and social purpose—minus, perhaps, the sizeable checks one might expect from such roles [3]. This emerging trend seems to be gaining traction in Asia as well, especially in the fast-growing economies of India and Vietnam. A 2022 report from KPMG noted that students in India now seem far more interested in taking hybrid jobs that offer them a shot at creative expression and more personal time [5]. This is a clear departure from seeking traditional jobs within corporate hierarchies.

Yet, in developing countries, the picture is more complex. Although many students still primarily want high-paying jobs because of their pressing economic needs, globalization, digital media, and exposure to foreign academic contexts are impacting their aspirations. For one thing, according to the International Labor Organization (2022), even young jobseekers in low- and middle-income nations are increasingly considering factors like job satisfaction and remote work opportunities when making employment decisions [6]. Then, too, as the World Bank (2021) observes, our nascent and recent digital economies are giving rise to more freelancing, entrepreneurial, and otherwise self-directed careers [7].

This transition is gradually happening in Bangladesh. A study that the British Council conducted in 2019 regarding the youth of Bangladesh found that there was an increasing interest among them in pursuing jobs that would afford them global mobility, personal growth, and a decent work-life balance [8]. Yet this same study also flagged a major mismatch between the expectations of graduates and the actual job offerings available to them. The traditional, student-preferred, government-job, ecosystem is now countered by a rise in enthusiasm for startup ecosystems and international careers that are hard to find, and harder still to get, in an outmoded labor market. Meanwhile, the university curricula that might prepare students for those ecosystem jobs remain stuck in the past.

This study revolves around three central themes—salary, work-life balance, and sustainability. Salaries have been the historically prioritized factor, taking the lead, especially in countries where economic stability and security are uncertain. According to Maslow's Hierarchy of Needs (1943), financial compensation gets to the most fundamental level of human motivation—the need for safety and survival [9]. But as we move along the staircase of human motivation, we see that salary is no longer glamorous and is no longer the motivating force it was at the basic level.

The balance between work and life, once viewed as a luxury, has become a necessity for many young professionals. Hofstede Insights (2020) contends that shifts in society and technological advancements have made time flexibility a more important aspect of job satisfaction than ever before [10]. Meanwhile, Clark (2001) considers the

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importance of pay to be as antiquated as it is when making a comparison with the importance of balance and very good mental health [11]. The reason, of course, is that well-being is now an aspect of job offers that young adults take very seriously. Sustainability, while increasingly critical in global hiring narratives, remains a less dominant factor in the Global South. Western studies have long shown that jobseekers are drawn to companies with strong ethical and environmental credentials [12]. But in Bangladesh, the integration of sustainability into employment decisions is still under-researched and appears underdeveloped. This gap is not just academic—it poses challenges for local firms trying to align with global ESG (Environmental, Social, and Governance) expectations. The lack of awareness of sustainability issues among new graduates will pose challenges to meeting the ethical expectations of global industry leaders.

To explore these evolving changes, this paper draws upon three fundamental work psychology theories. Both Maslow's theory and Herzberg's Two-Factor Theory (1959) offer relevant insights. While Herzberg's theory draws a distinction between hygiene factors (salary, job security) and motivators (advancement, recognition, and purpose), Maslow's Theory of Needs elucidates the hierarchy of needs, placing abstract goals like balance and fulfillment above basic needs.

The Youth Employment Trends of Bangladesh research has been concentrated around micro scale surveys. There is a significant gap in research that analyzes student preferences in a long-term framework across various university types and geographic areas. In addition, limited research has investigated work-life balance, salary, and sustainability as separate, yet interconnected factors of a career choice. This paper fills that void with a meticulous study of a longitudinal dataset that exceeds ten years in scope, with the intention of analyzing students' shifting preferences and their implications for higher education, policymaking, and prospective employment opportunities.

IV. METHODOLOGY

To analyze the development of undergraduate employment preferences in Bangladesh, this paper adopts a longitudinal descriptive research design using a pure secondary data approach. Since the purpose is to trace development over time, secondary data is the most precise and cost-effective part of analyzing the macro-trends in the priorities of the youth across different institutions and disciplines. The sets of data are based on nationally representative surveys on an international scale by established scholarly, state, and international institutions, carried out during 2010–2023.

The fundamental source of information becomes the Undergraduate Employment Preferences in Bangladesh Dataset, which refers to the answers given by more than 75,000 final-year students at 15 top public and privately funded universities. Among these are the University of Dhaka, BRAC University, BUET, North South University, as well as regional universities, which gives equal consideration to student opinion in all aspects of disciplines, regions, as well as institutions. The stratified random sampling method was used to conduct the surveys such that they adequately represented gender, academic backgrounds, and urban-rural demographics. Further information was sourced from longitudinal studies conducted by the World Bank STEP Skills Measurement Program, ILO School-to-Work Transition Surveys, and the labor market surveys of the Bangladesh Bureau of Statistics (BBS), University Grants Commission (UGC), and British Council. All the sources added special insights. An example is that the Higher Education Quality Enhancement Project (HEQEP) undertook tracer studies that reported the plans of the graduates in detail after graduating and their preferences in sectors. Studies conducted by the Bangladesh Association of Software and Information Services (BASIS) provided specific information on tech labor and entrepreneurship, whereas British Council reports investigated global mobility and cross-cultural desires [8]. With the data compiled on the background of multiple sources, the research develops a solid multidimensional vision of the changes in employment values during 13 years.

In order to guarantee the auditability of results over the years, a package of standardized variables is considered: salary expectations, work-life balance preference, and interest in organizational sustainability. Salary preference is the tendency to rank a high salary as one of the most important career criteria by the students. Work-life balance was measured by given responses of interest in flexible scheduling, mental health support, or personal time. Sustainability involved ethical work, CSR activities, and environmental awareness. Other variables included sector of choice (government, private, NGO, startup), expected first-month salary, willingness to work in a foreign country, entrepreneurial interest, and internships, which were also coded uniformly across data. Such definitions are correlated with the OECD and ILO frameworks to be internationally compatible and rigorous.

The analysis of the data was done in three steps. Initially, frequency (percentages) was involved in the descriptive statistics in capturing changes in employment values over the time periods, namely 2010, 2015, 2020, and 2023. It assisted in determining the main turning points, e.g., what preferences toward government jobs may change after COVID or what the boom in interest in entrepreneurship is. Second, time-series charts were performed to show the long-term trends through trend analyses of the 13-year data. When possible, percent change was found to determine how much increase or decrease of preference of students was. Lastly, correlational analysis, which majorly involved the use of the Pearson correlation coefficient, was employed in determining the strength of the relationships between key variables. As an example, the study asked whether the experience gained in internships was associated with greater

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employability, or whether students with international expectations were more inclined to appreciate sustainability.

Although the multi-year data is quite in-depth, there are still a couple of limitations. The year of the COVID-19 (2020–2021) reflected more urban institutions that had better digital infrastructures, and this could have created an underreporting effect against the voice of the rural population. Moreover, surveys overall failed to reflect the interest of informal sectors, e.g., freelancing or gig work, which have become increasingly important during the past five years. Changes in survey statements and response formats between years were also causes of variation that needed normalization, and this has been done by ensuring careful harmonization and recoding of variables.

Nevertheless, there are unique advantages of the secondary data approach notwithstanding these limitations. It allows determining generational tendencies and macro-level changes that could hardly have been determined with a single-time survey or through a fieldwork study of a small sample. It also gives ultimate external validity in that the data will be the representation of answers from a very broad range of institutions and geographic areas. Most importantly, this methodology allows researchers and practitioners to correspond student employment preferences to the wider policy discussions on graduate preparedness, university-employer collaboration, and youth employment options.

Through a longitudinal, data-based study based on validated survey tools, the study provides a stable platform through which the changing priorities of graduates can be interpreted and how better universities, governments, and interested employers can react to enhance responsiveness.

V. RESULTS

A. Descriptive Statistics

To examine the evolution of undergraduate employment preferences in Bangladesh from 2010 to 2023, descriptive statistics were used to report central tendencies (mean), variation (standard deviation), and range (min–max) for three key career priorities: salary, work-life balance, and organizational sustainability.

Variable	Mean (%)	Std. Dev.	Min	Max
Prioritize Salary	56.44	15.69	32.7	78.5
Prioritize Work-Life Balance	34.11	15.66	12.3	58.3
Prioritize Sustainability	9.45	0.34	9.0	10.1

Predictor Variable	β (Std.)	t	p-value
Expected Starting Salary	-3.022	-10.389	< .001
Govt. Job Preference (%)	-4.659	-9.566	< .001
Internship Participation (%)	+3.368	+5.335	< .001
Private Sector Preference (%)	-4.200	-12.670	< .001

These figures demonstrate a significant referral change in the work ethic attitudes. In particular, the supremacy of salary to be ranked first has been worn out, and the importance of having work-life balance has increased dramatically. On the contrary, sustainability was not of great importance at any one time and showed very little difference over the years. These findings can be used to establish some tendencies of graduate career thinking and change of levels of values.

B. Correlation Analysis

To explore factors associated with graduate unemployment, Pearson correlation coefficients were calculated among four key variables: unemployment rate, internship participation, abroad job intention, and expected starting salary. This analysis assesses the strength and direction of linear relationships between these continuous variables.

Table 1: Pearson Correlation Matrix – Factors Influencing Graduate Unemployment (N = 14)

Variables	1	2	3	4
1. Unemployment Rate (%)	1	.901**	.900**	.892**
2. Internship Participation (%)	.901**	1	.909**	.983**
3. Abroad Job Intention (%)	.900**	.909**	1	.963**
4. Expected Starting Salary (BDT)	.892**	.983**	.963**	1

Note: $p < .001$ (2-tailed) for all correlations.

All correlations were statistically significant at the 0.01 level, indicating strong positive associations between unemployment and each predictor. Specifically:

1. Internship participation and unemployment: $r = 0.901$, $p < .001$
2. Abroad job intention and unemployment: $r = 0.900$, $p < .001$
3. Expected salary and unemployment: $r = 0.892$, $p < .001$

This evidence implies that an increased rate of participation in an internship, international ambition and salary expectations are linked with high unemployment rates of graduates. In this case such a difference in graduate

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expectations and local labor market conditions may have contributed to underemployment or delay of joining the job market.

C. Regression Analysis

To further assess causal relationships, a multiple linear regression model was estimated with graduate unemployment rate (%) as the dependent variable. Independent variables included expected starting salary, government job preference, private sector preference, and internship participation.

Table 2: Regression Summary Table

All predictors were statistically significant at $p < .001$, confirming their strong association with graduate unemployment.

A more detailed model is shown below:

Variable	B (Unstd.)	Std. Error	β (Std.)	*t*	*p*
(Constant)	222.095	22.681	—	9.792	< .001
Expected Starting Salary	-0.001	0.000	-3.02	-10.3	< .001
Govt. Job Preference (%)	-2.486	0.260	-4.65	-9.56	< .001
Internship Participation (%)	1.573	0.295	3.368	5.335	< .001
Private Sector Preference (%)	-2.660	0.210	-4.20	-12.6	< .001

Interpretation:

1.The negative signs of the coefficients of expected salary, government job preference and preference towards the private sector mean that the greater the expectation level and job sector preference, the lesser is the rate of unemployment. It can be implied that those who have moderate expectations regarding their pay and have specific job interests will have a greater chance of succeeding in getting hired.

2.On the other hand, the positive coefficient of the internship participation (B = 1.573) is surprising and could be an indicator of the structural problems in the quality of internship and the subsequent employment ways. This may also indicate that the interned students might not ease easily into full-time jobs probably because of poor industry connection or poor placement.

The standardized beta values highlight the strongest predictors, with private sector preference (β = -4.200) and government job preference (β = -4.659) showing the most pronounced effects in reducing unemployment. Overall, regression model shows that clear job goals and realistic salary expectations are protective factors of unemployment, whereas it is not sufficient to participate in the internship to be employable, and this necessitates more effective systems of workplace learning and placement.

D. Graph Analysis

Figure 1. Trends in top employment preferences among Bangladeshi undergraduate students (2010–2023).

The graph displays the evolution of employment preference priorities among Bangladeshi final-year undergraduate students over the 13-year period from 2010 to 2023. It compares three priority types:

I.Prioritize Salary (Blue Line)

II.Prioritize Work-Life Balance (Red Line)

III.Prioritize Organizational Sustainability (Purple Line)

The Y-axis shows the mean percentage of students ranking each priority as their most important career preference, and the X-axis represents the years from 2010 to 2023.

The difference between employment preferences made by final-year undergraduates in 2010 and 2023 demonstrates that there is a drastic generational change in the values of career. The aspect of salary, which was the most influential impetus, has dropped drastically over the past, falling by 58% to 33% in 2023, suggesting that people are no longer driven purely by financial gains. On the contrary, work-life-balance preference boomed to an unprecedented 58% (up 374%). It parallels the increasing significance of flexibility, workplace-related mental health, and self-determination, which has been accentuated by the COVID-19 pandemic and changing work culture. Meanwhile, organizational sustainability was nearly at the same degree, roughly 9-10%, implying that students have little awareness or are less concerned with ESG (Environmental, Social, and Governance) factors. Such stagnation represents a lack of a policy and education, such that sustainability is perceived as inapplicable to the local employability. Taken together, these trends signify a more general shift in extrinsic to intrinsic career motivation, as the quality of life has replaced income as an axis of focus, whereas sustainability still represents an overlooked concern in the career-related desires of Bangladeshi graduates.

V. DISCUSSION

This longitudinal analysis shows that there has been a paradigm shift in what Bangladeshi undergraduates value in employment between 2010 and 2023. The most significant of these is the decline in the relevance of salary as the primary employment concern, which is accompanied by the considerable increase in the value placed on work-life balance. It denotes a more general generational reordering of value assessments in career outcomes, shifting from extrinsic drivers of value, like financial reward, to more intrinsic drivers of value, like mental health, freedom, and quality of life. The findings align with the Motivation-Hygiene Theory, put forth by Herzberg in 1959, which posits that although hygiene factors such as salary prevent dissatisfaction, intrinsic factors that motivate satisfaction include recognition, growth, and work-life balance.

The observation that in a developing economy like Bangladesh, the focus placed on attaining work-life balance by graduates has surged by 374% over the span of 13 years,

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serves as evidence that global workplace trends such as remote work and flexible working hours have permeated the career aspirations of students in developing countries. Such change was particularly accelerated by the COVID-19 pandemic, which redefined norms regarding work time, mental health, and employer support systems. These findings contribute to the increased cultural viability of non-standard employment metrics and support international reports, including the Global Gen Z Survey released by Deloitte (2023), which identified balance and purpose as the top drivers of career choice among young people globally [4].

By comparison, organizational sustainability has remained a low priority, and student interest has not changed significantly over time. Although Western literature (Greening & Turban, 2000; Smith & Nguyen, 2020) emphasizes the growing weight of Environmental, Social, and Governance (ESG) considerations in career choices, this study shows that Bangladeshi graduates are not highly engaged with sustainability issues in the workplace. This disparity can be explained by the limited curricular emphasis on sustainability, insufficient employer communication regarding CSR initiatives, or the overriding importance of financial and job stability concerns in a developing economy. Sustainability as an employment factor is therefore an underdeveloped domain, and targeted educational and policy measures are needed to raise awareness and bridge this gap.

The correlation and regression analyses provide deeper insights into the complexities of graduate unemployment. Strong positive relationships among internship participation, desire to work abroad, expected salary levels, and unemployment rates indicate that excessive exposure to global prospects or high ambition levels may paradoxically correlate with increased difficulty in obtaining domestic employment. This discovery calls for deeper scrutiny. One possible explanation is that exceptionally ambitious graduates are increasingly reluctant to take on low-paying or entry-level positions, leading to prolonged periods of unemployment or underemployment. It is also possible that the internships offered in Bangladesh are not sufficiently designed to provide pathways to employment, suggesting that work-integrated learning, as well as the linkages between industry and academia, are not well conceived or strategically structured.

In addition, the regression analysis shows that realistic salary expectations and sectoral clarity (preference for either government or private sector) are protective factors against unemployment. This implies that graduates with realistic attitudes toward wages, who enter the labor market with specific sectoral interests, are more likely to find employment.

The positive correlation between participation in internships and unemployment rates casts doubt on the efficacy of internships as a bridge to employment. It suggests possible systemic inefficiencies in the translation of internships into full-time employment, and/or a disconnect between the reality of graduate internships and the expectations of graduates, which may cause dissatisfaction and delay their entry into the job market.

VII. CONCLUSION

This study presents strong arguments to the effect that there has been a tremendous shift in the employment patterns of Bangladeshi undergraduates since 2010 and 2023. The single most dramatic change is a loss in prominence of salary as prime job selection factor and a dramatic increase in place of work life balance in central issues. This development supports the Motivation Hygiene Theory as defined by Herzberg, which is the fact that graduates are more interested in intrinsic satisfiers, i.e., autonomy, mental well-being, and meaningful work instead of the traditional extrinsic awards. In contrast, organizational sustainability is an area that has been significantly underemphasized and shows a particularly significant disconnect between ESG discussions around the globe and local graduate demands.

Correlation and regression studies also help in clarification of the intricate relationship that surrounds graduate unemployment. Although sensible wage requirements and definite sectoral interests (government and non-public) only turn into protective variables against liability to unemployment, excessively high expectations, characterized by the desire to work abroad and attend internships, ironically is related to the long periods of unemployment. This so-called paradox of ambition brings about several systemic gaps in quality and conversion of internship experiences and requires the increase of industry academic collaborations that have been strategically designed. Collectively, these results have great implications on higher education institutions, employers, and policymakers. The universities ought to incorporate soft skill education development, learning at workplaces and sustainability literacy into their curricular to curtail the gap between the competencies of graduates and the trends of the market. Employers need to provide flexible working environments, psychological assistance, and clear social enterprise activities to appeal to the modern graduate ethics The policy makers must encourage employer university collaborations and make compulsory standards of internship programs to make them work as real employment avenues. Despite its strengths, which lies in the size and the national representativeness of a longitudinal data, this study has several limitations. It is based on self-reported survey data that might be prone to response biases and fails to identify preferences of the informal sector and the gig economy. In future studies, mixed method designs ought to be used to determine the qualitative foundations behind graduates in decision making, and their analyses should be increased to new forms of work like platform-based freelancing.

With the help of throwing light to the changing landscape of graduate priorities and their labor market implications, the present research establishes a framework through which evidence-based interventions can be achieved towards helping the graduates of Bangladesh to become more

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employable, to achieve sustainable organizational practices, and to help Bangladesh to become a more resilient and human centered economy.

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Impact of Liquidity Ratio and Dividend on Share Price: A Study of Food and Allied, Engineering, and Pharmaceuticals and Chemicals Industries in Bangladesh

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Abstract -**This research focused to analyze impact of liquidity ratios, dividend on share price of three industries. The industries are engineering, food and allied, pharmaceuticals and chemicals. The total sample size for this research is 425. A total of 85 companies' data has been collected. Five years of data has been collected from annual reports and lanka bangla. The duration of the year is 2016-2020. The current ratio and share price have a significant negative relationship. Also, there is a negative relationship between quick ratio and share price. On the other hand, there is a strongly positive relationship between cash ratio and share price. In addition, there is a significant positive relationship between dividend and share price. Secondary data has been used for conducting this research. It is the core limitation of this research. Besides, we were not able to find some companies' data. And sample size has decreased because of that. This research wanted to find out the relationship between share price with liquidity ratios and dividend. Now general people, investors, shareholders, and creditors can make decisions based on our study's findings. We hope this research will be helpful for both academicians and professionals.**
Keywords - **Current ratio, quick ratio, cash ratio, dividend, share price.**

I.INTRODUCTION

A. Background of The Study

In this era everyone wants solvency. Not only rich people but general people want to invest their precious money. Their very priority is share market. And they invest their money based on many criteria. Share price is one of them. By knowing the share price of the company, investors take their decisions whether they will proceed or not. Financial analysts come to the conclusion about the company's situation based on copious factors. Every time companies try to maintain a decent level of liquidity. Liquidity refers to the ability of a firm to pay its short-term debt. It clarifies the company's affordability to pay its debt. If a company's liquidity is in weak position, it indicates a threat to the solvency. Liquidity considered as the buttress of the company. It is like the heart of the company. Without strong liquidity the company will be failed to achieve its goal. Management, investors, shareholders, creditors take decisions based on the liquidity condition of company. Liquidity level affect companies' profitability very significantly. Financial analysts also give their focus on liquidity. Management always make sure liquidity must be maintained at minimum standard level. Liquidity should not be excess of insufficient because both are not appropriate to run the company efficiently and effectively. And we know cash is the most liquid of assets. In addition, there are current ratio, cash ratio, quick ratio. These are acquainted as liquidity ratios. Current ratios specify company's capacity to repay their short-term loans that are due within the next year. Cash ratio which is familiar as most liquid assets to its current liabilities. This ratio indicates whether the company has adequate liquidity to remain in business. Quick ratio is also well known as acid ratio. It indicates the efficiency of assets that can be shifted into cash at any time. And this will not be affected the market price. Management, investors, shareholders and creditors has their sharp eye in liquidity ratio for decision making. Besides there are no standard for liquidity. It depends on the company's size, growth stability etc. Furthermore, these ratios are related to share price of a company When it comes to the dividend payment to the shareholders, managers feel difficulties. They are perplexed whether to give dividends or not. There are some investors who only invest in the company based on dividend. If dividend is low, they will not proceed. Dividend is given on two forms. Share dividend and cash dividend.

B. Rationale of The Study

Nowadays people want an extra source of income. They want to earn more money. Investing in stock exchange, buying company's share, freelancing, investing in startups etc. And the investors, shareholders take their decisions based on many factors. This research is focus on the relationship between liquidity ratios, dividend on share price. Most of the studies show the relationship between dividend and share price. However, dividend does not always define significant result. From this study we will find out the more accurate and significant result. This study will show whether there is significant relationship between liquidity ratio, dividend on share price. I hope this research will find insightful to the shareholders to take the accurate decisions. This research will figure whether liquidity ratio or dividend has any effect on share price of the company.

C. Research Questions

Four main questions of this research are:

1. Is there any significant impact of liquidity ratios on share price of listed engineering, food and allied, pharmaceuticals and chemicals companies?
2. Is there any significant impact of dividend on share price of listed engineering, food and allied, pharmaceuticals and chemicals companies?

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D. Research Objectives

Broad Objective

The broad objective of this study is to know the answer of significance impact of liquidity ratio and dividend on share price of listed engineering, food and allied, pharmaceuticals and chemicals companies in Bangladesh.

Specific Objective

There is some specific objective of this research. They are:

1. To identify the significant relationship between liquidity ratios and share price,
2. To identify the significant relationship between dividend and share price.

E. Limitations of the study

Every research has its limitations. This research is also not indifferent. The limitations of this research are:

1. Secondary data has been used for this research and this is its core limitations.
2. Some data has not been found. The sample size decreased because of that.

II. LITERATURE REVIEW

Everything has its impact. This impact can either be positive or negative. Share price is also not so indifferent. [18] figure out Return on Assets (ROA) has negative correlation with share price. Besides, Quick ratio has influence on share price [20] observed current ratio has a considerable influence on dividend growth highlights "Current ratio is a ratio to measure the ability of companies to pay short-term liabilities or debt that are due immediately when billed as a whole". [4] stated that liquidity ratio describes company's short-term obligations that are due soon, the company must have cash available or other current assets that can be converted into cash immediately. [5] observed that less current indicate that it has small current assets to pay their short-term liabilities. However, the company which has a high current ratio is not necessarily said to be good since a high current ratio may occur due to lack of effective cash and inventory management. And his study found that current ratio has not any effect on firm value. [11] found that there is weak but remarkable relationship between current ratio and stock return. [6] figured out that "Current Ratio and significant negative effect on the company's Automotive Earnings Growth in Indonesia Stock Exchange".

A. Quick Ratio

Quick ratio does not have remarkable relationship on return on assets. [26] stated that quick ratio is statically favorable and meaningful effect on stock returns in the construction and building sub-sector companies. They also found the company who quick ratio, the better the company is to fulfill its short-term obligations. [19]. observed that there is negative relationship between liquidity ratio and profitability measures. That research figured out positive association was found between quick ratio and net profit, current ratio and return on equity and quick ratio and return on equity.

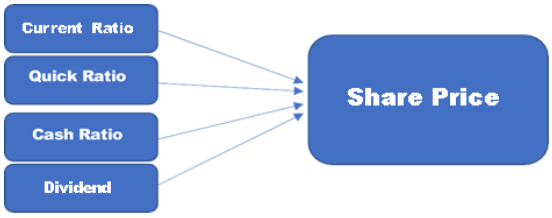
B. Cash Ratio

"Cash ratio has a strong negative interrelationship with leverage" [7]. Cash ratio has a positive and significant effect on dividend policy on the IDX 30 Index on the Indonesia stock exchange.

C. Dividend

[15] detected that the companies who give high dividends reduce risks and influence stock price of their share. [22] suggested that dividend payments reduce costs and increase cash flow. Their study observed that dividend policy does not affect the stock prices. Dividend announcements give the missing pieces of information about the firm and entitles the market to estimate the firm's current earnings stated by [12]. Dividend is remarkably correlated with earnings, earnings per share and previous year dividends [2]. [2] showed that when company declared dividends and as a result it has a favorable impact on stock prices. Nawaz, Anwar, and Ahmed (2010) have also the similar findings. Their study also found that company size and leverage negative negligible impact. [9] have also found a remarkable positive impact of dividend on stock price. [6] learned that dividend yield and dividend payout had significantly related share price volatility. [7] identified negative interrelationship between share price volatility and dividend yield and dividend payout.

D. Conceptual Framework



Research Hypothesis

H1: there is no relationship between liquidity ratio and share price
H2: there is relationship between liquidity ratio and share price
H3: there is no relationship between dividend and share price
H4: there is relationship between dividend and share price
This is all about literature review part.

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III. METHODOLOGY

A. Sample Selection and Variable Measurement

The data assembled for this research are secondary data. This study mainly focuses on three industries. They are engineering, food and allied and pharmaceuticals and chemicals. The companies are traded in Dhaka Stock Exchange (DSE). There are total of 85 companies' data has been collected. The period duration is 2016-2020. The sample size is 425. Five years of data has been collected for each company. The data has been collected from annual reports and lanka bangla portal.

In table 1 there is an overview of the sample size and population size.

Table 01
Summary of Sample and population size

Industry	Population (Company)	Sample size (Company)
Engineering	42	38
Food and Allied	20	16
Pharmaceuticals and Chemicals	31	31
Total	93	85

For this study I have chosen three independent variables and one dependent variable. The independent variables are dividend, current ratio, quick ratio, cash ratio. Current ratio, quick ratio and cash ratio are known as liquidity ration. Table two highlights the details about the variables.

Variables	Short	Type	Calculation	Expected Sign	Authors
Share Price	SP	Dependent	Share price at the end of the period	None	Badruzaman, J. (2020), Idawati, W., & Wahyudi, A. (2015)
Current Ratio	CR	Independent	Current Assets / Current Liabilities	+	Husna, A., & Satria, I. (2019), Nuryani, Y., & Sunarsi, D. (2020)
Quick Ratio	QR	Independent	(Cash + Marketable securities + Accounts receivable) / Current liabilities	+	Tumanggor, M. (2020), Warrad, L. (2014)
Cash Ratio	CAR	Independent	Cash and equivalent / Current liabilities	+	Okeke, L. N., Ezejiofor, R. A., & Okoye, N. J. (2021), Anshar, M., & Warimin, I. (2020)
Dividend	DV	Independent	Dividend at the end of the period	+	Adesola, W. A., & Okwong, A. E. (2009), Zakaria, Z., Muhammad, J., & Zulkifli, A. H. (2012)

B. Model of the study

Share Price = α + β1 CR + β2 QR + β3 CAR + β4 DV+ e

Methodology shows how the sample size has been selected. What are the variables have been chosen for this research, has been discussed in this specific part. There are four independent variables and one dependent variable. How the data has been collected. In chapter four findings and analysis will be discussed.

IV. FINDINGS &ANALYSIS

A. Descriptive Analysis

Variable	Observation	Mean	Std. Dev.	Min	Max
Share Price	425	48.7282	63.41138	-16.74	492.2
Current Ratio	425	2.707089	3.601884	.045	28.312
Quick Ratio	425	1.639553	2.292765	.07	15.58
Cash Ratio	425	.3066939	.9322779	.00031	10.046
Dividend	425	.4078353	1.390757	0	14

Figure 1: *Descriptive Statistics*

Figure 1 shows the descriptive statistics of this study. The mean value of current ratio is 2.707089. mean value of quick ratio is 1.639553. On the other hand, cash ratio is .3066939. The mean of current ratio is more than 2. That indicates that companies have the ability to cover its current liabilities two times. This is ideal. In addition, the mean of the quick ratio is 1.639553. The ideal ratio for quick ratio is 1. It also indicates company's financial condition is appropriate. On the other hand, mean of cash ratio is .3066939. Cash ratio less than 1 specify that companies have insufficient cash to cover their current liabilities. Besides, it also implies that companies are managing

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their inventory appropriately. And the mean of dividend is .4078353. That also indicates a very good situation for the companies.

B. Correlation Analysis

	Share Price	Current Ratio	Quick Ratio	Cash Ratio	Dividend
Share Price	1.0000				
Current Ratio	-0.1183	1.0000			
Quick Ratio	-0.1003	0.9281	1.0000		
Cash Ratio	0.0628	0.3748	0.4990	1.0000	
Dividend	0.4065	-0.0682	-0.0701	0.0698	1.0000

Figure 2: Correlation Analysis

Variable	VIF	1/VIF
Current Ratio	8.97	0.111477
Quick Ratio	7.80	0.128149
Cash Ratio	1.46	0.684087
Dividend	1.02	0.979822
Mean VIF	4.81	

Figure 3: Variance Inflation Factor (VIF)

Figure 3 indicates the correlation of the variables. We can see that there is very strong positive relationship between current ratio and quick ratio. Besides there is moderate strong positive relationship between cash and quick ratio, dividend and share price, cash, and current ratio. It also seems that there is weak negative relationship between current ratio and share price, quick ratio and share price, dividend and share price. From the variance inflation factor (VIF) we can observe that it is free from multicollinearity problem. The obvious reason is the value of VIF is below 10.

C. Regression Analysis

Number of obs	425
F (4, 420)	15.06
Prob > F	0.0000
R-squared	0.1744
Root MSE	57.891

Share Price	Coef.	Robust Std. Err.	t	P>|t|	[95% cons.	Interval]
Current Ratio	2.126859	1.15077	-1.85	0.065	-4.388845	.1351267
Quick Ratio	-.0591118	2.007059	-0.03	0.977	-4.004243	3.88602
Cash Ratio	5.587375	1.902846	2.94	0.004	1.847087	9.327664
Dividend	17.61672	4.722029	3.73	0.000	8.334969	26.89848
Cons	45.68438	3.168972	14.42	0.000	39.45536	51.9134

Figure 4: Regression Analysis

From the regression analysis we can see that the F-value which is also known as mean square value is 15.06. And the p value which is associated with the F-value is 0.0000. It indicated independent variables are effectively predict the dependent variable. R square value is 17.44%. It indicates that only 17.44% variance in share price can be predicted from the current ratio, quick ratio, cash ratio and dividend. And they are the independent variables. In addition, with the increase of 1 unit of current ratio 2.12 share price will be increased. On the other hand, when quick ratio will be increased of 1 unit, share price will be decreased by -.059. From figure 4 we see that for current ratio p value is .065. That means it has significant negative value. Cash ratio has significant positive value, and the value is .004 which is less than .05. Same situation also applies for dividend. The following chapter is a conclusion.

V. CONCLUSION

People's lifestyle is changing day by day. At present times, people want to live solvent and comfortable life. For getting that they must earn more money. That's why people want to invest their money. And they want to know the share price of the companies. And most importantly what are the factors that affect the share price.

From our research we can conclude that cash ratio and dividend have significant impact on share price of the companies. Current ratio and quick ratio have almost no impact at all. Most importantly quick ratio has strongly negative impact on share price. Our hypothesis 2 is partially accepted. And our hypothesis 4 is totally accepted. Investors can take decisions by checking cash ratio and dividend. Because these two have strongly significant effect on share price.

This study has been conducted by secondary data. This is the core limitations of this research. Data has been collected from annual reports and lanka bangla. Besides, some data has not been found. There are some recommendations for the investors, company for taking decisions. They are:

1.Companies should maintain standard liquidity to pay their short-term liabilities. If they can do that, they can operate their business properly.

2.Companies should pay the dividends. This will ensure the long-term strength of the fundamentals.

I hope this study will be helpful for researchers, academician, investors and for the general people.

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The Convergence of Traceability and Sustainability in Modern Supply Chains

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Abstract - **Global supply chains are transforming due to regulations, consumer demands, and market disruptions, all pushing for greater transparency. Serialization and traceability are key to this, creating a digital record of a product's journey from source to consumer. This convergence is vital for supply chain sustainability. Traceability helps verify environmental and social claims, builds consumer trust, and supports the circular economy by tracking product flows for reuse and recycling. It also minimizes waste during recalls and improves resource use, lowering carbon footprints. Technologies like IoT sensors, blockchain, and AI enhance data accuracy, security, and insights. Case studies in pharmaceuticals, food, and apparel show how traceability boosts safety, ethical sourcing, and compliance. However, adoption challenges—ranging from integration costs to partner alignment—must be addressed to realize its full potential. This paper argues that integrating traceability and sustainability is a strategic imperative. Organizations that embed these capabilities will achieve compliance, resilience, efficiency, and long-term competitive advantage.**

Keywords - ***Traceability, Sustainability, Supply Chains, Serialization, Circular Economy, Regulatory Compliance, Ethical Sourcing, Blockchain***

I. INTRODUCTION

Global supply chains are experiencing unprecedented pressure from regulators, consumers, and market volatility. Increasing demands for transparency, accountability, and ethical conduct have made supply chain sustainability a business imperative rather than a voluntary initiative. The traditional focus on cost and efficiency is being replaced by a broader framework that emphasizes environmental responsibility, social equity, and regulatory compliance. In this context, traceability and serialization have emerged as critical enablers of sustainable supply chains. Serialization—the process of assigning unique identifiers such as serial numbers, QR codes, or RFID tags to individual products—creates the foundation for granular visibility. Traceability builds upon this foundation by using these identifiers to monitor and document the movement, transformation, and condition of goods throughout the supply chain. Together, they form a digital thread that provides a verifiable history of products from raw material sourcing to end-of-life disposal. The convergence of traceability and sustainability addresses multiple challenges facing supply chains today. First, it allows companies to substantiate environmental and social claims, thereby reducing the risk of greenwashing and enhancing stakeholder trust. Second, it enables circular economy practices such as recycling, remanufacturing, and reuse by ensuring that materials and products are accurately tracked across reverse logistics channels. Third, it reduces waste and improves operational efficiency by facilitating precise recalls and providing real-time insights into inventory and logistics management. Finally, it ensures compliance with increasingly stringent regulations such as the U.S. Food Safety Modernization Act (FSMA 204), the Drug Supply Chain Security Act (DSCSA), and the European Union's Digital Product Passport (DPP). The purpose of this paper is to explore how serialization and traceability serve as strategic drivers of sustainability in modern supply chains. It synthesizes insights from academic literature, industry practices, and regulatory frameworks to highlight the opportunities, challenges, and future directions for integrating these capabilities. The paper argues that organizations that embed traceability into their sustainability strategies will not only achieve compliance but also build resilience, efficiency, and long-term competitive advantage.

II. LITERATURE REVIEW

Supply Chain Sustainability

The concept of supply chain sustainability extends beyond operational efficiency to encompass environmental stewardship, social responsibility, and long-term resilience [10]. Scholars emphasize that sustainability in supply chains involves balancing the "triple bottom line" of people, planet, and profit [28]. Companies are increasingly judged not only on financial performance but also on their ability to minimize environmental harm and uphold ethical labor practices. In practice, however, achieving sustainable supply chains has proven challenging due to limited visibility across multi-tier networks and the prevalence of opaque practices in global sourcing [11]. Recent studies argue that digital technologies are critical to bridging this visibility gap [15]. Transparency, underpinned by traceability systems, enables stakeholders to verify compliance with sustainability goals and regulatory mandates. Without traceability, sustainability claims remain unverifiable, leaving firms vulnerable to reputational risks.

B. Serialization as a Foundational Capability

Serialization is the assignment of unique identifiers to individual products, typically in the form of alphanumeric codes, barcodes, or RFID tags [5]. Initially developed for inventory management and anti-counterfeiting in industries such as pharmaceuticals, serialization has since become a cornerstone of modern supply chain management. For example, the DSCSA mandates unit-level serialization of prescription drugs in the U.S. to ensure patient safety and combat counterfeit medicines [6]. Academic literature underscores serialization as a prerequisite for granular traceability [9]. By creating item-level identities, serialization enables precise tracking, targeted recalls, and improved forecasting. Beyond compliance, serialization also supports

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sustainability by allowing firms to monitor product lifecycles and assess environmental impacts more accurately.

C. Traceability as a Strategic Enabler

Traceability is broadly defined as the ability to track and trace the history, application, or location of an item through recorded data [14]. Researchers distinguish between forward traceability (tracking products through the supply chain to the consumer) and backward traceability (tracing back from consumer to origin) [25]. Both forms are essential for sustainability: forward traceability enables targeted recalls and efficient resource use, while backward traceability ensures accountability in sourcing practices. Several studies link traceability directly to sustainability outcomes. For example, in the food sector, traceability systems have been shown to reduce food waste by isolating contaminated batches and preventing unnecessary recalls [22]. In the apparel industry, traceability enhances transparency in labor practices and material sourcing, thereby addressing social and environmental concerns [14]. Despite these benefits, researchers highlight challenges such as data interoperability, cost of implementation, and partner adoption [25].

D. Digital Technologies Powering Traceability

The literature highlights a range of enabling technologies that enhance traceability systems:

1.Internet of Things (IoT): IoT devices monitor environmental conditions such as temperature, humidity, and location in real-time, critical for ensuring product integrity and reducing spoilage [16]. 2.Blockchain: Blockchain provides an immutable, decentralized ledger for recording supply chain transactions. It ensures trust among stakeholders and prevents data manipulation [21]. 3.Artificial Intelligence (AI) and Data Analytics: AI enables predictive insights, anomaly detection, and demand forecasting using the vast data generated by traceability systems [24]. 4.Cloud Platforms: Cloud-based systems facilitate scalability, interoperability, and global accessibility of traceability data [23]. These technologies not only strengthen compliance and risk management but also amplify sustainability outcomes by optimizing logistics, reducing waste, and enabling verifiable claims.

E. Gaps in Existing Research

While significant work has been conducted on supply chain sustainability and traceability, integration between the two remains underexplored. Much of the literature treats traceability as a compliance or risk management tool rather than as a strategic driver of sustainability [12]. Few studies provide holistic frameworks linking serialization, traceability, and circular economy practices. Moreover, empirical research quantifying the sustainability benefits of traceability remains limited, particularly in multi-tier and cross-border supply chains. This paper aims to address these gaps by framing traceability as both a compliance necessity and a sustainability enabler, supported by case studies and cross-industry insights.

III.TRACEABILITY AS A SUSTAINABILITY DRIVER

A. Enhancing Transparency and Preventing Greenwashing

Consumers and investors are increasingly skeptical of generic sustainability claims [22]. Traceability systems enable firms to substantiate these claims with verifiable evidence, such as proof of recycled content, certified ethical sourcing, or carbon reduction measures. This transparency mitigates reputational risks associated with "greenwashing" and enhances stakeholder trust [14]. For example, blockchain-enabled traceability in coffee supply chains allows consumers to confirm farm-level sustainability certifications, reinforcing brand credibility.

B. Enabling Circular Economy Practices

The transition from a linear "take–make–dispose" model to a circular economy requires accurate tracking of products and materials across multiple life cycles [10]. Traceability supports circularity by:

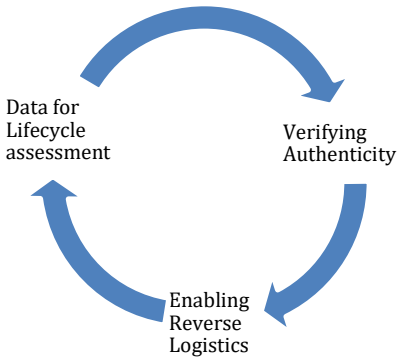
1.Verifying the authenticity of recycled or remanufactured materials.

2.Enabling reverse logistics for product take-back programs.

3.Providing data for lifecycle assessments (LCAs) and extended producer responsibility (EPR) reporting.

Industries such as electronics and apparel have begun embedding digital identifiers to facilitate reuse and recycling. For example, the EU's Digital Product Passport initiative will require manufacturers to provide traceability data that supports product repairability and recyclability [28].

Fig.1 Enabling Circular Economy



C. Reducing Waste and Optimizing Resources

One of the most tangible sustainability benefits of traceability is waste reduction. Traditional recall processes often cause the disposal of entire product batches, even when only a small subset is affected. Serialization and traceability enable targeted recalls, reducing both cost and environmental impact [27]. Similarly, real-time inventory visibility minimizes overproduction, spoilage, and obsolescence, particularly in food and pharmaceutical sectors where product integrity is time-sensitive [5].

D. Improving Operational Efficiency and Reducing Carbon Footprints

Beyond waste reduction, traceability generates data that can be used to optimize logistics networks. By analyzing transportation routes, companies can identify inefficiencies and reduce fuel consumption [7]. IoT-enabled monitoring ensures compliance with cold-chain requirements while minimizing unnecessary energy expenditure. These

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efficiencies not only lower operational costs but also contribute directly to carbon reduction targets [8].

E. Ensuring Regulatory Compliance and Ethical Sourcing

Governments worldwide are enacting stricter supply chain regulations addressing food safety, forced labor, and deforestation. Traceability provides the documentary evidence needed to comply with these mandates [7]. For example, under FSMA 204, food companies in the U.S. must maintain records of Key Data Elements (KDEs) and Critical Tracking Events (CTEs) to trace products in case of contamination [8]. Similarly, the EU Deforestation Regulation (EUDR) requires proof of non-deforestation in agricultural supply chains. By ensuring compliance, firms reduce legal risks while demonstrating their commitment to ethical and sustainable practices. This alignment strengthens brand reputation and creates long-term business resilience.

IV. ENABLING TECHNOLOGIES FOR TRACEABILITY

Traceability ecosystems are built on a combination of identification, data capture, and data-sharing technologies. These technologies not only ensure compliance but also amplify sustainability outcomes by improving efficiency, reducing waste, and enhancing trust.

A. Unique Identifiers

Serialization begins with unique identifiers such as QR codes, RFID tags, and NFC chips. According to GS1, over 10 billion items globally are scanned daily using GS1 standards [6]. QR codes have gained prominence in consumer-facing industries due to their low cost and ease of adoption, while RFID tags offer advantages in bulk scanning and automated data capture. For example, Walmart's RFID mandate for apparel suppliers reduced inventory inaccuracies by over 25%, leading to fewer stockouts and waste [9].

B. Internet of Things (IoT)

IoT sensors embedded in packaging and logistics assets enable real-time monitoring of conditions such as temperature, humidity, and shock. This is critical for perishable products like food and pharmaceuticals. A World Health Organization report estimated that up to 25% of vaccines are degraded due to poor cold chain management, a challenge IoT traceability directly addresses [18]. By preventing spoilage, IoT reduces both financial losses and environmental waste.

C. Blockchain

Blockchain offers an immutable, decentralized ledger for capturing supply chain transactions. IBM Food Trust, one of the largest blockchain traceability platforms, reduced the time to trace a product's origin from 7 days to 2.2 seconds in pilot programs with Walmart and Nestlé [11]. Beyond speed, blockchain ensures tamper-proof sustainability claims, enabling companies to combat greenwashing and enhance trust among stakeholders.

D. Artificial Intelligence and Data Analytics

AI leverages the massive data generated by traceability systems to deliver predictive insights. Applications include anomaly detection for counterfeit identification, demand forecasting, and logistics optimization. A McKinsey study estimated that AI-driven supply chain optimization can reduce forecasting errors by 30–50% and inventory costs by 20–50% [15]. When applied to traceability, these efficiencies directly translate into sustainability gains by minimizing waste and reducing unnecessary transportation.

E. Cloud-Based Platforms

Cloud computing underpins scalability and global accessibility. Platforms such as AWS Supply Chain, SAP Leonardo, and Oracle SCM enable real-time data integration across multi-tier networks. According to Gartner, 70% of supply chain organizations are investing in cloud-based solutions to improve transparency and collaboration [25]. Cloud platforms are also critical for aligning with regulatory mandates such as FSMA 204 and the EU Digital Product Passport, which require standardized data exchange across global stakeholders.

V. CASE STUDIES IN PRACTICE

To illustrate the real-world impact of traceability, this section presents case studies across three industries: pharmaceuticals, food and beverage, and apparel. These examples demonstrate how traceability contributes to both compliance and sustainability outcomes.

C. Pharmaceuticals: Patient Safety and Cold Chain Integrity

Pharmaceutical supply chains are highly regulated due to risks associated with counterfeit drugs and product degradation. Under DSCSA, all prescription drugs in the U.S. must be serialized by 2024. Serialization has already improved recall precision: during a pilot by the U.S. FDA, companies were able to isolate defective medicines at the unit level, reducing the volume of recalled products by over 80% compared to batch-level recalls [12]. Cold chain management is another critical area. IoT-enabled traceability ensures vaccines and biologics remain within specified temperature ranges. Pfizer's COVID-19 vaccine distribution relied on GPS-enabled thermal sensors that transmitted location and temperature data every five minutes [27]. This prevented spoilage and reduced waste in one of the most complex pharmaceutical supply chains ever executed.

A. Food and Beverage: Farm-to-Fork Transparency

Foodborne illness outbreaks highlight the importance of rapid traceability. The 2018 E. coli outbreak linked to romaine lettuce in the U.S. took weeks to trace, leading to the disposal of millions of pounds of safe produce. In contrast, Walmart's blockchain pilot with IBM Food Trust enabled the origin of mangoes to be traced in 2.2 seconds [22]. By isolating only affected batches, blockchain traceability reduces food waste, enhances consumer safety, and protects brand reputation.

Sustainability claims are also supported by traceability. Nestlé and Carrefour implemented blockchain-based transparency for their organic milk supply chain in France, allowing consumers to scan a QR code and verify farming practices, animal welfare, and carbon footprint metrics [14]. This not only builds consumer trust but also incentivizes suppliers to adopt more sustainable practices.

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B. Fashion and Apparel: Combating Greenwashing

The apparel industry faces criticism for opaque supply chains, poor labor conditions, and high environmental impact. Traceability is increasingly being used to verify material origins and sustainability claims. For example, H&M's "Conscious Collection" includes QR codes that allow customers to see the country of production and supplier information for each garment [19]. Circularity initiatives are also gaining traction. Fashion for Good, a global sustainability initiative, has piloted digital tracers embedded in textiles to verify the use of recycled fibers [20]. Blockchain platforms such as TextileGenesis enable brands like Adidas and Stella McCartney to trace fibers like organic cotton and recycled polyester through multi-tier supply chains, addressing the industry's greenwashing challenges.

Fig 2. Case study comparison table

Industry	Use Case	Technology	Outcomes
rmaceuticals	alization & d chain	Blockchain, alization	geted recalls, ced waste
d and Beverage	n to Form sparency	ckchain, QR es	er recalls, waste ction
arel	erial origin fication	ckchain, Digital	i-greenwashing

VI. CHALLENGES AND BARRIERS

While traceability delivers clear benefits in transparency, compliance, and sustainability, its widespread adoption faces several challenges. These barriers are both technical and organizational, reflecting the complexity of global supply chains.

A. High Implementation Costs

The initial investment in serialization equipment, IoT sensors, blockchain infrastructure, and integration with enterprise systems is significant. For small and medium-sized businesses (SMBs), these costs can be prohibitive. A Deloitte study found that over 60% of SMBs cite cost as the primary barrier to traceability adoption [5]. Without scalable and affordable solutions, adoption may remain concentrated among large multinational firms.

B. Integration with Legacy Systems

Many supply chain stakeholders continue to rely on outdated enterprise resource planning (ERP) and warehouse management systems. Integrating modern traceability technologies with these legacy platforms is technically complex and resource intensive [6]. Incompatibility often leads to fragmented data, limiting the effectiveness of traceability initiatives.

C. Data Accuracy and Interoperability

Traceability systems rely on accurate and standardized data. Inconsistent data entry, lack of adherence to global standards (e.g., GS1, EPCIS 2.0), and absence of interoperability across platforms reduce data reliability [9]. Without harmonized standards, achieving full visibility across multi-tier supply chains remains challenging.

D. Supply Chain Partner Resistance

Effective traceability requires collaboration among all supply chain actors, including raw material suppliers, manufacturers, distributors, and retailers. However, smaller partners may resist adoption due to cost, lack of technical expertise, or concerns over data privacy [12]. Trust and governance frameworks are needed to encourage participation and equitable data sharing.

E. Data Governance and Privacy Concern

Questions around who owns traceability data and how it can be shared create governance challenges. Suppliers may be reluctant to share sensitive data with downstream partners for fear of losing bargaining power. Moreover, regulatory frameworks like GDPR introduce additional complexity in ensuring privacy and data security [27].

F. Complexity of Multi-Tier Global Supply Chains

Global supply chains often span dozens of countries and involve hundreds of intermediaries. Traceability across such complex networks requires harmonization of standards and cross-border regulatory cooperation. Without coordinated international frameworks, companies risk fragmented compliance obligations and incomplete visibility [7].

VII. THE PATH FORWARD

Despite these challenges, the trajectory of global supply chains points toward increasing adoption of traceability as both a compliance requirement and a strategic differentiator. Several emerging trends and opportunities highlight the future direction of this field.

A. Regulatory Momentum

Governments are accelerating the adoption of mandatory traceability requirements. The U.S. Food Safety Modernization Act (FSMA 204) mandates the capture of Key Data Elements (KDEs) and Critical Tracking Events (CTEs) for high-risk foods by 2026 [8]. Similarly, the European Union's Digital Product Passport (DPP), set to launch under the Ecodesign for Sustainable Products Regulation, will require manufacturers to disclose product-level environmental data [7]. These regulations signal a future where traceability is no longer optional but compulsory.

B. Rising Consumer Demand for Transparency

Consumers are increasingly motivated by sustainability in purchasing decisions. A 2022 IBM survey found that 71% of consumers are willing to pay a premium for brands that demonstrate supply chain transparency [25]. Companies that provide verifiable traceability data are more likely to differentiate themselves and secure customer loyalty.

C. Advances in Technology

Emerging technologies are expanding the capabilities of traceability:Digital Twins create virtual models of physical supply chains, enabling predictive insights and scenario planning.

1.AI and Machine Learning enhance demand forecasting, fraud detection, and sustainability reporting.

2.Blockchain–IoT Convergence provides immutable, real-time data streams for high-risk supply chains such as pharmaceuticals and food.

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These innovations will reduce costs, improve scalability, and increase adoption across industries [18].

D. Business Model Innovation

New commercial models are making traceability more accessible. Pay-per-trace or subscription-based platforms lower barriers for SMBs by replacing upfront capital expenditures with scalable operational costs [30]. Collaborative industry platforms—such as IBM Food Trust in food and TextileGenesis in fashion—demonstrate how shared infrastructure can accelerate adoption.

E. Toward Circular and Ethical Supply Chains

Traceability will increasingly underpin circular economy initiatives by enabling material reuse, recycling, and extended producer responsibility (EPR) schemes. Similarly, it will support compliance with labor and environmental regulations by providing verifiable evidence of ethical practices [16]. Companies that embrace traceability not only reduce regulatory risks but also future-proof their supply chains against environmental and social disruptions.

VIII. CONCLUSION AND FUTURE RESEARCH

The convergence of traceability and sustainability marks a fundamental transformation in modern supply chain management. What once began as tools for compliance and operational efficiency—serialization, unique identifiers, and record-keeping—has evolved into a strategic framework for resilience, transparency, and ethical responsibility. By creating a digital thread that links products across their lifecycle, traceability enables organizations to substantiate sustainability claims, reduce waste, support circular economy practices, and optimize resource use.

The evidence from pharmaceuticals, food and beverage, and apparel industries demonstrates the tangible value of traceability. Targeted recalls reduce waste and protect consumer safety, blockchain systems deliver farm-to-fork transparency, and textile tracers combat greenwashing. At the same time, enabling technologies such as IoT, blockchain, and AI are reshaping the economics of traceability by lowering costs and improving scalability. Despite these advances, adoption barriers remain significant. High implementation costs, legacy system integration, data governance, and multi-tier complexity hinder progress, particularly for small and medium-sized enterprises. Overcoming these barriers will require regulatory clarity, harmonized standards, shared infrastructure, and innovative business models that distribute costs equitably across the value chain. Looking ahead, regulatory initiatives such as FSMA 204 and the EU Digital Product Passport, coupled with rising consumer demand for verifiable transparency, will make traceability non-negotiable. Companies that treat traceability not merely as a compliance tool but as a strategic enabler of sustainability will gain long-term competitive advantage by building trust, efficiency, and resilience into their supply chains.

Future Research Directions

This paper highlights the need for further academic inquiry in several areas:

1.Quantifying Impact: Empirical studies measuring the environmental and financial benefits of traceability across industries. 2.Consumer Behavior: Research on how traceability data influences consumer trust, purchasing decisions, and brand loyalty. 3.Cross-Border Frameworks: Comparative studies on traceability regulations across regions to develop globally harmonized models. 4.SMB Adoption Models: Exploration of scalable, cost-effective traceability solutions tailored for smaller firms. 5.Technology Integration: Investigation of digital twins, AI, and blockchain–IoT convergence in enabling predictive and adaptive supply chains.By addressing these gaps, future research can strengthen the academic and practical foundations for traceable and sustainable supply chains. The path forward is clear: transparency, once optional, is now a defining characteristic of supply chain excellence in the twenty-first century.

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Sustainable Practices: The Role of Eco-Friendly Décor in Shaping Consumer Perceptions at Events

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Abstract - **This study explores how sustainable décor and the use of eco-friendly materials—such as bamboo, jute, clay, and biodegradable products—affect consumer perception and behavior in the southern part of Bangladesh. As environmental concerns become increasingly significant, event organizers in this region are gradually adopting green practices. However, limited research exists on how local consumers perceive these initiatives and how they influence factors such as consumer satisfaction, brand trust, and future purchase intentions. This research examines the types of sustainable materials used in events across the southern region, the extent of consumer awareness regarding eco-friendly practices, and the impact of these elements on consumer behavior. A quantitative research approach, supported by surveys, interviews, and focus group discussions, was employed to uncover trends, correlations, and potential cause-effect relationships. Findings reveal that younger, well-educated consumers are more open to sustainable décor, yet cultural traditions and economic limitations hinder broader acceptance. While eco-friendly practices enhance satisfaction and trust among environmentally conscious consumers, concerns about the durability, prestige, and aesthetic appeal of green materials present ongoing challenges. The study recommends enhancing public awareness through education, incorporating regional cultural elements into sustainable event planning, and improving waste management. This research offers valuable insights for event professionals in the southern part of Bangladesh seeking to align sustainable operations with consumer expectations and promote long-term environmental sustainability within the local event industry.**
Keywords - **Sustainable event management, Green marketing, Consumer behavior, Eco-friendly décor, Southern Bangladesh.**

I.INTRODUCTION

The concern of climate change, scarcity of resources, and degradation of the environment has made global shift towards sustainability extremely important. Sustainability is no longer a trend to get on board with but a requirement especially in industries like event management organized. The environmental degradation caused by the traditional event practices: use of plastics, thermocol, artificial fabrics and cheap energy consumption is the major contributor as far as environmental problems are concerned. This has seen the event industry which is generally an industry that exhibits high consumption leading to waste be looked at through the lens of sustainability.

Sustainable event practice has become an emerging issue of concern on cultural pride and more environmental consciousness in semi-urban places such as Southern part of Bangladesh. Closeness to nature is one of the strongest features of these region, which is why eco-friendly event decor is particularly topical in this respect. Eco- friendliness using bamboo, jute, clay, cotton fabrics and recycled paper are gaining popularity as an alternative, sustainable method of conventional synthetic materials. The materials also lead to a decrease in waste and pollution and a growth in the local identity/skills of this region.

Sustainability in event management is meeting the current needs without the deprivation of future generations of their need. It focuses on low intensity resources and in the long run, with a preference to less environmental impact. Sustainability is not only a matter of providing alternatives but also a matter of redefining beauty and luxury comprehensively, ethically, culturally apposite and environmentally friendly. It is a process that questions the social expectations on the aesthetics of event and promotes a more conscious way of doing event industry. Consumer perceptions influence sustainability largely through cultural symbols, beliefs, and social norms, and thus the success of the sustainable practices in the event management field is often defined by these aspects. The event planners have to balance between environmental responsibility and consumer wants so that the designs are effective and culturally attractive. The consumers might perceive simple-looking, nature-inspired instrumentation of the device as a meaningful approach to the ecological issues, yet others might be interested in more conventional, more luxurious formulations.

Specifically, this study aims to explore whether the use of eco-friendly decor and sustainable materials in southern part of Bangladesh, especially in Barishal region the event industry can positively change consumer satisfaction, trust, and potential behavior. To address this, a quantitative survey relying on local perspective was conducted. This is the first time a research has explored consumer intentions of sustainable event practices in a semi-urban city like Barishal in a Bangladeshi context, filling a remarkable gap focused on by previous systematic reviews .Thus, this study seeks to offer practical guidance for event planners to embed sustainability within Barishal's culture and economic landscape.

II. LITERATURE REVIEW

The concept of sustainability continues to grow in the world and its application in developing countries such as

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Barishal, Bangladesh is minimal particularly in event management industry. Although major cities in the world are slowly embracing a green lifestyle, semi-urban metropolises such as Barishal are still full of conventional things like plastic, polythene, and artificial decorations. Yet, research initiatives like that of [11] report this change slowly as backdrop and stage decoration is being done by some of the organizers with bamboo, jute, and clay, but primarily in awareness events led by education institutes or non-profits.

Among the significant statements of the literature, is the fact that the consumer perception is highly based on aesthetic value, compatibility with their culture as well as price. [1] discovered that some young individuals and students who believe in sustainable decoration, the rest of the consumers concern themselves with cost minimization and the visuality factor of products. This shows a long-term lack of knowledge, as people are not aware about the environmental impact of conventional materials. According to [21] , consumers fail to see any added value through the eco-friendly practices, unless they are told about environmental benefit of these practices.

The other important revelation is the financial issue of carrying out sustainability. According to Chowdhury and Islam (2019), planners find it hard to consider using sustainable options since they are faced with tight budgets and unaffordable green alternatives. In addition, weddings and other religious functions are usually frowned upon by cultures that culturally require flashy and over-the-top adornments, which eco-friendly decorations can hardly match.

These boundaries notwithstanding, a youth movement makes in Barishal a room to change sustainably. Green-themed events that consumed recyclable materials and environmentally friendly lighting have been held in such institutions as Brojomohun College [1]. Emotional and symbolism significance of natural materials also takes place; the use of natural textures and green items result in the sense of placidity, nostalgia, and cultural pride, particularly in a nature-plentiful area, such as Barishal [22]. The literature further brings out the color psychology as one factor in the sense that it promotes green color which means growth, purity and peace. Using the decor in the events does not only increase the aesthetic nature of the events, but also imparts moral values of the environment as well as increasing brand awareness and confidence [5]. Moreover, emphasis is given to the issue of waste management as the pillar of sustainable events. According to [14,15], the most applicable and flexible approaches are reuse computer systems, composting, and recycling systems that could be adopted in the case of local events.

A. Consumer Behavior

The acceptance of eco-friendly event practice depends highly on consumer behavior. In Bangladesh, the younger and educated people prefer sustainable materials whereas the older ones, as well as the low-income consumers, are loyal to traditional, tacky decor. Such contrast puts much emphasis on the need to strive to know the local culture beliefs as flashy decor is also linked to prestige and status in the past. The trick to changing consumer behavior is providing them with more awareness and visible rewards, as it has been captured by Nusrat and Sultana (2020) and [11] among others; however, one of the things that can be done is presenting the environmental effects of sustainable materials.

B. Characteristics of consumers

There are some consumer attributes that determine how people prefer to have their events decorated in environmentally friendly ways. Studies indicate that younger generations (especially those below 21 years) would tend to use sustainable materials more, since they get exposed to international environmental movements more often. The women are also greener in their approach to events during gatherings within communities and families [12]. Unlike them, older people, particularly those who live in countryside, tend to choose cultural or elaborate decorations as it is customary and, because of their status. Furthermore, the people with the higher income are ready to afford green materials, and people with the lesser income would consider sustainable products to be of low quality.

C. Green aesthetics in psychology

Psychological implications of the green aesthetics are important in the comprehension of how the consumer perceives the environment friendly decor. The natural materials used in environmentally friendly construction in Barishal comply with the national culture and attachments to nature. Green color is not only perceived as a sustainability color but also as a show of growth, purity, and peace. Green design is often linked with a sense of peace and reminiscent effect among people in Barishal especially in events such as wedding and religious reminders. The emotional appeal of eco-friendly decor, which [22] speak about, can also increase the efficiency of such events and cause a positive change in how the consumer perceives the organizer of the event.

D. Use of Waste Materials

To minimize the eco-friendly impact of events, one must use sustainable materials. Traditional materials that are being used include plastic flowers and Styrofoam which cannot be recycled and cause pollution. Conversely, more environmentally friendly materials such as bamboo, jute and clay are biodegradable and put less strain on the environment. In addition, effective waste management concepts e.g. recycling, compost and reusing of the decoration materials, are vital in ensuring that the events are indeed environment-friendly. Many of the studies, such as those conducted by [14,15], argue that cleaning up and recycling using reusable materials are critical to preventing the impairment of nature.

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The good part about the use of sustainable materials has its issues such as being more expensive initially and that they are not easily accessible in the rural regions of the country like Barishal. Consumers also resist since they perceive treated and synthetics materials as more appealing and luxurious. However, the problem can be fixed as local cultural aspects can be incorporated into using more sustainable materials in the event industry in Barishal with more awareness.

III. METHODOLOGY

This research adopts a quantitative research design to examine the relationship between the use of environmentally friendly decorations and materials in event settings and consumer attitudes, behaviors, and satisfaction—specifically within the context of Barishal. The choice of a quantitative approach is based on the objective to gather measurable data from a larger population segment, allowing for statistical analysis to identify patterns, correlations, and potential cause-effect relationships. The central aim is to assess consumer awareness, perception of quality, emotional and intellectual responses, and behavioral intentions toward sustainable or "green" events.

The target population for this study consists of individuals aged 18 and above who have attended at least one event in Barishal within the past 12 months. A structured questionnaire was utilized as the primary data collection tool. The questionnaire was designed based on a review of existing academic literature on sustainable consumption, event management, and consumer behavior. It comprised closed-ended questions, including items formatted using the Likert scale, to capture quantifiable responses.

The survey instrument was divided into key thematic sections: consumer awareness of environmentally friendly materials, perceived aesthetic and functional quality of eco-friendly decorations, emotional and intellectual reactions to sustainable event setups, and willingness to support or recommend such events. The design of these sections aimed to gather comprehensive insights into both the cognitive and affective dimensions of consumer engagement with green practices.

A simple random sampling method was employed to ensure a representative sample, mitigate selection bias, and include participants from diverse demographic backgrounds. The final sample size comprised 200 respondents, considered sufficient to yield reliable and generalizable results in the context of a semi-urban population like Barishal. To maximize accessibility and participation, data was collected using both online and face-to-face survey methods—particularly during ongoing public events—to capture real-time consumer perspectives.

For data analysis, both descriptive and inferential statistical techniques were applied. Descriptive statistics such as frequencies, percentages, and means were used to summarize the respondent profiles and key variable distributions. Inferential techniques, including correlation analysis and regression modeling, were employed to examine the strength and direction of the relationships between variables. The analysis was conducted using SPSS software to ensure precision, validity, and consistency.

This methodological framework provides a systematic, data-driven approach to understanding the influence of environmentally conscious event practices on consumer mindsets. It offers valuable insights for event organizers, policy makers, and stakeholders by revealing the extent to which eco-friendly practices shape audience engagement, satisfaction, and sustainable behavioral intentions. Ultimately, the findings support informed decision-making and strategic planning toward a more sustainable event industry in Barishal.

IV. DATA ANALYSIS

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
dependent_variable	200	1.30	4.80	3.7112	.68542
independent_variable	201	1.60	4.70	3.9212	.75386
inde_variable	200	1.00	5.00	4.1800	1.02976
Valid N (listwise)	200				

The descriptive statistics of the three variables—dependent, independent, and index—offer valuable insights into their respective distributions. The dependent variable, based on 200 observations, ranges from a minimum of 1.30 to a maximum of 4.80. It has a mean of 3.71 and a standard deviation of 0.68542, indicating that the data points are generally concentrated toward the higher end of the scale, though some variability is present around the mean.

The independent variable comprises 201 observations, with values ranging between 1.60 and 4.70. Its mean is slightly higher at 3.92, suggesting a mild skew toward the upper end of the scale. The standard deviation is 0.75386, which is marginally greater than that of the dependent variable, reflecting a slightly wider spread of values.

The index variable includes 200 data points and spans the full scale, from 1.00 to 5.00. It has the highest mean among the three, at 4.18, indicating a strong tendency toward the upper end of the scale. With a standard deviation of 1.02976—the largest of the three—it demonstrates the greatest variability. This suggests that the index variable exhibits a broader range of responses compared to both the dependent and independent variables, implying more diverse participant perspectives or behaviors

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.789[a]	.622	.618	.42350	.622	162.135	2	197	.000	1.634

a. Predictors: (Constant), inde_variable, independent_variable

b. Dependent Variable: dependent_variable

The model summary demonstrates that the regression model significantly explains a substantial proportion of the

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variation in the dependent variable. The R value of 0.789 indicates a strong positive linear relationship between the independent variables and the dependent variable, suggesting a meaningful association between the predictors and the outcome. An R Square value of 0.622 implies that approximately 62.2% of the variance in the dependent variable is accounted for by the independent variables, reflecting a good model fit. However, it also suggests that 37.8% of the variance remains unexplained, leaving room for other contributing factors.

The Adjusted R Square value of 0.618 confirms the model's robustness, adjusting for the number of predictors and demonstrating that the explanatory power of the model is not artificially inflated. The Standard Error of the Estimate, calculated at 0.42350, indicates that on average, the predicted values deviate from the actual values by approximately 0.42 units—providing an estimate of the model's prediction accuracy.

Moreover, the F Change value of 162.135, accompanied by a highly significant p-value of 0.000, confirms that the overall regression model is statistically significant. This means that, as a group, the independent variables meaningfully contribute to explaining the variance in the dependent variable. Lastly, the Durbin-Watson statistic of 1.634, although slightly below the ideal value of 2, suggests only a weak positive autocorrelation among the residuals. While this points to a minor issue with autocorrelation, it does not pose a serious threat to the model's validity. Overall, the model is statistically sound, the predictors are significant, and the level of autocorrelation is within acceptable limits.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	58.158	2	29.079	162.135	.000[b]
	Residual	35.332	197	.179		
	Total	93.490	199			

a. Dependent Variable: dependent_variable

b. Predictors: (Constant), inde_variable, independent_variable

Analysis of Variance (ANOVA) was employed to determine whether consumer perceptions of events significantly differ based on the use of eco-friendly décor and sustainable materials. ANOVA is an appropriate statistical method for this study due to the multivariate nature of the research design, involving multiple independent variables influencing a single dependent variable—consumer perception.

The ANOVA results demonstrate an F-value of 162.135 and a p-value of 0.000, indicating that the model is statistically significant. This suggests that the interaction among the independent variables—such as environmental awareness, aesthetic appeal of the event, and perceived sustainability—plays a crucial role in explaining the variation in consumer perception. In other words, differences in how individuals perceive and respond to eco-friendly events are not due to random chance but are meaningfully explained by the tested variables.

The use of ANOVA supports the hypothesis that incorporating eco-friendly practices in event décor has a measurable and significant impact on consumer perception. It enables the researcher to assess whether observed differences in perception across various groups—such as those exposed to sustainable events or those with varying levels of environmental awareness—are statistically significant. This reinforces the study's findings and provides a robust basis for conclusions regarding the influence of sustainability on consumer attitudes within event settings

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	1.016	.159		6.397	.000		
	independent_variable	.468	.069	.516	6.812	.000	.335	2.986
	inde_variable	.206	.050	.310	4.091	.000	.335	2.986

a. Dependent Variable: dependent_variable

The regression model results are presented in the coefficients table, which includes both unstandardized and standardized coefficients for each predictor, along with their statistical significance. The unstandardized coefficient (B) for the constant (intercept) is 1.016 with a standard error of 0.159. The corresponding t-value is 6.397, and the p-value is 0.000, indicating that the constant is statistically significant.

For the variable labeled as independent variable, the unstandardized coefficient is 0.468, with a standard error of 0.069. The standardized coefficient (Beta) is 0.516, and the t-value is 6.812, with a significance level (p-value) of 0.000. These results demonstrate a strong and statistically significant positive influence of this variable on the dependent variable, making it the most impactful predictor in the model.

Similarly, the independent variable has an unstandardized coefficient of 0.206 and a standard error of 0.050. The standardized Beta is 0.310, with a t-value of 4.091 and a p-value of 0.000, confirming that this predictor also exerts a statistically significant and positive effect on the dependent variable, although its influence is comparatively weaker than that of the independent variable.

In terms of collinearity diagnostics, the Tolerance value is 0.335, and the Variance Inflation Factor (VIF) is 2.986 for both predictors. Since the VIF values are well below the conventional thresholds of 5 or 10, this suggests that multicollinearity is not a serious concern in the model. Overall, the regression results confirm that both predictors significantly contribute to explaining the variance in the dependent variable, with no indication of problematic multicollinearity.

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Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions (Constant)	Variance Proportions independent_ variable	Variance Proportions inde_variable
1	1	2.962	1.000	.00	.00	.00
	2	.030	9.940	.72	.01	.23
	3	.008	19.674	.27	.99	.77

a. Dependent Variable: dependent_variable

The Collinearity Diagnostics table gives details of the possible multicollinearity among the predictors in the regression model. It gives the report on eigenvalue, condition index, and variance proportions of every dimension of data. The eigenvalue of the Dimension 1 is 2.962 with condition index of 1.000 which depicts that there exists no Multicollinearity problems in this dimension since the condition index value of 1 is usually an indication that there is no serious Multicollinearity. All the variance proportions of constant, independent variable and independent variable in Dimension 1 are equal to 0.00, which means that this dimension does not have a significant relationship with predictors. The eigenvalue of the dimension 2 is 0.030 with a condition index of 9.940 which indicates that there is some moderate collinearity in dimension 2.

The proportion of variances indicates that the independent variable has a variance proportion of 0.72 which is high hence this dimension is strongly related to. Conversely, the proportion of variance in this dimension that belongs to the constant and independent are very small, having values 0.00 and 0.23, respectively. The third dimension has an extremely small eigenvalue of 0.008 with a larger condition index of 19.674, and this is a definite indication that there could be multi-collinearity amongst the predictors. The proportion of variances in Dimension 3 indicates that the independent variable is strongly related to this dimension with a variance proportion of 0.77 whereas the independent variable has a lower proportion of 0.99.

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2.0641	4.2445	3.7112	.54060	200
Residual	-2.31757	1.11241	.00000	.42136	200
Std. Predicted Value	-3.047	.987	.000	1.000	200
Std. Residual	-5.472	2.627	.000	.995	200

a. Dependent Variable: dependent_variable

The Residual Statistics table shows important information regarding the residuals of the constructed regression model, being the differences between observed and predicted values. The table gives a report of the predicted values, residuals, standardized predicted values, and standardized residuals of the dependent variable. The Predicted Value ranges between 2.0641 and 4.2445 with a mean of 3.7112 and standard deviation of 0.54060. It indicates that the forecasted values are fairly near to the true mean of the dependent variable and there is variability in the forecasted values as shown by the standard deviation.

The Residual row indicates that the range of residuals is between -2.31757 and 1.11241 with a mean of 0.00000. The zero mean residual is an indication that on average the model predictions are not biased, that is, there is no systematic under- or over-prediction. The residential standard deviation is 0.42136, which shows how the residuals are dispersed around the zero mean. In the case of Standardized Predicted Value the maximum and minimum values are -3.047 and 0.987 respectively and the average is 0.000 which indicates that standardized predicted values are concentrated around zero as they should be. The standard deviation equals 1.000, which means that they are standardized.

The values of Standardized Residual have the range between -5.472 and 2.627 with the mean value of 0.000 and the standard deviation of 0.995. Standardized residuals give a standardized value of the distance between each prediction and the actual value, whose values are usually expected to be within the range of -2 to 2 in a good fitting model. The distribution of the standardized residuals indicates that the bulk of the residuals lie within this interval therefore showing that the predictions of the model are largely accurate.

Correlations

		dependent_variable	independent_variable	inde_variable
dependent_variable	Pearson Correlation	1	.768**	.730**
	Sig. (2-tailed)		.000	.000
	N	200	200	200
independent_variable	Pearson Correlation	.768**	1	.816**
	Sig. (2-tailed)	.000		.000
	N	200	201	200
inde_variable	Pearson Correlation	.730**	.816**	1
	Sig. (2-tailed)	.000	.000	
	N	200	200	200

**. Correlation is significant at the 0.01 level (2-tailed).

The correlation table presents the Pearson correlation coefficients among the three variables included in the regression model: the dependent variable and two independent variables. These coefficients, along with their significance levels, offer insight into the strength and direction of the relationships between the variables.

The dependent variable shows a strong and positive correlation with the first independent variable (r = 0.768), which is statistically significant at the 0.01 level, as indicated by the double asterisks. Similarly, it also demonstrates a positive but slightly weaker correlation with the second independent variable (r = 0.730), which is also significant at the 0.01 level. These findings suggest that both independent variables have a significant and positive association with the dependent variable

Furthermore, the two independent variables are themselves highly correlated (r = 0.816), and this relationship is likewise significant at the 0.01 level. This strong inter-correlation between the predictors implies a potential overlap in what they measure or influence. However, while the high correlations underscore strong associations, they also warrant attention to potential multicollinearity in the regression analysis. Overall, the

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correlation results confirm the relevance of all three variables in understanding the dynamics within the model.

V. FINDINGS

A. Attitude to Eco- Friendly Materials

In southern region especially in Barishal, awareness of eco-friendly materials is growing, particularly among the youth and educated segments of the population. Event attendees, including locals and students, increasingly appreciate the use of biodegradable, jute, bamboo, and clay materials by organizers [12] .However, many clients still prioritize the visual appeal and affordability of traditional party decorations. Changing these consumption preferences is challenging in the short term, as a significant portion of the population continues to favor conventional, flashy displays over sustainable alternatives, valuing aesthetic impact over environmental responsibility.

B. Consumer Satisfaction and Trust

Eco-friendly materials positively influence consumer satisfaction with events, especially when attendees understand their environmental benefits [21]. Incorporating green practices—such as natural lighting, bamboo, and biodegradable products—enhances perceived event quality, fostering greater trust in organizers. Consumers who recognize an event's sustainability tend to develop a more favorable attitude toward the organizer, increasing the likelihood of recommendations and repeat attendance. This underscores that effectively communicating sustainability not only improves event perception but also strengthens consumer loyalty, positioning environmentally responsible practices as a valuable strategy in event management.

C. Cultural Influence and resistance

In Barisal, eco-friendly materials face limited acceptance among older generations, who often associate traditional, ornate decorations with social status and prestige. Flashy, synthetic ornaments, especially in weddings and religious functions, are widely favored for their perceived grandeur. However, nature holds deep cultural significance in Barisal, a region renowned for its rivers and lush greenery. This cultural connection can give eco-friendly materials an emotional appeal to locals. By aligning such materials with local traditions and aesthetic values, organizers can enhance their acceptance. Integrating environmental responsibility with cultural pride may bridge generational preferences and foster broader appreciation [1].

D. Economic Factors

A large number of consumers in Barishal are price sensitive and eco-friendly materials, which are more sustainable in most cases, are usually costly. This poses a great obstacle towards mass adoption, particularly in an economy where cost-effectiveness is a dominant factor. The event planners at Barishal have been experiencing problems with regard to striking a balance between being sustainable and being affordable.

E. Use of waste Materials

Barishal events often rely heavily on non-biodegradable materials like plastics and Styrofoam, contributing to environmental degradation. While there is a visible shift toward sustainable options such as jute, clay, and bamboo, these remain scarce and costly. Event organizers who adopt sustainable materials have successfully reduced waste, with some incorporating reusable and recyclable items. The research also emphasizes that effective waste management is crucial for achieving truly sustainable events, highlighting its role in minimizing environmental impact and promoting responsible event practices.

VII. RECOMMENDATION

A. Awareness Program

Educate the people, in particular, older generation on the impacts of non-biodegradable materials on the environment and the benefit they can gain by adopting the utilization of environment-friendly materials. This may be done by conducting awareness activities, working with schools and non-governmental organizations besides information sessions at events. Challenge the event planners to take the responsibility of enlightening the participants about the sustainability initiatives put in place at the events. This can be in signatures, pamphlets or even in the form of short talks given out on how the decor and material used is helping to make the environment greener.

B. Employ Local Culture in Environmentally Sustainable Practice

Promoting the use of culturally significant materials—such as bamboo, jute, and clay—while incorporating modern and aesthetically appealing designs can bridge the gap between traditional ornate décor and sustainability. Event organizers should highlight how eco-friendly materials like jute mats and bamboo structures can evoke positive cultural associations and sentimental value. By aligning these sustainable elements with local traditions, the décor becomes more appealing to the community, fostering acceptance and appreciation while preserving both cultural identity and environmental responsibility.

C. Inexpensive Sustainable Development Goals

Eco-friendly materials remain a significant challenge for many due to their higher costs. Event planners should consider sourcing sustainable materials locally to reduce expenses, while engaging local craftsmen and small businesses to make eco-friendly options more affordable and appealing to the community. Additionally, emphasizing the long-term cost benefits of sustainable materials—such as reduced waste disposal expenses and the potential for reuse—can help shift public perception. Highlighting both economic and environmental advantages can encourage broader acceptance and adoption of sustainable practices in Barishal's event industry.

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D. Effective Waste Management plan

The best practices that event organizers should focus on include waste management plans that may entail the installation of different bins (recycling, composting and general garbage). The collaboration with the local waste managing firms may contribute to mitigating the environmental devastation caused by the events. It could also be thought that the introduction of sustainable practices could be induced by involving the participants of the event into separating their wastes, as well as by providing incentives (discounts on environmentally-friendly behavior).

E. Green Certification and eco-friendly Brand

Green certifications or developing an eco-friendly brand identity can greatly benefit event organizers by enhancing the credibility of their sustainability efforts. Using eco-labeled products and materials at events allows attendees to clearly recognize and appreciate the sustainable practices in place, fostering trust, strengthening brand reputation, and encouraging continued support from environmentally conscious consumers.

F. Connect the Local Influencers and the Youth

Harness the energy of youth and influence of opinion leaders to promote sustainable event practices. Youth, being more receptive to eco-friendly concepts, can effectively spread the message across wider community segments. Collaborating with local change-makers and hosting sustainability-focused events can foster a community-driven approach, encouraging broader participation and commitment to environmentally responsible event organization

These guidelines will help Bangladesh's event industry gradually overcome barriers to sustainable practices, making eco-friendly event management the norm. Consequently, consumers will no longer see sacrificing sustainability as an option, fostering a stronger commitment to environmentally responsible events across the sector.

VII. CONCLUSION

This paper demonstrates that while sustainable practices—such as the use of biodegradable and locally sourced materials—are gradually gaining traction within the event management sector in Bangladesh, widespread consumer adoption remains limited. Younger, more educated, and environmentally conscious populations show a greater preference to embrace sustainable designs and approaches. In contrast, older generations and lower-income groups continue to favor traditional, ornate decorations. The primary challenges inhibiting the broader implementation of sustainability initiatives include financial constraints, imbedded local preferences, and insufficient awareness regarding the benefits of eco-friendly materials.

Importantly, the research highlights that sustainable event décor positively influences consumer satisfaction, brand trust, and long-term loyalty, particularly when the environmental impacts are clearly communicated. This presents a valuable opportunity to integrate sustainability into the traditional cultural fabric of southern part by promoting the use of culturally relevant materials such as bamboo, jute, and clay.

To effectively overcome existing barriers, strategic efforts should focus on comprehensive educational campaigns, increasing the affordability and accessibility of locally produced sustainable materials, and enhancing waste management practices during events. Furthermore, the adoption of green certifications and the promotion of sustainability practices aligned with local cultural values can strengthen consumer acceptance and credibility.

Although progress towards sustainable event management is gradual, the positive momentum observed offers a promising foundation for future growth. This evolving trend not only has the potential to transform practices within Barishal but also to serve as a model for other semi-urban and developing regions, contributing to the broader advancement of environmentally responsible event management in Bangladesh.

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The Role of AI in Transforming Consumer Behaviour

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Abstract- **Artificial intelligence (AI) continues to be a growing presence in consumer-centric industries and is changing the way people interact with brands and make buying decisions. From customizing recommendations to simulating human-like conversations, AI tools are transforming expectations around convenience, trust, and personalization. We have analysed past works on the use of AI in fields such as retail, banking, healthcare, and digital marketing to explore how its use is influencing consumer behaviour in real-world settings. From our study we were able to conclude that AI improves personalization, optimizes service quality, and guides customers across their journey for an optimal buying experience. Even though using AI has led to an upward trend in growth and consumer responsiveness, transparency and trust remain central to its acceptance. Some studies have shown that the advent of the COVID-19 pandemic has led to an accelerated integration of AI in consumer's everyday consumption habits, with many saying that they will continue to shop online even in the post-pandemic era. Regardless of the benefits, concerns surrounding data privacy, user control, and authenticity still remain. This review bridges past findings and outlines key areas for future study on the role of AI in transforming consumer buying behaviour**.

Keywords: **Artificial Intelligence, Consumer Behaviour, Personalization, Trust and Privacy, Digital Marketing**

II.INTRODUCTION

In recent years, AI has emerged as one of the most transformative forces in consumer-focused industries. By using machine learning, natural language processing and predictive analytics companies are changing customer interactions and decision making. AI is now deeply embedded in e-commerce platforms, banking apps, healthcare solutions and retail environments, how customers evaluate options and buy [1]–[3]. This is visible in both pre and post pandemic times. Early studies focused on personalization and service automation [4] but the COVID-19 crisis accelerated adoption across digital channels making AI driven experiences the new normal [5], [6]. Customers are now engaging with recommendation systems, virtual assistants and AI enabled marketing tools that guide their preferences and loyalty [7], [8].

But AI in consumer markets also brings challenges. Trust, transparency and data privacy are big concerns [9], [10]. Customers like personalized offers but worry about the ethical use of data and algorithmic manipulation [11]–[13]. So, understanding how AI changes customer behavior requires balancing its benefits and limitations [14], [15].

This paper reviews 25 academic studies to see the impact of AI on customer behavior, focusing on personalization, trust, transparency, ethics and the future of customer brand relationships.

III.METHODOLOGY

This study follows a systematic literature review (SLR) approach using secondary data. Initially over 50 papers were gathered from portals like Google Scholar, ResearchGate, IEEE Xplore, Springer, Emerald and ScienceDirect, with keywords AI in consumer behavior, AI personalization, digital marketing AI and trust in AI adoption.

After screening for relevance and removing duplicates 25 papers were finalised. Of these the first 16 core papers formed the foundation [1]–[16], and 9 additional high quality papers were added to the dataset [17]–[25]. Papers were selected if they:

- Examined AI's role in changing customer decision making, personalization or trust.
- Were peer reviewed or preprint academic sources.
- Provided empirical findings, conceptual models or systematic reviews.This structured approach ensured the literature was both comprehensive and academic.

IV.LITERATURE REVIEW

A. Personalization and Engagement

The greatest contribution of AI is in personalization where algorithms inspect the preference of the customers in order to present product suggestions. E-commerce and video streaming recommendation systems result in greater satisfaction and purchase intention [3], [7], [17]. A number of works reveal that personalization raises trust and loyalty of the brand with the targeted recommendation intervening in the chain of trust–satisfaction–loyalty [18].

B. Trust, Transparency, and Privacy

While consumers insist on personalization, more important to the adoption of AI is trust and transparency. Lack of clarity about the operation and exploitation of algorithms and personal data evokes suspicion [9], [11], [19]. Transparent AI models encourage engagement while opaque algorithms discourage adoption [21]. Customers are caught between liking personalization benefits and fearing privacy risks [23], [24].

C. AI in Industry-Specific Applications

The adoption of AI crosses various sectors. In retailing, recommender systems and chatbots improve the shopping

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experience through lowering the search costs [12], [20]. In internet finance, consumer credit risk is predicted and personalization is enhanced using AI models that sway financial services trust [22]. Likewise, healthcare and banks apply AI to improve the quality of services and fine-tune the interactions with consumers [2], [5].

D. COVID-19 and Acceleration of AI Adoption

The pandemic of COVID-19 prompted the widescale implementation of AI. Companies were utilizing internet solutions, and consumers were getting used to interfaces and shopping with the power of AI [1], [6]. Research reveals that the shift has a long-term impact where consumers are planning to continue shopping with the help of AI after the pandemic [15], [25].

IV. RESULTS

The meta-analysis of 25 studies reveals the top four areas of findings. Second, personalization using AI has become the driver of consumer choice. Recommender systems and predictive models present reliable and positive outcomes on purchase intention, satisfaction, and repeat purchase behavior [3], [7], [17], [18]. When implemented in a store environment, information overwhelm is relieved by simplified consumer choice-making processes, whereas in media and video-on-demand systems, personalization of recommendations enhances involvement and loyalty [12]. These outcomes suggest that personalization is no longer a marketing adjunct but a strong predictor of consumer choice-making.Second, AI increasingly improves convenience and efficiency across sectors. According to consumers, AI saves search time, enhances product discovery accuracy, and produces smoother purchase experiences [5], [20]. We see this for instance in the way chatbots powered with AI are increasingly displacing human assistance in e-commerce and banks with quicker and more accurate support. Likewise, in financial services, AI systems are capable of forecasting consumer demands and offering tailored personal finance advice [22]. These outcomes underscore the creation of time-effective, frictionless consumer experiences that is delivered by AI.

Third, the strongest mediator of AI adoption is found to be trust. Although perceived value is increased with personalization, consumers are very much fretting about the collection and usage of data [9], [11], [19]. There are a few studies that present the "personalization–privacy paradox," where consumers relish the personalized experience but are reluctant to do so because of the suspicion of being watched and lack of control [23], [24]. It is found that loyalty and adoption are determined by trust and that consumers insist upon the fairness and clarity of the algorithmic decisions [21]. Lastly, the pandemic caused a structural adjustment in consumer dependence on AI. Digital-first shopping became routine with COVID-19 for many consumers, and it continued long after restrictions were lifted [1], [6], [25]. Research supports that AI-powered platforms are now a lasting feature of consumers' lives with adoption that is increasingly higher in the developed and developing economies. It demonstrates that AI has changed from a supporting tool to a fundamental feature of the consumer experience.

V. DISCUSSION

The outcomes verify that the adoption of AI has entrenched itself in consumer behaviour, but the character of this incorporation is twofold. While on the one hand it adds value through the alleviation of decision effort and the achievement of higher satisfaction and loyalty through it, it jeopardizes consumer autonomy and agency through excessive reliance upon it.

Trust consistently appears as the balancing force: when consumers believe AI systems are transparent and ethical, adoption rises. Conversely, opacity or misuse of personal data undermines willingness to engage [19], [21]. This underscores the need for explainable AI and regulatory frameworks to govern algorithmic marketing practices. The pandemic environment expands this movement further. Adopting AI increased because of necessity, but the continued adoption is a harbinger of a long-term shift in consumer culture. Companies need to accept that personalization with AI is no longer a choice but an expectation [6], [25]. But companies also need protection against "algorithmic fatigue," in that very exposure to personalization causes decision fatigue or mistrust [23].

From a broader perspective, the findings suggest that AI is not merely changing consumer behaviour in isolated ways; it is redefining the consumer decision-making process itself. The processes of problem recognition, information seeking, evaluation, and purchase are increasingly guided by computer systems rather than consumers alone fundamentally restructuring the decision-making process itself.

VI. CRITICISMS AND LIMITATIONS

Despite the general agreement about the strengths of AI, the examined literature presents many of the weaknesses. Sectorial imbalance is the main weakness: the overwhelming majority of the studies is focused on e-commerce and electronic retailing [3], [12], whereas markets such as healthcare, education, and public services are underrepresented [2], [5]. This narrow focus limits the generalizability of findings across industries. Geographical bias is another constraint. The majority of the existing studies come from advanced economies, particularly the United States, Europe, and some Asian nations, while developing countries are yet to possess relevant adequate evidence [6], [17]. The gap isolates knowledge regarding the effect that varies in culture and infrastructure has on the adoption of AI. There are methodological errors also observable. A great deal of the literature is reliant on surveys and self-reported attitudes that do not necessarily

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resonate with consumers' behaviours per se [9], [11]. There is a lack of experimental and long-term work that does not permit the study of shifts in consumer behaviour and trust in the long term.

Lastly, whereas moral issues like bias, privacy, and transparency are often recognized, very limited studies empirically verify them [19], [20], [23]. Consequently, we continue to lack correspondence between theoretical debate and consequential consumer effect. Future research has to take up more robust empirical designs in order to narrow this chasm.

VII. CONCLUSION

Artificial intelligence is no longer just a supplementary device in marketing but a disrupting power that is moulding consumer behaviour. It propels personalization, fine-tunes service delivery, and builds interactions but at the same time creates concerns regarding trust, confidentiality, and fairness. The pandemic expedited adoption and made interactions powered by artificial intelligence a mainstay of the future consumer behavior. The business imperative is to find a balance between innovation and responsibility. The future of research needs to centre on explainable AI, cross-cultural adoption patterns, and the long-term psychological effects of AI-driven personalization. AI will only maintain a disruptive impact on consumer dynamics if it is transparent, truthful, and adheres to regulations.

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Different Types of Expenses and Their Effects on Profitability Enhancement: Empirical Evidence from Food and Allied Industries of Bangladesh

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Abstract: **Due to their fragile financial structure and very competitive market circumstances, the food and allied sectors require effective cost control solutions. In this context, the study's goals were to investigate the operational costs of the food and related industries and how they affect the improvement of profitability by firm size and business sector. This study contributes to look at the impact of different types of expenses on profit after tax. Unbalanced Panel data from 14 Food and allied companies was gathered for this study, which spanned the years 2009 to 2023. This paper employed the 2SLS and GMM model. This study found that cost of goods sold, operating expense, administrative expense and finance expense have the significant positive relationship with profit after tax. Sophisticated cost-cutting abilities, such as balancing productivity and revenues while limiting quality adverse effects, are essential to improving the operational performance of the food and related industries. Additionally, because economies of scale reduce expenses, business size has an effect. However, in order to increase earnings, owners of food and allied industries, particularly major companies, should think about enhancing food quality rather than depending solely on the benefits of advertising.**

Keywords: **Profit after tax; Cost of goods sold; Operating expenses; Administrative expense; Marketing and Selling expense; Finance Expense JEL Classification: F21, F23, J23, J32**

I. INTRODUCTION

In order to attain the best results in terms of profitability and overall organizational success, outsourcing projects must be strategically managed, as [5] highlighted the complex dynamics of outsourcing and its effects on corporate performance. [4] conducted a study using multivariate regression, with interest, salary, and provision expenditures as independent factors and Net Profit Margin (NMF), Return on Equity (ROE), and Return on Assets (ROA) as dependent variables. The ability of the organization to sustain its profit year after year is referred to as profitability. According to the linear regression model, only one of the independent factors has an effect on the other two dependent variables, although two dependent variables significantly affect one of the dependent variables. [3] shown that internal failure costs have a negative and substantial impact on PT. Sang Hyang Seri's (Persero) profitability, but the costs of preventive and appraisal have a partial positive and non-significant impact. However, external failure costs have a negligible negative impact on profitability. [2] stated that setting standards and upholding performance in accordance with them is how cost control is carried out since, as management strives to boost productivity for more profit, costs will rise, and each area of responsibility will be responsible for collecting them. The purpose of their research was to explain how cost control may be implemented successfully to control expenditures and boost rather than decrease profitability. [1] demonstrated that, in contrast to the traditional paradigm, cost-to-serve assessment yields precise and complete customer information that permits a more thorough customer profitability analysis. [6] stated that the Coca-Cola Company has increased its profitability by implementing a cost-control plan, but there are still deadly risks to its profitability, such as the poor use of its assets to make money and IRS disputes. [7] discovered that distinct data is taken out for pricing considerations and for profitability calculations. The results of the study also show that businesses employ a hierarchy of profit metrics in their quarterly profitability analysis reports and that the primary function of profitability analysis is to draw attention to the need for more thorough research.

The empirical model and estimation methods are discussed in the next section. In Section 2, we reviewed the related literature. In Section 3, explains our empirical findings. Finally, we provide some closing observations in the last part.

II. LITERATURE REVIEW

[8] showed that standard costing has a major beneficial impact on cost reduction. Additionally, it was noted that a company's profit rises in proportion to its use of standard costing. [9] found that the growth of Fintechs (FTI), banks' assets (TA), interest-bearing asset profitability (NIM), credit risks (NPL), and cost control (CTI) are all positively correlated with banks' profitability (ROE). (2) The influence of fintechs on banks' profitability is "U" shaped.

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[10] stated that an understanding of the evolving function of process control in operations and profit/loss metrics is beneficial. Even if process control has the greatest influence on corporate decision-making today, there are still a lot of obstacles that need to be overcome if it is to optimize its financial impact throughout the whole organization.
[11] stated that the business had sustained positive operating profit and consistent growth up to 2021, when revenue increased but profit indicators did not increase as much as anticipated, unlike in previous years. The cost of sales was primarily impacted by the volatility and unavailability of foreign exchange, which also had an effect on the price of raw materials and other manufacturing inputs. In comparison to previous years, distribution and administrative costs stayed constant and even decreased in 2021. [16] stated that cost advantage, cost leadership, and cost efficiency are all favorably impacted by strategic cost management. He added that cost advantage is positively correlated with cost leadership and cost efficiency; and cost efficiency has a favorable impact on firm profitability. Furthermore, the links between strategic cost management and company profitability can only be mediated by cost efficiency. [32] stated that using cost-cutting strategies has increased organizational profitability. On the basis of this, the research suggested that the firm use linear programming (LP) methodologies to ensure that components and raw materials are purchased on time to satisfy production and sales requirements. [14] showed a strong positive correlation between financial control systems and business profitability. It was suggested that manufacturing companies use appropriate and reliable control methods in order to continually enhance their application of financial control procedures. [13] found that there is a significant amount of cost inefficiency in the life insurance sector in comparison to earnings, and inefficiency has a negative correlation with profitability metrics like return on equity. According to organizational structure and inefficiency research, stock (shareholder-owned) businesses are just as lucrative and efficient as mutual (policyholder-owned) businesses.
[12] stated that Cost-effective banks are more lucrative during the epidemic. Furthermore, they discovered that robust financial success is linked to revenue diversification. In order to maintain sustainable and robust financial performance during times of crisis when interest revenues are sticky, our findings add to the body of literature by suggesting that bank management implement aggressive expense control and revenue diversification techniques.
[23] demonstrated a substantial inverse association between Malaysian commercial banks' performance and non-performing loans (NPLs) and cost effectiveness. However, the performance of Malaysian commercial banks is found to be significantly positively correlated with bank size. The article outlines a number of strategic and policy consequences, including the need to continue managing credit risk, reducing non-core lending operations, improving system transparency, controlling costs, and enacting more forgiving anti-trust and competition laws.

[22] showed that macroeconomic factors and financial market structure have an impact on the profitability of banks, both local and international, in addition to the unique features of individual institutions. Although their effects and relationships with earnings are not necessarily the same for domestic and international banks, all the variables—aside from concentration in the case of domestic banks' profits—are relevant. In order to demonstrate how efficient cost control may boost profitability, [21] looked at different cost structures and how they affect pricing tactics. It also looks into how operational effectiveness and economies of scale might lower expenses while increasing output. Best techniques for maximizing profit margins while preserving competitive pricing are identified by the research using case studies from a variety of sectors and empirical data analysis. The ultimate goal of this effort is to give companies a thorough framework for evaluating their financial performance and making wise decisions that promote long-term success. [20] showed that at the 0.01 significant level, there was a 0.601 association between inventory management procedures and profitability. He suggested that inventory control procedures and industrial and business profitability are positively and significantly correlated. With an R square value of 0.361, changes in inventory control procedures may account for 36.1% of the associated variance in profitability.

[19] stated profitability and cost stickiness were shown to be negatively and significantly correlated in his study. He suggested that enterprises are unable to control selling, general, and administrative (SG&A) expenses, which eventually results in decreased earnings. Additionally, there is a positive correlation between business size and profitability, meaning that larger firms are more profitable than smaller ones, and a negative correlation between leverage and profitability, meaning that corporations have more debt. [18] showed that all predicting factors were significantly explaining profitability. Additionally, an alluring result of expenditure preference behavior is the interplay between cost effectiveness and bank operations within the macroeconomic context of each nation. In order to satisfy all stakeholders, they promoted prioritizing cost efficiency, which has the potential to achieve both greater returns and the use of existing resources.

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[17] showed that financial management techniques and the profitability of SMEs are positively correlated, but that this link is unaffected by agency cost as a moderator.
[24] demonstrated the importance of corporate governance practices in emerging nations. However, not every aspect of corporate governance is important. According to some research, CEO duality has no discernible effect on a company's financial success, but board features and ownership structure improve it. We emphasize that the company's stability cannot be replaced by such procedures.
[25] stated that the primary subjects, factors, and indices associated with demand-side flexibility profitability analysis. Along with the impact of energy markets, pricing, and standards on revenue maximization. The review's results show that the structure of the energy market, the assets involved, the cost of power, and the compensation currently paid for ancillary services all have a significant impact on how profitable flexibility services are.
[26] presented an examination of hotel profitability using financial data from 27 hotel firms that operate in Tunisia. Managerial efficiency is demonstrated to be significant while maintaining geographical and operating contracts as constants using Data Envelopment Analysis (DEA) and Return On Assets (ROA) analysis. However, the profitability of hotels is significantly impacted by these two factors. Other factors that have an impact include hotel size, debt levels, crisis event exposure, and managers' educational backgrounds.
[27] stated that full-service restaurants may face significant challenges due to high prime costs, such as food and salary expenses, which might result in lesser profitability when compared to their limited-service counterparts. Enhancing full-service restaurants' operational performance requires advanced cost-cutting techniques, such as limiting quality degradation while balancing productivity and revenues.
[28] did an empirical analysis of the variables influencing Spanish banks' profitability between 1999 and 2009. We come to the conclusion that a high proportion of loans in total assets, a high proportion of client deposits, strong efficiency, and a low ratio of questionable assets are all linked to the high bank profitability throughout these years. Furthermore, the bank's return is also increased by greater capital ratios, but only if return on assets (ROA) is employed as the profitability metric. There is no indication of scale or scope economies or diseconomies in the Spanish banking industry. Lastly, our analysis shows that commercial and savings banks operate differently.

III. METHODS

This paper conducted an exploratory analysis by using the following data and techniques.

Data:

Secondary unbalanced panel data of 14 food and allied companies during the period of 2009-2023 is compiled from the websites of those companies. The data comprises the information of 15 years of 14 food and allied companies that considers 11 variables. Among these, 13 variables, 1 dependent variable, 5 control variables and 5 independent variables.

Methods:
This paper conducted a step-by-step model-based combined analysis. At first, the Two Stage Least Square model (2SLS) model is used to outline the relationship between PAT and some variables related to investment in assets among the 14 food and allied companies in Bangladesh. Then Generalized Method of Moments model (GMM) is employed to determine the relationship between PAT and same variables mentioned above.

Variables and description:

SL	Name	Type	Source	Description
1	LnPAT	Dependent	Annual Report	Log normal of Profit after tax
2	LnTA	Control	Annual Report	Log normal of Total Assets
3	LnTR	Control	Annual Report	Log normal of Total Revenue
4	LnTE	Control	Annual Report	Log normal of Total Equity
5	LnSC	Control	Annual Report	Log normal of Share Capital
6	LnRE	Control	Annual Report	Log normal of Retained Earnings
7	LnCOGS	Explanatory	Annual Report	Log normal of Cost of goods sold
8	LnOE	Explanatory	Annual Report	Log normal of Operating expenses
9	LnADMIN	Explanatory	Annual Report	Log normal of Administrative expense
10	LnMSD	Explanatory	Annual Report	Log normal of Marketing Selling and Distribution expense
11	LnFIN	Explanatory	Annual Report	Log normal of Finance Expense

IV. RESULTS AND DISCUSSION

This study investigates how variation in expenses incurred (i.e., cost of goods sold, operating expenses, administrative expenses, marketing selling and distribution expenses, finance expenses) is associated with profit after tax in selected companies. We used the Two Stage Least Square (2SLS) model to estimate this association.

In column (1) in Table 1, we estimate a baseline model with only the control variables, such as total assets, total revenue, total equity, share capital and retained earnings. The control variables generally have the predicted indications, where total asset has significant positive coefficients. Share capital and retained earnings coefficients are negative and statistically significant in all models. According to earlier research, a firm's operational efficiency is significantly moderated by its size [35, 36]. Generally speaking, big businesses are superior to small

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businesses in terms of market strength, economies of scale, managerial know-how, and financial resource accessibility [37].

In other words, small businesses may be at a competitive disadvantage when it comes to managing their human resources, budgetary restrictions, and bargaining power with suppliers and customers. Since small businesses may better serve certain market segments by providing specialized goods or superior customer service, they should focus on these clients or markets rather than competing with bigger businesses in order to overcome these inherent challenges [36].

This study uses five proxies of expenses incurred, such as cost of goods sold expense, operating expense, administrative expense, marketing selling and distribution expense, finance expense. [33] stated that the cost of raw materials (CoRM) and profit before taxes for Nigerian manufacturing firms were shown to be significantly correlated negatively. Their study came to the conclusion that, over the reviewed period, cost containment significantly improved the profitability of Nigerian manufacturing enterprises. As a result, proper raw material management and alternate sourcing are advised.

In Table 1, columns (2), (3), (4), (5) and (6) show five proxies for measuring incurred expenses: such as cost of goods sold, operating expenses, administrative expenses, marketing selling and distribution expenses, finance expense. Other than control variables, in column (2) shows that cost of goods sold have significant positive relationship with profit after tax. In column (3) shows operating expense has significant positive relationship with profit after tax. In column (4) shows administrative expense has significant positive relationship with profit after tax. In column (6) shows finance charge has significant positive relationship with profit after tax in 2SLS model.

[32] indicated that the function of materials management must be recognized, and it has been proposed that a company must correctly execute the materials management aim described in this study in order to become profitable. All costs necessary to sell goods, such as rent, utilities, insurance, fees, etc., are included in selling, general and administrative expenses. Since the fixed cost per unit falls as sales rise, the connection between selling, general and administrative expenditures and sales is negative in manufacturing businesses, where the majority of selling, general and administrative expenses are roughly fixed [29]. Because of this, [30] proposed that either an extraordinary sales effort or ineffective cost control is the cause of a disproportionate growth in selling, general and administrative expenditures over sales. Similarly, [31] demonstrated that a rise in the selling, general and administrative cost ratio indicated negative profitability in the future. Similarly, when a food company expands, its selling, general and administrative expense ratios would not increase much. As a result, selling, general and administrative expenditures need to resemble variable costs. Consequently, this study anticipated that higher selling, general and administrative expenditures would have a detrimental impact on company profitability.

Table 1. Panel 2SLS (IV) Estimation Results

	(1)	(2)	(3)	(4)	(5)	(6)
LnTA	.895***	.938***	.922***	.928***	.885***	.896***
	(3.27)	(3.50)	(3.50)	(3.39)	(3.20)	(3.39)
LnTR	.041	-.09	-.044	.034	.004	-.01
	(0.24)	(-0.60)	(-0.31)	(0.24)	(0.03)	(-0.07)
LnTE	.285	.503**	.424**	.391*	.419*	.399**
	(1.22)	(2.41)	(2.14)	(1.91)	(1.90)	(2.02)
LnSC	-.282**	-.461*	-.424**	-.485**	-.429**	-.425**
	(-1.35)	(-2.42)	(-2.29)	(-2.41)	(-2.12)	(-2.28)
LnRE	-.08	-.074**	-.076**	-.06*	-.059*	-.08**
	(-2.26)	(-2.13)	(-2.24)	(-1.72)	(-1.66)	(-2.32)
LnCOGS	-.058	.102***				
	(-0.59)	(2.65)				
LnOE	.16		.134***			
	(1.18)		(3.25)			
LnADMIN	-.047			.06*		
	(-0.68)			(1.75)		
LnMSD	-.029				.028	
	(-0.65)				(0.93)	
LnFIN	.112					.135***
	(0.75)					(3.14)
Observations	105.000	105.000	105.000	105.000	105.000	105.000
Mean dependent var	17.125	17.125	17.125	17.125	17.125	17.125
SD dependent var	2.615	2.615	2.615	2.615	2.615	2.615
R-squared	0.485	0.453	0.471	0.431	0.419	0.467
F-test	8.865	13.513	14.533	12.394	11.771	14.334
Prob> F	0.000	0.000	0.000	0.000	0.000	0.000

t-statistics in parentheses

***,**and* denote significance at 1, 5 and 10% respectively

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Table 2.GMM Estimation Results

	(1)	(2)	(3)	(4)	(5)	(6)
L.LnPAT	.026	.019	.019	.018	.02	.025
	(0.23)	(0.18)	(0.18)	(0.17)	(0.18)	(0.23)
LnTA	2.398***	2.384***	2.38***	2.377***	2.401***	2.384***
	(4.50)	(4.65)	(4.68)	(4.64)	(4.71)	(4.69)
LnTR	.325	.248	.254	.254	.319	.271
	(0.77)	(0.65)	(0.67)	(0.66)	(0.83)	(0.71)
LnTE	.244	.287	.29	.291	.25	.262
	(0.55)	(0.70)	(0.71)	(0.71)	(0.61)	(0.64)
LnSC	-1.511*	-1.528*	-1.513*	-1.502*	-1.579*	-1.496*
	(-1.66)	(-1.75)	(-1.75)	(-1.72)	(-1.84)	(-1.73)
LnRE	.02	.01	.012	.012	.017	.01
	(0.29)	(0.16)	(0.19)	(0.19)	(0.29)	(0.16)
LnCOGS	-.221	.074				
	(-0.43)	(1.28)				
LnOE	.091		.083			
	(0.32)		(1.37)			
LnADMIN	.091			.088		
	(0.15)			(1.33)		
LnMSD	.029				.073	
	(0.20)				(1.29)	
LnFIN	.116					.085
	(0.39)					(1.39)
Observations	62.000	62.000	62.000	62.000	62.000	62.000
Mean dependent var	17.266	17.266	17.266	17.266	17.266	17.266
SD dependent var	2.731	2.731	2.731	2.731	2.731	2.731
Chi-square	30.896	32.581	33.080	32.771	32.396	33.008
Prob > chi2						

t-statistics in parentheses

***,**and* denote significance at 1, 5 and 10% respectively

V. CONCLUSION

This study analyzed the factors that affect profitability in Food & Allied industries. The study used a dataset spanning 15 years and using 2SLS and GMM models for analysis. The results indicate that the factors influencing profitability differ greatly depending on the industry. Efficient utilization of expenses in the Food & Allied industry is essential, with a focus on operating expense control. These findings emphasize the necessity of using industry-specific approaches in asset management and financial planning. Managers should customize their strategies according to the distinct attributes of their industry, while policymakers should cultivate conditions that promote effective utilization of resources and optimization of operations. While the study offers significant insights, it is recommended that future research expands its reach to encompass new industries and investigates more dynamic economic conditions.

Implications: These findings have significant practical consequences for managers, industry stakeholders, and policymakers. Managers should customize financial strategies based on the unique attributes of each industry, as indicated by the results. Emphasizing expense management rather than capital spending can improve profitability in areas such as Food & Allied. The study emphasizes the significance for policymakers to establish a legislative framework that fosters a conducive climate for enterprises to enhance operational efficiencies. This may entail implementing measures that enhance financial accessibility, foster optimal asset utilization, and stimulate innovation in inventory management and capital allocation strategies.

Constraints and Prospects for Further Investigation: Although this study offers useful insights into the elements that determine profitability in key industries in Bangladesh, it is also subject to certain limitations. The utilization of a dataset spanning 15 years may not encompass all the fluctuating changes in the economic environment, and the concentration on food and allied industries restricts the applicability of the conclusions to all sectors. Future study has the potential to broaden its focus by incorporating supplementary industries, investigating various time periods, and employing alternative econometric models to capture more intricate processes.

The study improves comprehension of factors that contribute to profitability in Bangladesh, emphasizing the significance of tailored strategies for various industries to promote long-lasting growth.

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The Effectiveness of AI in Personalised Teaching: A Review

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Abstract- **Using Artificial Intelligence (AI) is no longer limited to business operations to achieve greater efficiency in today's world. With the recent release of GPT5, resources are ever easier to find and read through, cutting down on hours of research time for students and educators alike. Seeing students at all academic levels use AI to learn new languages, create designated routines for studying, or write homework assignments is now a common sight. The use of AI in education is a widely discussed topic among scholars. The following literature review draws findings from several papers found on academic databases, including Google Scholar, Springer Nature, Emerald, and IEEE Xplore, with the primary research question in mind: *How effective is AI as a personalised tutor?* Our study aims to answer this question by synthesizing related works on the issue, without focusing on any one subject or academic level in which AI can be made to serve as a personal educator/helper. At the same time, we also seek to discuss how ethical this phenomenon is, and whether schools should ditch traditional teaching methods for AI-equipped tools.**

Keywords: **AI in teaching, personalised teaching, AI as a personalised tutor, AI tutors, ChatGPT, AI in education, democratization of education**

II.INTRODUCTION

Artificial intelligence (AI) has significantly altered the way professors teach. It has made personalised learning feasible and scalable. AI is increasingly being utilized to tailor content, speed, and feedback to each student's unique needs. This includes adaptive learning platforms, intelligent tutoring systems (ITS), and, right now, big language models like ChatGPT [1], [2]. Researchers found that this change made students more involved, allowed them to learn on their own, and helped them do better in school overall [3, 6]. As AI gets easier to access, college students are using it to help them with their schoolwork. They utilize them for a lot of different things, like learning a new language or getting help with their homework [6]. AI-based tutoring systems have evident advantages, such as being available at any time of the day, being able to teach in numerous ways, and making students less reliant on teachers. Nonetheless, the incorporation of AI in educational contexts raises numerous serious concerns. Critics raise various questions, including the possibility that AI teachers would not adequately address students' social and emotional needs in the same manner that human educators can [5], [7], [9]. It has been noticed that students who are already at a disadvantage do not have equal access to AI educators. There is growing concern that over-reliance on AI technologies will impair children's capacity to acquire critical thinking abilities and solve problems autonomously [8]. This study aims to find out how useful artificial intelligence may be for individualized training as things change. This is done by looking at both old studies and new data collected through a systematic literature review. The study includes a lot of different levels and subjects of education. It looks at how AI affects education by weighing the pros and cons of possible benefits against ethical and practical problems that haven't been solved yet [4].

III.METHODOLOGY

We drew results for this paper by conducting a systematic literature review of past works done on this topic and other related areas pertaining to AI in education by other authors. We used a total of 23 research papers taken from well-reputed journals like Springer Nature, IEEE XPLORE, AIP Publishing, ISRES Publishing, and a book chapter from Intech Open to synthesize our findings.

IV.LITERATURE REVIEW

Modern education is being reshaped with the use of Artificial Intelligence (AI), which enables personalised learning experiences to adapt to a user's individual needs and preferences [1], [7]. AI-driven content, as well as educational and student-centric model sequences, are now leveraged by adaptive learning systems to deliver personalized instructions, pacing, and assessments to learners [2]. In our research, we came across two models: a) the educational model, and b) the student model. The educational model (better known as the pedagogical model) designs learning objectives, provides distributed practice sessions until mastery of the topic, and offers corrective feedback at regular intervals. On the other hand, the student model is responsible for constantly tracking performance to adjust task difficulty levels such that it fits within each learner's zone of proximal development [2], [6]. Intelligent Tutoring Systems (ITS) such as Betty's Brain and MetaTutor act as effective platforms for students to self-examine and self-regulate their learning strategies and often include key functions such as goal setting, reflective evaluation, and self-monitoring - all of which lead to better learning outcomes and skill transfer [3]. Generative AI (GAI) systems such as ChatGPT further broaden the horizons of these capabilities by imitating human-like speech, offering 24/7 availability, and delivering multi-channel resources catered to each user's auditory, visual, and kinesthetic learning preferences [2], [6].

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In one of the studies used as a reference in this paper, a survey of 247 undergraduate students concluded that a total of 68.8% of the students admitted to employing ChatGPT for personalised tutoring, thus highlighting the model's rapid adoption rate, as well as its perceived effectiveness in nurturing engagement and comprehension even among university students [6].

Even though several benefits relating to knowledge acquisition and learner engagement are listed as key benefits to the use of AI in teaching, concerns related to data privacy and security, socio-emotional development, and algorithmic bias still face AI tutors [7].

Moreover, the risk of learners becoming over-reliant on AI systems is always looming just over the horizon, with experts across literature arguing that students' tendency to "*prefer faster solutions (stemmed from generative AI recommendations) over slower ones backed by practicality is limiting their ability to make decisions, critically explore content for educational and research purposes, and perform comprehensive analytical reasoning*" [8].

Some scholars contend that using AI tutors in teaching may also broaden the gap between privileged and underprivileged students across borders, with the latter receiving the short end of the stick [7]. This notion is backed by the argument that historically underrepresented populations usually get to use the AI teaching tools once it has already been made available to the large-scale public, when making changes to the system may prove to be more difficult than if it had been pointed out in the pilot-testing period (when historically well-supported populations had the opportunity to try it out). As a result, when the underrepresented groups use the tools, it does little to cater to their way of learning, as the model has already been programmed for their well-represented counterpart [9]. On top of that, AI systems cannot yet cater to learners' socio-emotional needs by offering the same level of sympathy as human tutors, and only using AI tools in teaching may also inhibit students from realising their higher-order needs, such as teamwork and creativity [3], [5]. Furthermore, most AI learning tools remain solely focused on very specific performance metrics, oftentimes only that relating to the content the student needs help with, and thus overlooks other key areas of importance such as general competencies and the learning agency of students, as defined in frameworks like the OECD Learning Compass 2030 [5], [9].

One interesting study we came across delved into the use of AI for the *processes* of learning rather than the *products* of education. As defined by the author of the original paper, the product of a learning program would be an essay that a student writes, which can then be used to gauge the student's understanding of a certain subject - or in other words, the process by which they were able to learn about said subject. The same study then went on to investigate how AI learning tools could be used to reduce maths anxiety in students and concluded that the practical application of AI in mathematics improved learners' acumen in the subject by giving them a heightened sense of control and value [3].

Even though AI tutors are versatile enough to promise the democratization of education on a global scale by attenuating the impact of teacher shortages and expanding the reach of quality education to remote and underserved communities [4], this feat still requires global governments to address technological barriers so that strong data governance can be guaranteed.

Lastly, we believe that while AI is effective as a personalised tutor - helping students attain one-on-one lesson plans catered to their individual needs, among other things - it alone cannot be used as a method of imparting beneficial knowledge. As such, crucial principles like honesty, empathy, respect, responsibility, and kindness cannot be taught to students without the existence of an actual teacher in the learning space from whom learners will pick up on manners, etiquette, and good conduct simply through observation.

V.FINDINGS & DISCUSSION

AI is reshaping the entire framework of personalised learning across all levels, from early childhood to higher education and even vocational training. Its growing ability to deliver catered instruction to students stems from its roots in automated adaptive learning systems backed by its capability to analyse learner behaviour, and deliver dynamic feedback without a significant lapse in time. Current literature confirms that AI-based personalised learning systems stimulate better learning outcomes, enhance students' engagement, and give learners better access to education, despite questions around overreliance, empathy gaps, and fairness being raised.

Throughout all stages of learning, AI tutors and Intelligent Tutoring Systems (ITS) have displayed the potential to replicate or even surpass some of the benefits of interpersonal human interaction between teachers and students in the classroom. Some studies we reviewed highlighted how AI supplements student learning by offering on-the-spot adaptation to a learner's pace, skill level, and progress so that they're not under- or overwhelmed by the study load; hence, helping instructors bridge learning gaps more effectively than traditional classroom methods [2], [7]. Tools like MetaTutor and ChatGPT, among other dialogue-based platforms, have exhibited the ability to foster metacognitive skills such as self-regulation, goal-setting, and reflection in learners [2], [3], [11]. As such, these systems have become increasingly important in higher education and self-learning conditions, where individual attention from instructors is limited [24].

A study by OECD published in the OECD Digital Education Outlook in 2021 [9] mentioned how AI-based platforms can aid educators in having a better understanding of their students so that they can intervene with the students' learning journey at the right time. For instance, chatbots and automated tutors provide instantaneous feedback and generate constructive learning frameworks that are in line with a learner's current level of understanding [6], [11], [18]. AI tutors are especially helpful in mathematics and language education, where studies have shown that they

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increase information retention through techniques like spaced repetition and retrieval practice, often at a much lower cost and higher availability than human alternatives [3], [5], [16].

A noteworthy benefit of using AI tutors is their ability to promote equity in education. Personalised AI systems have been proven to provide access to quality teaching resources, which is particularly helpful in underserved communities and in communities where experienced tutors are rare [12], [20], [21]. Technical schools in the UAE used AI-enabled tools in vocational education and have reported that it helped reduce dropout rates and supported student progress through predictive modelling and personalised content delivery [10]. Likewise, students with disabilities, language learners, and students from multinational or multicultural backgrounds all reported having benefited from the ability of AI tools to cater instructions across sensory modes (text, audio, and video) [10], [22], [23].

From an analytical point of view, personalised AI tutors are associated with enhanced learner motivation and knowledge acquisition. Studies have shown how AI tools helped improve psychological engagement and the overall quality of learning by adjusting the task complexity and providing on-the-spot support through feedback [6], [21]. Generative AI tools, specifically, such as ChatGPT, are more adept at helping students achieve better performance in problem-solving and reflective thinking [13], [15], [23]. These AI tools also help tutors by reducing grading time, making content creation less time-consuming, and serving personalised alerts for each learner - all of which helps educators allocate more time to the human-centric aspect of teaching.

Despite all this, AI systems have multiple limitations. One of the most frequently discussed concerns across the literature is the absence of human empathy in AI-driven education tools. Even though AI can simulate conversational flow and give learners immediate feedback on their performance, it often struggles to understand emotional cues, subtle lapses in motivation, or socio-cultural dynamics that humans can easily manage [3], [6], [12]. Multiple researchers have warned against over-reliance on AI, stating that it would lead to reduced educational diversity and over-standardised student experiences [14].

An increasing number of research studies are also highlighting the effect of overreliance on AI systems for learning, stating that doing so is weakening students' critical thinking skills over time [8], [18]. On top of that, algorithmic bias and data privacy issues remain pressing since AI systems are constructed upon a bed of training data obtained through machine learning (ML), and the responses provided by the AI tool will only be as fair as the data it was provided with. In other words, faulty or biased data may lead to further discrimination than traditional learning experiences [17].

Evidence from Gabriel et al. [3] and OECD [9] both show that blended learning environments - where AI and human teachers co-exist side by side - yield the best outcomes. Furthermore, AI systems may often tend to be too lenient or over-affirming, which may lead to students developing a false sense of proficiency, which will only affect them negatively down the line [11], [14].

Some learners have also mentioned that they feel 'disconnected' with the AI when the responses come in too fast or are too impersonal [13]. Technical and vocational learners may have a higher likelihood of feeling this way since their study content is mostly based on practical and applied methods [10], [20].

VI.CONCLUSION

To conclude, we affirm that AI plays a significant role in transforming education by way of increased personalisation. Its core strengths lie in automating and scaling individual support, improving engagement, and making education more accessible. Needless to say, if AI systems should be implemented across all educational levels and scenarios, they must first be built ethically - keeping cultural and socio-dynamic context in mind, and used alongside human intellect. Instead of making the whole discussion about one or the other, AI tutors should be used to augment rather than replace human educators. While AI systems provide automated instructions, instantaneous personalised feedback, and access to a large pool of information, human teachers can nurture students through empathy and instill core morals and values in them, to ensure learners turn out to be good people and not just good students. At the end of the day, the efficacy of AI in education isn't just a measure of how fast it can help students get the work done, but rather about whether it can be used to foster pedagogical integrity, data transparency, and inclusivity within students.

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The Impact of Geopolitical Tensions on Global Supply Chains and Inflation Dynamics

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Abstract- **Geopolitical tensions are increasingly shaping the stability of global supply chains and the dynamics of inflation. Traditional analyses often examine these domains separately and overlook their recursive interconnections. This study develops a Geopolitics, Supply Chain, Inflation (GSI) framework to explain how shocks originate, propagate, and persist through feedback loops. The paper draws on thematic literature and three case studies: the Russia–Ukraine war, the U.S.–China trade war, and the COVID-19 pandemic. It shows that geopolitical disruptions, whether driven by military conflict, protectionist policy, or systemic health crises, share common economic effects. These disruptions break down supply chains and transmit into both cost-push and demand-pull inflation. The findings reveal that policy responses designed to stabilize economies, such as subsidies, monetary tightening, or reshoring, often create new vulnerabilities that feed back into the system and generate further instability. This recursive dynamic challenges linear models of geopolitical risk and inflation by showing how interventions can amplify rather than resolve fragilities. The GSI framework thus advances the understanding of inflation as an evolving outcome of repeated geopolitical and structural interactions, providing a conceptual tool for navigating an era where shocks are systemic, spillovers are global, and instability is self-reinforcing.**

Keywords: **Geopolitical Risk, Global Supply Chains, Supply-Side Inflation, Geopolitics–Supply Chain–Inflation (GSI) framework, Cost-Push Inflation, Political Economy**

I.INTRODUCTION

The twenty-first century has witnessed an intensification of geopolitical tensions, ranging from the U.S.–China trade war to the Russia–Ukraine conflict and the global disruption triggered by the COVID-19 pandemic. These events have underscored the deep interdependence of modern economies and exposed the vulnerabilities of global supply chains.

Disruptions in logistics, energy flows, and agricultural trade have not only destabilized production networks but also generated significant inflationary pressures worldwide [1], [3], [8]. The consequences of these dynamics are profound, as inflation driven by geopolitical factors tends to spill over across borders, creating uncertainty for firms, households, and policymakers alike.

The study of geopolitical risk (GPR) has evolved as a crucial field for understanding these dynamics. Research demonstrates that GPR is both measurable and predictive, shaping trade flows, financial markets, and macroeconomic stability [1], [9], [10]. However, while the role of geopolitical shocks in disrupting economic systems is well recognized, their transmission mechanisms through global supply chains and into inflationary processes remain underexplored. Supply chain resilience research has advanced significantly [2], yet it lacks a unifying framework that integrates the interplay between geopolitical disruptions, supply chain fragility, and inflationary outcomes.

Inflationary dynamics themselves are contested in economic theory. While classical models distinguish between demand-pull and cost-push inflation, recent evidence suggests that supply-side disruptions and geopolitical shocks increasingly dominate current price dynamics [4], [5]. Energy crises exemplify this pattern: sharp increases in energy prices, often triggered by geopolitical events, cascade through production systems, raise input costs, and contribute to persistent inflationary spirals [5]–[7]. In addition, post-crisis analyses indicate that global trade resilience depends heavily on structural adjustments in supply networks following COVID-19 and the Ukraine war [12]. Similarly, food and agricultural markets, highly exposed to war and trade restrictions, have become key drivers of sectoral volatility and social instability [8], with tariff shocks further exacerbating vulnerabilities in staple crop dependencies [13].

Despite the richness of individual strands of literature, a major gap persists in synthesizing these dimensions into a coherent explanatory framework. Existing studies often analyze geopolitics, supply chains, and inflation separately, overlooking how these elements interact in reinforcing cycles. Addressing this limitation, the present study introduces the Geopolitics–Supply Chain–Inflation (GSI) framework, which conceptualizes the progression of shocks from geopolitical origins, through supply chain networks, to inflationary outcomes. By synthesizing thematic literature and analyzing case studies—including the Russia–Ukraine war, U.S.–China trade tensions, and COVID-19 disruptions—the framework traces how shocks originate, transmit, and materialize in inflation. Furthermore, incorporating the energy–food nexus perspective highlights how crises in one domain amplify systemic vulnerabilities across others [14], [15]. In doing so, it offers insights for

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central banks, firms, and policymakers navigating an era of heightened geopolitical risk.

II.LITERATURE REVIEW

2.1 Geopolitical Risk as a Catalyst of Supply Chain Disruption

Geopolitical risk (GPR) has become a central concept in explaining disruptions to global economic systems. Scholars argue that GPR is not only a descriptive indicator of instability but also a predictive tool with measurable economic implications [1]. The literature shows that geopolitical shocks manifest through conflicts, sanctions, and trade restrictions, all of which destabilize global value chains. For instance, bibliometric analyses highlight how supply chain resilience scholarship has expanded significantly in recent years but still struggles to consolidate around a coherent theory [2]. Trade wars represent a clear example of this vulnerability, with protectionist policies reshaping production flows, raising costs, and creating uncertainty for firms engaged in international trade [3]. These findings suggest that GPR functions as the *origin point* of the GSI framework, where shocks are generated before cascading into downstream disruptions.

2.2 Supply Chain Breakdown and Inflation Transmission

The breakdown of supply chains has a direct bearing on inflation dynamics. Shortages of inputs, transport bottlenecks, and shifts in sourcing strategies transmit geopolitical shocks into higher costs for producers and consumers. Theoretical debates continue around whether recent inflationary episodes are demand-pull or cost-push in nature, with growing evidence that cost-push dynamics dominate in the wake of supply disruptions [4]. Supply chain fragility amplifies the inflationary impact, as disruptions propagate through just-in-time production networks and concentrated supplier bases [3]. In the GSI framework, supply chains represent the *transmission channel* through which geopolitical risks are converted into inflationary pressures.

2.3 Energy Markets as a Geopolitical Inflation Channel

Energy markets occupy a unique role in the literature as both a driver and amplifier of inflation. Studies show that energy crises, often triggered by geopolitical events, generate immediate and widespread inflationary effects [5]. Empirical evidence from the euro area demonstrates strong pass-through of energy price shocks into consumer inflation [6], while analyses of historical price cycles confirm the persistence of such effects in creating inflationary spirals [7]. Furthermore, geopolitical risk interacts with energy markets in complex ways, as energy dependence and policy responses determine the scale of inflationary outcomes [10]. Within the GSI framework, energy serves as a *critical node* amplifying the transmission of shocks across the global economy.

2.4 Food, Agriculture, and Sectoral Volatility

Beyond energy, food and agriculture represent sectors highly vulnerable to geopolitical disruptions. The Russia–Ukraine war provides a salient example, as restrictions on grain and fertilizer exports triggered severe food inflation in European markets [8]. Rising food prices not only exacerbate household burdens but also generate political instability, highlighting the sectoral sensitivity of inflationary shocks. This body of literature emphasizes that geopolitical risk has asymmetric impacts across industries, with food and agriculture particularly exposed to supply-side disruptions. In the GSI framework, these sectors illustrate *sector-specific vulnerabilities* that magnify inflationary pressures.

2.5 Structural and Political Economy Perspectives

A structural perspective situates the inflationary consequences of geopolitical risk within broader political economy debates. Scholars argue that geopolitical risk interacts with the global energy transition, shaping both vulnerabilities and opportunities in the shift toward renewable sources [9]. Historical surveys of energy markets reinforce the long-term entanglement of geopolitical risk with structural economic outcomes [10]. These perspectives highlight that inflationary dynamics are not merely cyclical but embedded in long-term processes of energy dependence, institutional adaptation, and global power realignment. In the GSI framework, this represents the *structural dimension* that determines how shocks evolve over time.

2.6 Gaps and the Need for Integrated Frameworks

While the literature provides rich insights into each component of the GSI framework, significant gaps remain. Studies on GPR emphasize predictability and economic effects [1], [9], [10], while supply chain resilience research points to vulnerabilities without integrating inflationary outcomes [2]. Energy and food markets are widely studied, but analyses often remain sector-specific [5]–[8]. Few attempts have been made to synthesize these literatures into a single explanatory model. This fragmentation underscores the need for an integrated framework that links geopolitical risk, supply chain breakdowns, and inflation dynamics in a systematic way. The present study addresses this gap by advancing the Geopolitics–Supply Chain–Inflation (GSI) framework, designed to trace the progression of shocks from their origins to their inflationary consequences.

III. CONCEPTUAL FRAMEWORK

Global supply chains are increasingly recognized as the main arena where geopolitical shocks and macroeconomic forces converge. Existing research has examined geopolitical risk [1], supply chain resilience [2], and inflation transmission [4]–[7] as separate themes. Yet, the lack of integration across these strands limits our understanding of why disruptions persist and why inflationary effects often outlast the initial shock. To address this gap, this study advances the Geopolitics–Supply Chain–Inflation (GSI) framework, which emphasizes the recursive, multi-level, and path-dependent nature of these dynamics.

The framework is anchored in three complementary theoretical traditions. From complex systems theory, it draws the idea that global supply chains function as adaptive yet fragile networks. A disruption in one node—such as an

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energy choke point or a port closure—propagates quickly through the system and multiplies across sectors [2]. From international political economy (IPE), the framework interprets geopolitical events as strategic exercises of power rather than random shocks. Trade wars, sanctions, and energy leverage, for example, are deliberate political choices that reshape production and trade patterns [1], [3], [8]. Finally, inflation transmission theory explains how cost-push and pass-through mechanisms transform these disruptions into persistent price pressures [4], [5]. In other words, once costs rise in key inputs such as fuel or food, they cascade throughout the economy, reinforcing inflationary spirals [6]–[8], [10].

The framework operates across multiple levels of analysis. At the firm level, companies confront input shortages and rising transportation costs, leading to strategies such as supplier diversification or reshoring [2]. At the sectoral level, amplifiers such as the energy and food industries transmit localized disruptions across the entire system [5]–[8], [10]. For instance, an oil price spike raises costs not only for transport but also for manufacturing and agriculture, magnifying the original shock. At the macro level, governments and central banks respond through monetary, fiscal, and trade policies, reshaping global supply networks in ways that often stabilize in the short term but embed new risks over the longer horizon [3], [9], [10].

The distinctive contribution of the GSI framework lies in its focus on recursive dynamics. Inflationary pressures lead central banks to raise interest rates, but tighter credit can also suppress investment in logistics and diversification, leaving supply chains weaker for the next shock [4]. Similarly, protectionist measures designed to shield domestic markets often fragment trade networks and push prices higher, reinforcing the very inflation they seek to control [3]. Inflation itself can intensify geopolitical tensions by fueling unrest, prompting populist policies, or triggering new trade restrictions [8]. Even forward-looking strategies such as accelerating the energy transition may create new vulnerabilities, as countries become dependent on rare minerals and technologies concentrated in a few regions [9], [10].

In sum, the GSI framework highlights that global economic instability is not a matter of isolated shocks followed by recovery. Instead, each disruption—and the policies devised to manage it—plants the seeds for the next round of instability. Rather than returning to equilibrium, the global economy evolves through cycles of disruption, response, and renewed fragility. This recursive, self-reinforcing character is what distinguishes the framework and positions it as a tool for analyzing the persistence of crises in an era of heightened geopolitical tension.



IV.METHODOLOGY

This study adopts a qualitative, integrative research design that combines a systematic thematic literature synthesis with comparative case study analysis. Such a design is particularly suited to examining complex, multi-level phenomena where geopolitical events, supply chain disruptions, and inflationary outcomes interact in recursive ways that cannot be captured through linear or purely quantitative models [1], [2], [4].

4.1 Research Design

The research follows an exploratory-conceptual design. The aim is not to test a single hypothesis, but to build a theoretically grounded framework—the Geopolitics–Supply Chain–Inflation (GSI) model—capable of explaining the persistence and recurrence of disruptions. The design is justified by the fragmented nature of the existing literature, where geopolitical risk studies [1], supply chain resilience research [2], and inflation analyses [4]–[7] remain largely siloed. Integrating these bodies of work into a unified model required a flexible methodology combining conceptual synthesis and empirical illustration.

4.2 Thematic Literature Synthesis

The literature review was conducted using a structured thematic synthesis approach. Sources were first categorized into three clusters: (i) studies on geopolitical risk and uncertainty [1], [3], [8]; (ii) research on supply chain resilience and disruption transmission [2]; and (iii) works addressing inflationary mechanisms, with a focus on energy and food shocks [4]–[7], [9], [10]. Within each cluster, key mechanisms and conceptual contributions were identified and compared. This process enabled the identification of overlaps and gaps, particularly the absence of integrative models connecting geopolitics, supply chains, and inflation. The synthesis informed the development of the GSI framework in Section 5.

4.3 Case Study Integration

To complement the conceptual framework, the study employs a comparative case study method. Case studies were selected using a theoretical sampling logic, focusing on events that exemplify different types of geopolitical

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shocks and their inflationary consequences. Three cases were chosen:

- The Russia–Ukraine war, which disrupted energy and food markets, leading to inflationary surges across Europe[8].
- The U.S.–China trade war, which introduced tariff barriers and input price volatility, illustrates protectionist-driven cost pressures[3].
- The COVID-19 pandemic, which, while primarily a health crisis, triggered geopolitical responses that strained supply chains and reshaped inflation dynamics [2], [4].

These cases were not chosen for statistical representativeness but for their ability to demonstrate mechanisms central to the GSI framework: energy shocks, trade disruptions, and systemic crises. Comparative analysis across these cases enhances the explanatory depth of the framework, allowing for both pattern recognition and contextual differentiation.

V.DISCUSSION

The dynamics of the Geopolitics–Supply Chain–Inflation (GSI) framework can be better understood by examining how shocks originate, how they propagate through production networks, and how they culminate in inflationary pressures. Crucially, these dynamics are recursive, meaning that responses to each disruption create new vulnerabilities and potential triggers for subsequent crises. This section elaborates the framework across five interrelated dimensions: geopolitical risk as a supply chain trigger, the transformation of disruptions into inflationary outcomes, regional and sectoral vulnerabilities, structural consequences, and the synthesis of these elements into a coherent model of dynamic instability.

5.1 Geopolitical Risk as a Supply Chain Trigger

Geopolitical events often represent the first node of disruption in the global economy. Wars, sanctions, and trade disputes not only hinder the free flow of goods but also reshape production networks through deliberate exercises of political power. For instance, the Russia–Ukraine war restricted exports of energy and grain, while the U.S.–China trade war disrupted the flow of intermediate goods vital to global electronics and manufacturing [3], [8]. These events highlight that geopolitical shocks cannot be considered exogenous anomalies; rather, they are endogenous to the functioning of the global political economy and represent deliberate strategies that ripple through supply chains.

5.2 From Supply Disruption to Inflation

The passage from disruption to inflation is mediated primarily through cost-push and pass-through mechanisms. Rising energy prices, whether due to conflict or market uncertainty, cascade into transport, manufacturing, and agriculture [5]–[7]. Food markets reveal similar vulnerabilities, as disruptions in grain and fertilizer supplies during the Russia–Ukraine conflict translated into sharp increases in global food prices [8].

This dynamic speaks directly to a long-standing macroeconomic debate: is inflation primarily driven by demand-pull pressures or by supply-side constraints? Recent work suggests that post-2020 inflation has been predominantly cost-push in nature, amplified by global supply chain bottlenecks and geopolitical risk [4]. The GSI framework reinforces this position by showing that inflationary episodes in the current era are less about overheating demand and more about systemic fragilities in global production and distribution. In other words, geopolitical shocks exert a magnifying effect: what begins as a localized disruption in one sector reverberates across others, ultimately materializing in widespread inflation. Evidence from post-COVID and Ukraine war disruptions further suggests that trade resilience remains uneven, with structural bottlenecks amplifying inflationary persistence [12].

5.3 Regional and Sectoral Vulnerabilities

The severity of disruption and inflationary effects is uneven across regions and sectors. European economies, with their dependence on Russian energy, have experienced sharper and more persistent inflationary pressures compared to more diversified economies [6], [8]. Likewise, food-importing countries are disproportionately affected by disruptions in agricultural exports. The vulnerability of specific sectors such as logistics, semiconductors, and fertilizers reveals the asymmetric nature of geopolitical shocks.

These differentiated effects underscore the need to analyze vulnerabilities not only in aggregate macroeconomic terms but also in relation to structural dependencies. The framework highlights that regional integration into specific supply networks—whether energy pipelines, agricultural imports, or rare-earth minerals—shapes exposure to shocks. This will become clearer in Section 6, where the comparative analysis of Europe, the U.S.–China nexus, and global pandemic disruptions illustrates how context amplifies or dampens vulnerabilities. For example, tariff shocks on staple crop imports have been shown to intensify exposure in already fragile food-importing economies, worsening inflationary pressures [13].

5.4 Structural Outcomes and Long-Term Effects

While inflation is often treated as a cyclical phenomenon, the GSI framework demonstrates that it is increasingly structural. Central bank tightening, intended to control inflation, reduces investment in infrastructure and diversification, leaving supply chains more fragile [4]. Similarly, protectionist measures such as reshoring or tariffs may reduce short-term exposure but create longer-term inefficiencies, raising costs throughout the system [3].

The energy transition illustrates another layer of structural consequence. While aimed at reducing fossil-fuel vulnerabilities, it introduces new dependencies on critical minerals, many of which are geographically concentrated [9], [10].. Studies of the energy–food nexus further confirm that crises rarely remain sector-specific; disruptions in one

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sector (e.g., energy) spill over into others (e.g., agriculture and health systems), entrenching long-term inflationary fragilities [14]. The recursive cycle of attempted solutions generating new fragilities illustrates the path-dependent nature of geopolitical-economic instability.

5.5 Conceptual Synthesis

The discussion reveals that geopolitical shocks, supply chain fragility, and inflationary pressures are not isolated episodes but interconnected stages in a recurring cycle. Each stage reinforces the next, creating a recursive system of instability. Instead of disruptions being temporary shocks followed by recovery, the GSI framework shows that responses themselves—whether monetary tightening, trade protectionism, or energy transition—plant the seeds for the next disruption.

Looking ahead, this recursive instability suggests that the "age of shocks" is unlikely to subside. Future tensions over decarbonization, technological sovereignty, and strategic reshoring will almost certainly generate new disruptions. As Section 6 illustrates, whether through Russia's energy weaponization, U.S.–China tariff escalation, or pandemic-induced bottlenecks, the pathways remain consistent: geopolitical shocks amplify vulnerabilities in supply networks, which then translate into persistent and uneven inflationary dynamics. By incorporating the cross-domain perspective of energy–food linkages, the GSI framework also anticipates how next-generation shocks may propagate in unexpected but systemic ways [15]. The recursive feedback loops identified in the GSI framework thus offer a valuable lens for anticipating—not merely explaining—the next wave of disruptions.

VI. CASE STUDY ANALYSIS

6.1 Russia–Ukraine War and European Energy-Driven Inflation

The Russia–Ukraine war represents the clearest example of how geopolitical shocks cascade through supply networks into inflationary pressures. Prior to the conflict, the European Union was heavily dependent on Russian natural gas, which accounted for roughly 40% of its imports [8]. The outbreak of war in February 2022, coupled with subsequent sanctions and retaliatory supply cuts, transformed energy markets overnight. Gas flows through Nord Stream pipelines fell drastically, while oil embargoes and price caps reshaped global supply patterns.

From a GSI perspective, the war illustrates how geopolitical shocks generate first-order disruptions (energy shortages), which then produce second-order effects across multiple sectors. As natural gas prices surged, electricity costs rose sharply, feeding into industrial production and household consumption [5], [6]. Fertilizer prices increased due to higher natural gas costs, pushing agricultural prices upward and triggering food inflation, especially in import-dependent economies [8]. This chain reaction confirms the recursive dynamics of the framework: an initial energy shock multiplied across supply networks, producing broad-based inflation.

The inflationary spiral in Europe also demonstrates how policy responses can reinforce instability. Central banks in the euro area tightened monetary policy aggressively, raising borrowing costs for firms and households. While intended to curb demand-pull inflation, these measures reduced investment in diversification strategies, keeping Europe structurally dependent on volatile global energy markets [4], [6]. Governments attempted to cushion households through subsidies and price caps, but such measures created fiscal burdens and delayed incentives for long-term energy transition. In effect, short-term stabilization planted the seeds of future fragility, consistent with the recursive loops identified in the GSI model.

Furthermore, the case highlights the global spillovers of regional conflicts. As European buyers scrambled for liquefied natural gas (LNG), competition drove up global prices, affecting Asian importers who were not directly involved in the conflict. Similarly, disruptions in Ukrainian grain exports through the Black Sea pushed global food prices higher, worsening food insecurity in developing economies. Thus, what began as a regional geopolitical event became a global inflationary shock.

In sum, the Russia–Ukraine war exemplifies how energy dependencies translate geopolitical instability into persistent inflationary pressures. It also demonstrates how responses—monetary tightening, subsidies, and rapid diversification—create new dependencies and vulnerabilities, confirming the GSI framework's recursive logic.

6.2 The U.S.–China Trade War and Global Input Price Volatility

The U.S.–China trade war, initiated in 2018 and intensifying through 2019–2020, represents a different but equally consequential geopolitical disruption. Unlike the sudden onset of the Russia–Ukraine war, the trade war unfolded as a sequence of escalating tariffs, countersanctions, and regulatory restrictions. These measures disrupted global supply networks not through direct physical shortages but by introducing uncertainty, altering input costs, and fragmenting production structures [3].

From the GSI perspective, the trade war reveals how policy-driven protectionism functions as a geopolitical shock. Tariffs imposed on steel, aluminum, and a wide range of intermediate goods increased costs for U.S. manufacturers while also forcing supply chain reconfigurations. Similarly, Chinese countermeasures, including restrictions on U.S. agricultural imports and the targeting of technology supply chains amplified volatility. The result was an environment of price instability, where firms faced both higher input costs and heightened uncertainty about future trade flows.

The inflationary consequences were not uniform. In the U.S., consumer prices rose most visibly in tariff-affected goods such as washing machines and electronics. However, the more profound impact was structural, as supply chains began to reorganize. Firms accelerated moves toward "China+1" strategies, shifting production to Vietnam, Mexico, and other alternatives. While these adjustments

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aimed to reduce long-term exposure, they created short-term inefficiencies, including higher costs, coordination problems, and reduced economies of scale. In other words, diversification itself generated inflationary pressure, reinforcing the recursive loop identified in the GSI framework.

Moreover, the trade war exposed the global economy to second-order vulnerabilities. For example, U.S. restrictions on semiconductors and related technology imports accelerated China's drive for technological self-sufficiency. This has contributed to the creation of parallel ecosystems, increasing the risk of duplication and inefficiency in global production networks. These fragmentation pressures—while geopolitical in origin—manifest economically as cost escalation and supply rigidity, feeding into inflationary tendencies across advanced manufacturing sectors.

Policy responses again reinforced instability. U.S. attempts to subsidize reshoring and domestic production under frameworks such as the CHIPS Act reflect an effort to stabilize supply chains. Yet, by concentrating supply networks domestically, these strategies risk future vulnerabilities should internal shocks (such as labor shortages or domestic political disruptions) occur. Much like Europe's energy crisis, the trade war illustrates how remedial measures create future fragilities rather than resolving systemic risk.

Finally, the trade war highlights the global reach of bilateral disputes. Supply chain reconfigurations forced ripple effects across Southeast Asia, Latin America, and Africa, where economies became integrated into restructured value chains. The result was an uneven inflationary pattern: while some emerging economies benefited from increased foreign investment, they also faced higher domestic prices as global production costs rose.

In sum, the U.S.–China trade war demonstrates how protectionist measures, intended to safeguard national economies, can trigger systemic inefficiencies that fuel global inflationary pressures. This case reinforces the recursive insight of the GSI framework: policies aimed at risk mitigation frequently embed the conditions for new forms of vulnerability.

6.3 COVID-19 Pandemic and Geopolitical Responses to Supply Chain Stress

The COVID-19 pandemic represents a unique case of systemic disruption where a global health emergency rapidly translated into geopolitical, economic, and supply chain crises. Unlike the Russia–Ukraine war or the U.S.–China trade conflict, the pandemic did not originate as a deliberate political act. However, state responses to the crisis, including export restrictions, vaccine nationalism, and border closures transformed a health shock into a geopolitical-economic disruption with profound inflationary consequences [2], [4].

From the perspective of the GSI framework, COVID-19 demonstrates how non-political shocks can become politicized through state interventions. In the early months of the pandemic, countries imposed export bans on medical equipment, pharmaceuticals, and food staples. Such restrictions deepened supply shortages, creating bottlenecks in critical value chains. At the same time, widespread lockdowns disrupted global logistics networks, producing port congestions, container scarcities, and surges in shipping costs. These disruptions quickly fed into inflation by raising transport and input costs across multiple sectors.

The inflationary dynamic of the pandemic was complex, combining supply-side and demand-side forces. On the one hand, bottlenecks in production and transport increased costs, consistent with cost-push inflationary pressures [4]. On the other hand, unprecedented fiscal and monetary stimulus in advanced economies boosted aggregate demand at a time when supply capacity was constrained, creating demand-pull inflation. The coexistence of these forces blurred traditional inflation typologies, reinforcing the need for an integrated framework such as GSI to explain how supply constraints and policy responses interact recursively.

Geopolitical dimensions became evident as the pandemic progressed. Competition for vaccines between advanced and developing economies underscored global inequality and created tensions in international cooperation. Similarly, supply chain localization debates accelerated, with governments and firms considering reshoring or nearshoring of strategic industries such as pharmaceuticals and semiconductors. While intended to enhance resilience, these efforts mirrored the recursive logic observed in other cases: by attempting to reduce dependence on global supply chains, states created new inefficiencies and dependencies, thereby embedding the conditions for future disruptions [2].

The pandemic also highlighted the interconnectedness of global supply chains in a way not seen before. Shortages in semiconductors, driven by factory shutdowns in Asia, cascaded into automobile production slowdowns in Europe and North America. Food prices rose not only due to logistics bottlenecks but also because of labor shortages in agriculture. These multi-sectoral disruptions illustrate the GSI framework's emphasis on recursive amplification: shocks in one domain (health) reverberate across multiple economic layers, producing inflationary outcomes that persist long after the original trigger subsides.

In summary, the COVID-19 case demonstrates how a non-geopolitical crisis can evolve into a geopolitical-economic event through state responses. It also reveals the hybrid nature of pandemic-driven inflation, combining both demand-pull and cost-push mechanisms, while reinforcing the recursive insight that policy remedies aimed at stabilization frequently create new forms of fragility.

VII.COMPARATIVE INSIGHTS

The three case studies—the Russia–Ukraine war, the U.S.–China trade war, and the COVID-19 pandemic—reveal both the diversity of geopolitical disruptions and the underlying regularities in how such shocks translate into inflationary dynamics. When considered together, they provide robust

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evidence for the recursive logic of the Geopolitics–Supply Chain–Inflation (GSI) framework.

A first insight is that geopolitical shocks vary in origin but converge in effect. The Russia–Ukraine conflict emerged from a conventional military confrontation, the U.S.–China dispute from deliberate economic policy choices, and the COVID-19 pandemic from an exogenous health emergency. Yet in all three cases, the disruptions translated into inflation through supply chain fragilities, whether in energy, trade, or logistics. This convergence underscores that while the triggers differ, the pathways of disruption share common features: bottlenecks, rising costs, and policy responses that amplify instability.

A second insight is the sectoral specificity of vulnerability. The Russia–Ukraine war demonstrated how energy dependence makes inflation highly asymmetric, with Europe facing greater shocks than other regions. The U.S.–China trade war showed that advanced manufacturing and technology sectors are disproportionately exposed to protectionist measures. The pandemic highlighted the multi-sectoral nature of systemic shocks, from semiconductors to food and transport. This suggests that vulnerabilities are not evenly distributed but shaped by structural dependencies embedded in global supply networks.

A third comparative finding is the role of policy responses as amplifiers of future fragilities. In all three cases, interventions intended to stabilize economies had recursive effects. European subsidies and price caps created fiscal strains and delayed long-term diversification [6]. U.S. reshoring efforts under the CHIPS Act reduced dependence on China but created new inefficiencies and risks of overconcentration [3]. Pandemic-era stimulus boosted short-term demand but collided with constrained supply, intensifying inflationary pressures [4]. These examples confirm the GSI framework's claim that responses to shocks frequently plant the seeds for the next cycle of instability.

The cases also differ in the temporal dynamics of inflation. The Russia–Ukraine war produced an immediate energy shock that rapidly transmitted into food and industrial prices. The trade war generated slower, cumulative inflationary pressures through rising tariffs and long-term reconfiguration. The pandemic produced hybrid inflation: initial deflationary tendencies from lockdowns quickly gave way to both cost-push and demand-pull inflation as supply constraints met expansionary policies. These variations highlight that while the inflationary pathways differ in speed and intensity, the recursive loops of disruption and response remain consistent.

Finally, the comparative analysis demonstrates the global nature of spillovers. Regional shocks invariably became global inflationary events. Europe's scramble for liquefied natural gas drove up energy prices in Asia, while U.S. tariffs reshaped trade flows across Southeast Asia and Mexico. Similarly, pandemic-induced shortages in semiconductors and shipping containers cascaded across continents. This suggests that in an era of deeply integrated value chains, no geopolitical disruption remains geographically contained; spillovers are systemic and unavoidable.

Taken together, these insights show that the GSI framework captures both the common mechanisms of disruption and the context-specific dynamics that shape outcomes. By analyzing cases across different types of shocks—military, policy-driven, and systemic—the framework demonstrates its explanatory breadth. More importantly, it highlights the recursive nature of global economic instability: rather than temporary anomalies, geopolitical disruptions are embedded in a cycle where each crisis and response generate the preconditions for future inflationary shocks.

VIII. CONCLUSION

This study has examined the complex relationship between geopolitical tensions, supply chain disruptions, and inflationary dynamics, offering both a systematic review of the literature and a comparative analysis of three critical cases: the Russia–Ukraine war, the U.S.–China trade war, and the COVID-19 pandemic. While these disruptions differ in origin—military conflict, protectionist policy, and global health crisis—they converge in their economic consequences, illustrating how geopolitical shocks are transmitted through fragile supply networks into persistent and uneven inflation.

The central contribution of this paper is the development of the Geopolitics–Supply Chain–Inflation (GSI) framework, which demonstrates that disruptions are not isolated anomalies but components of a recursive cycle. Geopolitical shocks create first-order supply chain breakdowns, which translate into cost-push and demand-pull inflation. Policy responses, whether monetary tightening, subsidies, or trade protectionism—aimed at stabilizing the system often create new inefficiencies, dependencies, or fiscal vulnerabilities. In other words, each attempt at resolution plants the seeds for the next disruption. This recursive logic distinguishes the GSI framework from existing approaches that treat geopolitical risk, supply chains, and inflation as separate domains.

The case studies reinforce the framework's explanatory power. Europe's energy dependence during the Russia–Ukraine war exposed how concentrated vulnerabilities amplify shocks. The U.S.–China trade war showed how protectionist measures restructure supply chains in ways that raise long-term costs. The COVID-19 pandemic highlighted how non-political crises can become politicized, transforming health shocks into geopolitical-economic disruptions. Comparative insights reveal that although the speed and intensity of inflationary outcomes vary, the recursive cycle of disruption and response remains consistent across cases.

These findings carry important implications. For policymakers, the GSI framework underscores the limits of

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short-term stabilization strategies that fail to address structural fragilities. For firms, it highlights the importance of resilience strategies that go beyond diversification to include adaptive capabilities in the face of systemic volatility. For the academic community, it provides a theoretical foundation for integrating research on geopolitics, supply chains, and inflation, fields that have too often remained siloed.

At the same time, this study is not without limitations. By relying on conceptual synthesis and selected case studies, it does not provide econometric quantification of the recursive loops. Future research could empirically test the GSI framework by combining global supply chain data with measures of geopolitical risk and inflation expectations. Another promising avenue lies in examining emerging domains—such as the energy transition, artificial intelligence, and critical mineral supply chains—that may constitute the next frontier of recursive instability.

In conclusion, the GSI framework advances understanding of how geopolitical tensions shape global economic outcomes in an era of heightened uncertainty. By tracing the pathways from shocks to supply chain disruption and inflation, and by revealing the recursive feedback loops that perpetuate instability, the framework offers a lens not only for explaining recent crises but also for anticipating the contours of future ones. In a world where shocks are increasingly systemic and interconnected, the challenge is not merely to recover from disruption but to break the cycle of fragility that drives it.

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Sustainability Trends in Green Financing for SMEs

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Abstract - **Green financing has emerged as a key tool for promoting sustainability among Small and Medium Enterprises (SMEs), yet many still face challenges in accessing the funds required for transition. Critical enablers such as corporate governance, stakeholder engagement, and supportive regulatory incentives expand opportunities for SMEs to adopt sustainable practices. While green finance fosters environmental responsibility, innovation, and transparency through sustainability reporting, implementation remains uneven. Barriers including unclear regulations, collateral demands, low financial literacy, and limited sectoral access continue to slow adoption. This paper reviews global patterns, drivers, and obstacles shaping green financing for SMEs, drawing evidence from China, Pakistan, Malaysia, Indonesia, Vietnam, the United States, and Europe. By examining regional contexts, the study highlights the conditions that enable or restrict financing uptake and offers insights for strengthening SME development through sustainable finance.**
Keywords - **Green financing, Green corporate governance, Sustainability trends, SMEs**

I.INTRODUCTION

Small and Medium Enterprises (SMEs) are widely regarded as central drivers of economic growth, employment generation, and innovation. However, they often encounter structural barriers in obtaining financial resources needed to transition toward sustainability. Green financing has emerged as a crucial solution, referring to the channeling of financial resources into projects and enterprises that deliver environmental benefits while supporting long-term economic growth [1]. This includes financial instruments such as loans, bonds, equity, and credit facilities that fund renewable energy, energy efficiency, sustainable agriculture, waste management, and clean technology initiatives.

Recent studies emphasize that green financing enhances both the environmental and financial performance of SMEs by aligning business models with sustainability objectives. In China, for example, green corporate governance combined with financing mechanisms has been shown to improve SMEs' sustainable outcomes, demonstrating governance as a critical enabler [2]. Similarly, research on Pakistan's textile and leather sectors shows that targeted green financial interventions foster cleaner production processes and sustainable industrial growth [1]. Sustainability reporting, particularly when combined with digital tools, has also emerged as a significant factor in strengthening transparency and accountability, thereby easing access to finance [3], [6].

Globally, SMEs are increasingly pressured to adopt sustainable practices not only by regulators but also by consumers and international supply chains. Evidence indicates that embedding data-driven financial models and environmentally responsible strategies within SME operations improves competitiveness and supports long-term growth [4], [5]. Yet, widespread adoption remains uneven due to barriers such as regulatory uncertainty, high compliance costs, limited financial literacy, and underdeveloped institutional structures [10]–[13], [15].

In response to these dynamics, this paper undertakes a systematic literature review to analyze global sustainability trends in green financing for SMEs. Drawing on examples from China, Pakistan, Malaysia, Indonesia, Vietnam, Europe, and the United States, it explores the enablers, constraints, and technological innovations shaping SME access to green finance. The aim is to provide an integrated perspective on how SMEs can leverage sustainable financing for growth, while also identifying policy and research gaps that must be addressed for broader adoption.

II.METHODOLOGY

This study follows a literature review approach to explore global trends in green financing for Small and Medium Enterprises (SMEs). The literature was sourced from a mix of peer-reviewed journal articles, conference papers, and institutional reports, primarily accessed through reliable databases like Scopus, Web of Science, ScienceDirect, and Google Scholar. Additionally, grey literature and policy documents from respected organizations such as UNEP and the German Development Institute were included to provide a comprehensive perspective. We focused on research published between 2014 and 2025 to capture both foundational knowledge and recent developments in the field. After applying clear inclusion and exclusion criteria, 21 key studies were chosen for in-depth analysis. These studies span a range of geographical regions, including China, Pakistan, Malaysia, Indonesia, Vietnam, the United States, and Europe, ensuring a well-rounded and diverse outlook on the topic.

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III.LITERATURE REVIEW

A. Definition of Green Financing

Green financing refers to the provision of financial resources for projects and enterprises that generate environmental benefits while supporting sustainable economic growth [1]. Within the SME context, it enables businesses to adopt sustainable practices and strengthen competitiveness. In China, for example, the integration of corporate governance with green finance has been shown to enhance SMEs' sustainable performance [2]. In Pakistan's textile and leather industries, access to green financial tools has encouraged cleaner production methods and long-term growth [1]. Additionally, sustainability reporting and the use of digital systems improve accountability and transparency, making financing more accessible [3], [6].

Lindenberg [18] describes green finance as covering both public and private investments, environmental protection efforts, and supporting institutional frameworks. Ozili [19] highlights its role in mobilizing financial flows toward achieving Sustainable Development Goals (SDGs). Similarly, Hu [20] stresses the importance of embedding ecological considerations into financial systems, while UNEP [21] situates green finance as a core component of the broader sustainable finance agenda.

B. Global Sustainable Trends

Sustainable financing has become a global priority for SMEs, with studies consistently showing that it strengthens both environmental and financial performance. In China, governance-based financing models improved SME sustainability outcomes [2]. Pakistan's experience with targeted financing confirmed the role of green finance in enabling cleaner production [1]. In the United States, incorporating green financing into business strategies was found to enhance competitiveness [5]. Globally, sustainability reporting supported by digitization has emerged as a significant trend, improving accountability and stakeholder trust [3], [6]. Export-driven SMEs have also benefited from adopting green innovation and readiness, boosting their performance in international markets [8].

C. Key Enablers of Green Financing

Several factors have been identified as critical to the success of green financing. Leadership commitment and organizational readiness have been highlighted as essential for facilitating SME transitions [7]. Sustainability reporting plays a dual role by ensuring compliance while strengthening credibility with stakeholders [6]. Entrepreneurial orientation and innovation also serve as important enablers, driving competitiveness and export performance [8], [9]. Comparative studies in Malaysia and Indonesia show that supportive institutional frameworks significantly amplify the positive impacts of green finance [14].

D. Barriers to Green Finance

Despite progress, many obstacles hinder the adoption of green financing by SMEs. European businesses often struggle with resource limitations, regulatory ambiguity, and high compliance costs [13]. In India, fragmented policies and weak institutional systems act as major barriers [15]. Malaysian SMEs face constraints such as limited access to capital, insufficient training, and technological gaps [11]. Broader studies classify these barriers into financial, technological, and informational categories, with knowledge gaps emerging as a recurring issue preventing SMEs from pursuing sustainable practices [10], [12].

E. Regional Evidence

The effectiveness of green financing varies across regions. In Pakistan's textile and leather sectors, green finance has supported industry-specific improvements [1]. In China, corporate governance is a key factor driving the effectiveness of financial mechanisms [2]. Studies in Malaysia and Indonesia reveal that institutional frameworks are vital for ensuring financial sustainability [14]. In Vietnam, SMEs achieved performance improvements through green financing when they possessed sufficient readiness and capability [17]. European SMEs, by contrast, continue to face barriers despite some supportive enablers [13], whereas U.S. SMEs benefit from integrating sustainability into financial planning [5].

F. Technology and Innovation

Technological progress has become a decisive factor in expanding SME access to green finance. Digitalization has enhanced reporting transparency and accountability [3]. Fintech solutions enable SMEs to embed sustainability criteria into financial decision-making [4]. Greentech ecosystems, which combine finance, technology, and sustainability, have emerged as collaborative platforms supporting adoption [16]. Entrepreneurial innovation and green-oriented strategies further increase access to finance and boost competitiveness [8], [9].

IV.RESULTS

The review of selected studies provides detailed insights into how SMEs engage with green financing and the implications of these practices. Findings are organized into five thematic areas:

A. Global Sustainable Trends

Research consistently shows that SMEs across the world are adopting sustainability goals through green financing initiatives. In China, Wang et al. [2] found that when governance structures were linked to financing, SMEs achieved significant improvements in both

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financial and environmental performance. Similar evidence from Pakistan's textile and leather industries highlights that access to targeted green financing encouraged cleaner production practices and sustainable growth [1]. In the United States, Ogunyemi and Ishola [5] reported that embedding green financing into SME strategies enhanced competitiveness in global markets. Sustainability reporting has also emerged as a worldwide practice, acting both as a compliance tool and as a way to strengthen reputation, with Appiah-Kubi et al. [3] and Atanasov [6] stressing the role of digital tools in boosting accountability. Singh et al. [8] further showed that export-oriented SMEs achieved superior performance internationally when they adopted green innovation and readiness, linking sustainability directly to global trade competitiveness.

B. Key Enablers of Green Financing

Leadership and governance have been repeatedly identified as essential for green transitions. Huy and Phuc [7] emphasized that leadership commitment and organizational readiness were critical factors in Vietnam's SME sustainability journey. Atanasov [6] and Appiah-Kubi et al. [3] found that sustainability reporting not only ensured regulatory compliance but also strengthened external trust. Entrepreneurial orientation was equally important, as Aftab et al. [9] showed that adopting green entrepreneurial practices significantly boosted firm performance. Comparative studies from Malaysia and Indonesia further confirmed that supportive policies and institutional structures magnify the benefits of green finance [14].

C. Barriers to Green Finance

Despite opportunities, SMEs face considerable challenges in adopting green financing. Musa and Chinniah [11] highlighted that Malaysian SMEs often struggle with limited access to capital, insufficient training, and weak institutional support. Rekik and Bergeron [10] pointed to informational and technological gaps as key obstacles to adoption. Alayón et al. [12] categorized barriers into financial, organizational, and technological dimensions, underscoring the systemic nature of the challenges. In Europe, Moursellas et al. [13] identified high compliance costs, market pressures, and limited resources as significant limitations. Kaushik [15] added that in India, fragmented policies and low levels of financial literacy further restrict SME participation in green finance.

D. Regional Evidence

Regional evidence underscores both similarities and differences in green financing adoption. In Malaysia and Indonesia, Abidin et al. [14] showed that supportive institutional frameworks improved SMEs' financial sustainability. Thuong [17] reported that in Vietnam, the effectiveness of green financing depended on organizational readiness. In Pakistan, Kumar et al. [1] observed that access to green finance encouraged cleaner production, while Wang et al. [2] highlighted the importance of governance in China. In Europe, barriers outweighed enablers [13], while in the U.S., SMEs benefited from integrating sustainability directly into financing strategies [5].

E. Technology and Innovation

Technological advancements are playing a decisive role in enabling green financing. Appiah-Kubi et al. [3] and Atanasov [6] stressed that digital reporting tools enhanced transparency and accountability. Ogunyemi and Ishola [4] demonstrated how fintech solutions allow SMEs to incorporate sustainability metrics into financial planning. Zournatzidou [16] highlighted the significance of Greentech ecosystems as platforms that link finance, technology, and sustainability. Singh et al. [8] found that innovation readiness strengthens the link between green finance and competitiveness, while Aftab et al. [9] emphasized the contribution of green entrepreneurship to SME excellence.

V. DISCUSSION

The evidence confirms that green financing plays a pivotal role in supporting SMEs' sustainability transitions, although adoption varies significantly across contexts. SMEs in developing economies often encounter greater barriers than those in developed markets. For example, in Malaysia and India, systemic obstacles such as high compliance costs, fragmented regulations, and low financial literacy restrict adoption [11], [15]. Nevertheless, targeted programs such as Pakistan's textile sector initiatives demonstrate that access to green finance can lead to measurable environmental and industrial improvements [1]. In contrast, SMEs in advanced economies like the United States benefit from stronger institutional support and consumer-driven incentives, which make the adoption process smoother [5]. These differences highlight the context-dependent nature of green finance effectiveness.

Entrepreneurial orientation emerges as a strategic asset that mediates the relationship between green financing and firm performance [9]. From a theoretical perspective, institutional theory provides a useful lens, as practices such as corporate governance and sustainability reporting strengthen organizational legitimacy and stakeholder confidence [2], [6].

The findings carry practical implications for multiple stakeholders. Policymakers should address systemic barriers by developing clearer regulatory frameworks, offering subsidies, and improving financial literacy programs. Financial institutions are encouraged to design SME-friendly instruments such as green credit products and digital finance platforms. SMEs themselves should invest in innovation and adopt sustainability reporting systems to enhance access to funding. For export-oriented SMEs, incorporating green strategies can also create new opportunities in international markets [8].

VI. LIMITATIONS and FUTURE RESEARCH

The review draws solely on secondary literature and does not include empirical data collection, which restricts

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the ability to validate findings through direct SME perspectives. Limited attention has been given to the potential role of fintech and blockchain in expanding SME access to sustainable finance. Moreover, there is a lack of longitudinal studies assessing the long-term outcomes of green financing initiatives. Future research should also examine the impact of consumer and market pressures as additional determinants of adoption.

VII.CONCLUSION

This review underscores the dual importance of green financing: it not only advances environmental sustainability but also enhances the competitiveness of SMEs. The findings show that governance structures, innovation, sustainability reporting, and supportive institutions are vital enablers of adoption, while persistent barriers such as weak policies, high costs, and knowledge gaps continue to limit progress. Regional comparisons reveal that SMEs in developed economies benefit from stronger institutional frameworks, whereas firms in developing contexts often rely on targeted sector-specific initiatives to realize the benefits of green financing. At the same time, technological drivers including digitalization, fintech solutions, and Greentech ecosystems are transforming access to sustainable finance, although further study is needed to understand their long-term effects. Importantly, SMEs that embrace green financing not only improve their environmental performance but also strengthen resilience and competitiveness in global markets. Moving forward, collaboration among governments, financial institutions, and SMEs will be crucial to removing barriers, promoting digital financial ecosystems, and expanding research into underexplored regions. Ultimately, green financing should be regarded both as an environmental necessity and as a strategic business opportunity, positioning SMEs as active contributors to global sustainability agendas.

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The Role of Organizational Culture in Shaping Leadership Effectiveness: Evidence from Multinational Corporations

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Abstract- **In an increasingly globalized corporate environment, leadership effectiveness within multinational corporations (MNCs) is closely shaped by the cultural contexts in which these organizations operate. While previous research has examined the broad relationship between organizational culture and leadership, there remains a significant gap in understanding how these dynamics unfold in emerging-market settings particularly within South Asia. This study addresses that gap by exploring how organizational culture influences leadership effectiveness in MNCs operating in Bangladesh, focusing specifically on the interplay between cultural alignment, adaptive leadership behavior, and organizational systems. Adopting a qualitative, constructivist research design, the study employed thematic analysis of in-depth interviews with 17 senior- and mid-level leaders from eight MNCs across key sectors such as finance, telecommunications, garments, and pharmaceuticals. The analysis uncovered three major themes: (1) cultural misalignment between globally standardized organizational practices and locally embedded socio-cultural norms, (2) the critical role of culturally adaptive leadership behaviors including hybrid leadership styles and cultural intelligence in managing cultural complexity, and (3) the importance of organizational enablers such as onboarding, reverse mentoring, and HR-led cultural integration in mediating leadership challenges. The findings reveal that leadership effectiveness in the Bangladeshi MNC context is not a static managerial trait but a dynamic, culturally embedded process that requires both individual flexibility and institutional scaffolding. The study proposes a conceptual framework positioning organizational culture as a mediating variable between leadership strategies and outcomes. It contributes to the advancement of cross-cultural leadership theory by contextualizing global models within the realities of an emerging market, and it offers actionable insights for HR practitioners, executive coaches, and global leadership development programs aiming to enhance cultural adaptability and strategic alignment.**

Keywords: **Leadership Effectiveness, Cultural Intelligence, Adaptive Leadership, Organizational Culture, Cross-Cultural Management**

I.INTRODUCTION

In the dynamic arena of global commerce, multinational corporations (MNCs) are increasingly defined not merely by the scale of their transnational operations, but by their capacity to manage cultural complexity. As organizations expand across borders, their performance is shaped not only by strategic coherence and operational proficiency but also by the interdependence between organizational culture and leadership effectiveness, two pivotal factors that underpin internal cohesion and sustained competitive advantage [25], [9], [26].

Organizational culture encompasses the shared values, norms, assumptions, and symbolic practices that inform behavior and decision-making throughout all levels of an organization [22],[28]. In contrast, leadership effectiveness pertains to a leader's ability to mobilize individuals and teams toward collective goals through influence, vision, and adaptive responsiveness [20],[27]. Within MNCs, these constructs interact in complex and often unpredictable ways, especially when global corporate norms are applied across divergent local cultural contexts.

The GLOBE study and related cross-cultural leadership frameworks [15], [29] have demonstrated that leadership effectiveness is intrinsically shaped by societal culture, resulting in significant regional variations in leadership expectations. As such, incongruities between global corporate culture typically informed by Western leadership paradigms and local cultural norms may diminish managerial credibility, disrupt communication channels, and negatively affect employee engagement [19], [11]. This tension is particularly salient in Bangladesh, a rapidly developing South Asian nation that is witnessing increasing MNC presence in sectors such as telecommunications, garments, pharmaceuticals, and finance. While these firms introduce global best practices, they must contend with a local managerial culture characterized by high power distance, collectivism, and a preference for hierarchical, relationship-based leadership traits that often diverge from egalitarian, feedback-oriented Western models [23],[30]. Leaders operating in this dual environment must therefore reconcile global organizational expectations with localized leadership preferences.

Despite the breadth of scholarship on organizational culture and leadership independently, limited research has explored how these domains interact within emerging market

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contexts such as Bangladesh. Furthermore, much of the existing literature privileges quantitative methodologies and Global North perspectives, offering limited insight into the real-time, culturally grounded adaptations employed by leaders in the Global South [6], [12]. This underscores a pressing need for qualitative, context-rich studies that illuminate the lived leadership experiences within culturally hybrid organizational ecosystems.

1.1 Research Questions

This study is guided by the following research questions:

- How does organizational culture influence leadership behavior in MNCs operating in Bangladesh?
- What cultural challenges do leaders face within these organizations?
- How do leaders adapt their leadership styles in response to evolving and diverse cultural expectations?

1.2 Research Objectives

The key objectives of this study are to:

- Examine the impact of organizational culture on leadership effectiveness in MNCs operating in Bangladesh.
- Identify critical cultural challenges and leadership dilemmas encountered by MNC leaders.
- Explore adaptive leadership strategies that align local cultural expectations with global organizational imperatives.

1.3 Significance of the Study

This research contributes both practical and theoretical insights to the fields of organizational behavior, cross-cultural management, and global leadership. From a practitioner's standpoint including HR professionals, consultants, and leadership development specialists, the study offers evidence-based recommendations for localizing leadership approaches to build trust, increase engagement, and drive performance in culturally diverse teams [2], [1].

From an academic perspective, the study advances cross-cultural leadership theory by integrating grounded empirical findings from a South Asian, Muslim-majority context. It challenges the predominance of Western leadership frameworks and emphasizes the significance of contextual intelligence, cultural adaptability, and hybrid leadership approaches [10], [24].

Ultimately, this research reinforces the notion that effective global leadership is not predicated on the transplantation of universal best practices, but on the nuanced understanding and strategic integration of localized cultural capital [17]. As Bangladesh emerges as a strategic node in global value chains, cultivating culturally intelligent leadership will be critical to sustaining high-performing, resilient multinational organizations.

II. LITERATURE REVIEW

The intersection of leadership effectiveness and organizational culture has long been a central concern among management scholars. However, its manifestation within multinational corporations (MNCs) operating in culturally heterogeneous environments particularly in the Global South require nuanced, context-specific analysis. This literature review synthesizes five major thematic domains: (1) the relationship between national and organizational culture, (2) leadership adaptability and cultural intelligence, (3) the synergy between leadership and organizational culture, (4) systemic enablers of culturally aligned leadership, and (5) theoretical reconceptualization's and critical perspectives. This synthesis is situated within the context of Bangladesh, an emerging South Asian economy with a growing MNC footprint and distinctive cultural dynamics.

2.1 National vs. Organizational Culture: Managing Cultural Intersections in MNCs

In MNCs, the interplay between national and organizational culture constitutes a foundational leadership challenge. National culture shaped by religious, linguistic, and political histories is embedded through generational socialization [10]. Bangladesh, for instance, is deeply influenced by Islamic traditions, colonial legacies, and collectivist norms, all of which inform deference to authority, relational leadership practices, and informal hierarchies.

Conversely, organizational culture is shaped internally through mechanisms such as HR policies, leadership practices, and symbolic rituals. While more malleable than national culture, organizational culture is often influenced by the values of the parent company, typically headquartered in the Global North [22].

The dissonance between these cultural layers may generate conflicting leadership signals, particularly in areas such as decision-making and communication. Without local adaptation, leadership behaviors may lack legitimacy even when aligned with formal authority [15]. For MNCs in Bangladesh, this raises a critical leadership dilemma: Should leadership practices be localized for cultural congruence, or standardized for corporate consistency?

2.2 Leadership Adaptability and Cultural Intelligence: Navigating Complex Cultural Terrain

Cultural intelligence (CQ) has emerged as a critical leadership capability in diverse organizational

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environments. Rather than simply understanding cultural differences, CQ entails reflexivity and real-time behavioral adaptation [11], [19]. Leaders with high CQ adjust their communication style, delegation practices, and decision frameworks to remain effective while preserving authenticity.

In Bangladesh where workplace interactions are characterized by indirect communication, emotional expressiveness, and relationship-based dynamics CQ is essential, not optional. Adaptive leadership, grounded in practices like listening, contextual decision-making, and symbolic engagement with local norms, has been found to enhance team engagement and performance [21].

Furthermore, the application of indigenous frameworks such as Islamic leadership, which emphasizes humility, justice, and collective welfare offers culturally resonant alternatives to dominant Western paradigms [23]. Such frameworks align with both religious values and social expectations in Bangladesh, reinforcing leadership legitimacy in culturally grounded ways.

Adaptive leadership is also a moral endeavor. Leaders who cultivate psychological safety, ethical clarity, and resilience are more likely to foster robust, inclusive organizational cultures [2].

2.3 Leadership–Culture Synergy: The Co-evolution of Belief and Behavior

Leadership and culture are not discrete forces; they co-evolve through continuous interaction. Leaders serve as cultural architects, shaping norms through symbolic behaviors such as promotion criteria, feedback styles, and reward systems [20]. Simultaneously, existing cultural frameworks constrain leadership behaviors to those considered legitimate and meaningful within the local context [14].

In high-context cultures such as Bangladesh, leadership effectiveness hinges on fostering shared learning, ritualized collaboration, and community-based dialogue [8]. Mechanisms for employee voice such as structured feedback systems enable iterative alignment between leader behavior and cultural expectations [18].

Moreover, this synergy is not static. Cultural openness and innovation are more sustainable when leadership actively supports cross-boundary learning and experimentation [5]. As organizational culture adapts, so must leadership through mutual shaping and dynamic recalibration.

2.4 Organizational Enablers: Systems That Support or Suppress Leadership Adaptation

Leadership adaptability does not operate in isolation; it is profoundly shaped by institutional infrastructure. Systems such as onboarding protocols, communication frameworks, mentorship initiatives, and intercultural training constitute the scaffolding that enables or constrains leadership effectiveness [22].

Culturally intelligent leadership should be institutionalized as a strategic competency intentionally evaluated, supported, and developed through HR systems [1]. In some Gulf MNCs, such systematization has led to improvements in sustainability and inclusion outcomes.

In contrast, most Bangladeshi MNCs lack such formalized systems. Leadership development often relies on imported models that fail to reflect local cultural realities [12]. This creates a misalignment between leadership ideals and on-the-ground implementation, particularly for mid-level managers navigating intercultural complexities.

Furthermore, emerging technologies such as HR analytics offer new tools for tracking leadership behavior and cultural feedback in real-time, thus enabling data-driven and contextualized development strategies [13].

2.5 Reconceptualizing Leadership Effectiveness in Culturally Complex MNCs

Leadership effectiveness must be redefined as a relational, adaptive, and systemic construct rather than a fixed individual trait. Double-loop learning, as introduced by Argyris [3], provides a useful model wherein leaders question not only their behaviors but also the underlying values that inform them.

This reflexive model is especially relevant in Bangladesh, where MNC leaders juggle competing expectations from headquarters and local stakeholders. Integration of local cultural values into innovation and strategy has been shown to increase buy-in and enhance performance [17].

Organizational learning frameworks that embed leadership development within broader cultural systems also contribute to enhanced adaptability and resilience, particularly in volatile or transitional environments [21].

2.6 Rival and Critical Perspectives: Questioning Dominant Assumptions

While much of the literature emphasizes alignment, adaptability, and CQ, critical scholars offer alternative perspectives. Banerjee [4] argues that global leadership models often function as ideological tools that impose Western values under the guise of universality. These models may marginalize indigenous leadership values such as harmony, spiritual purpose, and communal belonging.

In Bangladesh, such critiques are particularly salient, given the country's postcolonial context, religious diversity, and socio-economic asymmetries. Calls for decolonizing

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leadership theory emphasize the need to recognize and legitimize non-Western epistemologies [23], [6].

Moreover, rival perspectives caution against over-adaptation. While responsiveness is crucial, excessive cultural relativism may dilute core leadership values and organizational coherence [5]. Effective leadership thus requires a balance between cultural sensitivity and principled consistency.

This literature review underscores a central insight: leadership is inherently contextual. It emerges at the intersection of social expectations, institutional frameworks, and personal values. In the context of MNCs in Bangladesh, effective leadership is not imported, it is cultivated through contextual intelligence, moral reflexivity, and systemic alignment.

As global corporations become more diverse and interconnected, the capacity to bridge global imperatives with local wisdom will define the next generation of organizational leadership. Rather than viewing hybridity as a challenge, this complexity should be reframed as a strategic opportunity to redefine leadership from the margins outward.

III. METHODOLOGY

3.1 Research Design

This study employs a qualitative, exploratory research design to investigate how organizational culture influences leadership effectiveness within multinational corporations (MNCs) operating in Bangladesh. A qualitative approach is particularly well-suited for examining complex, socially constructed, and context-dependent phenomena such as leadership and culture, which cannot be adequately captured through numerical generalization [14], [12].

Anchored in the constructivist paradigm, this research acknowledges that knowledge is co-constructed through human interaction and interpretation. Accordingly, the study aims to elicit rich, narrative accounts from organizational leaders to uncover the subjective meanings they attach to cultural dynamics, leadership behavior, and adaptive strategies.

This methodological choice also responds to persistent gaps in the literature specifically, the over-reliance on Western-centric and quantitative models that frequently overlook the lived realities of leaders in emerging-market settings such as Bangladesh [23], [6].

3.2 Sampling Strategy

A purposive sampling strategy was adopted to select participants capable of providing contextually rich, experience-based insights into leadership practices within culturally complex organizations. Eligibility criteria included:

- A minimum of five years in a managerial or leadership role within an MNC.
- Recent or ongoing exposure to cross-cultural leadership challenges.
- Willingness and ability to participate in a 45–60-minute, in-depth interview.

Participants were drawn from MNCs in key sectors of the Bangladesh economy telecommunications, garments, pharmaceuticals, finance, and fast-moving consumer goods (FMCGs) to ensure sectoral diversity and enhance thematic saturation.

To broaden the range of voices and access less visible networks, snowball sampling was used in conjunction with purposive sampling. Initial participants referred to additional qualified individuals, facilitating access to varied leadership experiences.

A total of 17 interviews were conducted, aligning with qualitative standards for sample adequacy in thematic analysis. Recruitment continued until thematic saturation was achieved, that is, when no new conceptual insights emerged from additional interviews.

3.3 Data Collection

Data was collected through semi-structured, in-depth interviews, enabling consistency across interviews while allowing flexibility to explore context-specific themes. The interview guide was informed by the literature [22], [24], [23] and organized into three primary thematic areas:

- Perceptions of organizational culture and its local manifestations.
- Experiences of leadership challenges where global norms clashed with local expectations.
- Adaptive strategies for reconciling global leadership practices with cultural realities.

Sample interview questions included:

- “How would you describe the organizational culture of your company?”
- “Can you share an example where cultural expectations shaped a leadership decision?”
- “What leadership strategies have you found effective in navigating cultural diversity?”

Interviews were conducted in either English or Bengali, based on participant preference, and were audio-recorded with informed consent. All recordings were transcribed and translated, and a back-translation protocol was employed to preserve semantic accuracy in bilingual responses.

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3.4 Ethical Considerations

This study followed strict ethical protocols consistent with institutional and international standards for research involving human subjects. Ethical clearance was obtained from the Institutional Review Board (IRB) of the affiliated university before data collection commenced.

All participants were provided with a consent form and an information sheet outlining the study's purpose, data handling procedures, and their rights, including the right to withdraw at any time without penalty.

To maintain anonymity and confidentiality, pseudonyms were assigned and identifying details removed from all transcripts. Audio files and transcripts were stored on encrypted, password-protected devices with access restricted to the research team.

Participants were also invited to review their interview summaries, supporting member validation and enhancing the credibility of data interpretation.

3.5 Data Analysis

The data were analyzed using Thematic Analysis, a widely respected method for identifying, analyzing, and reporting patterns within qualitative data [Braun & Clarke, 2006]. Its flexibility makes it well-suited for uncovering both explicit and latent meanings in interpretive datasets. The analysis followed six sequential phases:

- Familiarization – Immersive reading and annotation of transcripts.
- Initial Coding – Line-by-line coding of relevant data using NVivo software.
- Theme Generation – Organizing codes into conceptual clusters (e.g., "cultural dissonance," "adaptive leadership," "structural enablers").
- Theme Review – Cross-case comparison to ensure thematic consistency and distinctiveness.
- Theme Definition – Refinement of thematic labels with reference to theory and prior literature.
- Report Production – Narrative synthesis of findings, supported by illustrative quotes and integrated with scholarly frameworks.

To ensure rigor and trustworthiness, multiple strategies were employed:

- Data triangulation across sectors and roles.
- Member checking with a subset of participants.
- Reflexive journaling by the lead researcher to acknowledge positionality and minimize interpretive bias.

3.6 Limitations

While this study provides rich, context-specific insights, certain limitations must be acknowledged:

- Limited Generalizability – As is common in qualitative research, the findings are not statistically generalizable but offer conceptual insights that may be transferable to similar contexts.
- Translation Complexity – The translation of Bengali interviews into English may have introduced subtle semantic shifts. Back-translation and peer review were used to minimize such risks.
- Positional Bias – Despite reflexive practices, the researcher's academic and cultural background may have influenced interpretation.

Nonetheless, this study offers a credible and empirically grounded account of how leaders in Bangladeshi MNCs navigate cultural complexity. The findings contribute to both theoretical development and practical leadership strategies in culturally hybrid organizational environments.

IV. RESULTS AND FINDINGS

A total of 17 in-depth, semi-structured interviews were conducted with mid- to senior-level leaders across eight multinational corporations (MNCs) operating in Bangladesh. Participating organizations spanned key sectors including telecommunications, pharmaceuticals, finance, and garments industries central to Bangladesh's global economic integration.

Drawing from thematic analysis, three interrelated core themes and corresponding sub-themes were identified. These illuminate how organizational culture influences leadership effectiveness, the cultural tensions leaders face, and the strategies and systems employed to navigate and mediate cross-cultural complexities.

4.1 Overview of Emergent Themes

Core Theme	Sub-Themes
Cultural Alignment and Misalignment	Power Distance, Communication Norms, Role Ambiguity
Leadership Adaptability	Cultural Intelligence, Hybrid Leadership Styles, Relational Sensitivity
Organizational Mediation Mechanisms	HR Facilitation, Cross-Cultural Onboarding, Knowledge Sharing Structures

Theme 1: Cultural Alignment and Misalignment

A recurring pattern across interviews was the inherent cultural friction between the organizational culture imposed by global headquarters and the deeply rooted socio-cultural norms prevalent in Bangladesh. Many participants emphasized that global HR norms, flat hierarchies, and

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informal communication styles often failed to resonate with local employees, who typically value hierarchical clarity, respect for seniority, and relational deference.

"Our head office culture promotes open-door policy and flat hierarchy. But in Bangladesh, employees expect direction and formality. It creates confusion unless the leader balances both."

— Participant 4, Telecom Sector

This finding reflects Hofstede's high-power distance and collectivist orientation in South Asian cultures, where formality and role clarity are equated with organizational stability. Moreover, it supports [9] who cautioned against assuming that corporate culture can be universally replicated across national contexts.

Participants also highlighted tensions around communication norms. Open disagreement, encouraged in Western MNCs as a sign of engagement, was often interpreted by Bangladeshi staff as disrespectful or confrontational. Leaders found themselves navigating role ambiguity, where expectations from HQ contradicted local norms creating interpretive dilemmas around authority, initiative, and loyalty.

Theme 2: Leadership Adaptability

Participants who demonstrated high levels of team cohesion, low attrition, and improved performance consistently shared leadership approaches that were adaptive, context-sensitive, and emotionally intelligent. These leaders engaged in a form of cultural triangulation, blending transactional structures with transformational inspiration, while always being attentive to local social codes.

"You cannot lead here just by metrics or structure. You must understand family, respect, emotion… I try to be firm, but also like an elder brother to my team."

— Participant 7, Finance Sector

Such narratives echo the importance of Cultural Intelligence (CQ), the capacity to read and respond to culturally embedded cues. Leaders emphasized relational awareness, nonverbal cues, and the need for situational code-switching, adjusting their style depending on the formality of setting, age or gender of colleagues, and internal organizational dynamics.

A particularly insightful finding emerged around gendered leadership adaptation. Female leaders often prioritized trust-building, inclusion, and narrative persuasion, particularly when managing teams with generational or gender diversity. This highlights the intersectionality of leadership practices and suggests that adaptive leadership is not only culturally but also socially constructed.

Some leaders described their leadership styles as hybrid, combining accountability-driven KPIs with emotionally resonant behaviors aligned with Islamic or familial values. This is called flexible leadership models in dynamic cultural environments.

Theme 3: Organizational Mediation Mechanisms

While individual adaptability was central, several participants emphasized the critical role of organizational systems, especially HR, in mitigating cultural misalignment. HR-led onboarding programs, cross-cultural training, and reverse mentoring (where locals educate expatriates) were viewed as highly effective tools in reducing misunderstandings and enhancing cultural integration.

"We now do culture orientation both ways expats learn Bangladeshi norms, and locals learn global business etiquette. That has reduced conflicts and turnover."

— Participant 11, Pharmaceutical Sector

These practices mirror the structural enablers of adaptive leadership identified in [5] and [10] who emphasized the importance of intentional community learning structures in fostering cross-cultural understanding.

In addition, participants cited the effectiveness of employee voice mechanisms such as anonymous feedback portals, community dialogues, and inclusive decision-making platforms in fostering psychological safety and adaptive leadership cultures. Such systems reduced dependency on individual leaders to resolve all conflicts personally, embedding shared cultural translation into the organization's routine operations.

Furthermore, cross-functional knowledge-sharing tools (e.g., internal learning platforms, shared language glossaries, and storytelling sessions) were mentioned as spaces where organizational culture and national culture could gradually co-evolve, enhancing cohesion across hybrid teams.

Collectively, these findings suggest that leadership effectiveness in MNCs in Bangladesh is fundamentally cultural and systemic. Leaders who thrive are not simply charismatic or authoritative, but those who engage in reflective, adaptive, and emotionally intelligent practices grounded in contextual awareness.

Yet, individual adaptation alone is insufficient. Effective leadership is also contingent upon organizational infrastructure HR practices, onboarding design, and dialogical mechanisms that facilitate cultural translation and hybridization. The most resilient leadership models, therefore, are neither globally imposed nor locally insular, but co-constructed through continuous negotiation between global strategy and local norms.

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4.2. Conceptual Framework



Fig. 1. Conceptual framework

This conceptual framework illustrates the dynamic and multi-level interplay of cultural and organizational forces that shape leadership effectiveness in multinational corporations (MNCs) operating in Bangladesh. The model integrates top-down global influences, bottom-up local cultural expectations, and institutional mediation mechanisms, emphasizing the need for leadership adaptability in culturally complex environments.

i. Organizational Culture
Positioned at the top-left of the framework, organizational culture reflects the global values, structures, and leadership norms embedded within MNCs typically shaped by the headquarters. It influences leadership practices through:

- Corporate policy frameworks
- Leadership KPIs
- Performance management systems

Top-down influence is shown by an arrow pointing from organizational culture to Cultural Alignment and Misalignment, indicating how global cultural models are introduced into the local context.

ii. National Culture
Located at the top-right, national culture represents Bangladesh's deeply rooted cultural values, such as:

- High power distance
- Collectivism and family-based loyalty
- Relational and indirect communication
- Islamic ethical traditions

A bottom-up influence arrow shows how national culture shapes how leadership and organizational directives are interpreted and responded to by local teams.

iii. Cultural Alignment and Misalignment
At the center of the framework, this oval represents the tension zone where organizational and national cultural expectations collide or align. This space is where:

- Misinterpretations of leadership intent arise
- Conflicting expectations about authority and communication are negotiated
- Cultural hybrids may emerge

This stage determines whether leaders will face cultural resistance or acceptance.
iv. Leadership Adaptability
Directly below the cultural alignment node, Leadership Adaptability represents the leader's behavioral, emotional, and cognitive responsiveness to the cultural terrain. It encompasses:

- Cultural Intelligence (CQ)
- Use of hybrid leadership styles (e.g., combining transactional metrics with relational leadership)
- Emotional sensitivity to hierarchical and relational norms
- Gendered approaches to leadership adaptation

Adaptable leadership is critical for moving from cultural alignment toward effective outcomes.

iv. Leadership Effectiveness
This is the outcome node, shaped by the leader's ability to navigate and reconcile cultural differences. It manifests as:

- Improved team cohesion
- Enhanced employee trust and engagement
- Reduced cultural friction
- Achievement of both global KPIs and local legitimacy

This node connects back to the system via a feedback arrow.

v. Organizational Mediation Mechanisms

Sitting beside Leadership Adaptability, this component emphasizes the structural support that enables leaders to adapt more effectively and reduce cultural strain. These mechanisms include:

- Cross-cultural onboarding
- Reverse mentoring (local to expat)
- Culture training and dialogue forums
- Knowledge-sharing platforms
- Employee voice systems

The feedback loop from Leadership Effectiveness to Organizational Mediation Mechanisms represents how successful leadership experiences inform system-level practices, creating learning loops that institutionalize what works.

Feedback Dynamics
The use of directional arrows across the model signifies dynamic interactions, rather than linear causality:

- Culture flows both ways: Organizational values are projected downward, while local expectations push upward.
- Leaders operate in the middle, constantly negotiating, adapting, and co-creating culture.
- Effective leadership feeds back into the system through structural and strategic learning.

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Purpose of the Framework

This framework challenges simplistic, one-way models of global leadership and instead proposes a multi-directional, context-sensitive model. It acknowledges that:

- Leadership is not a transplantable skill, but a relational and cultural practice.
- Culture is not a barrier, but a site of negotiation and innovation.
- Systems must evolve to support, not burden, the leader's adaptive work.

This framework is particularly suited to emerging market contexts like Bangladesh, where global business practices meet deeply local values.

V. DISCUSSION AND INTERPRETATION

This research examined how organizational culture influences leadership effectiveness in multinational corporations (MNCs) operating in Bangladesh, a country characterized by high-context communication, collectivist norms, and pronounced hierarchical traditions. Drawing on insights from 17 in-depth interviews, the study revealed three interconnected themes: cultural alignment/misalignment, adaptive leadership strategies, and the role of institutional mediation. These themes collectively offer a nuanced understanding of how leadership is enacted and negotiated in transnational contexts. The sections below interpret these findings considering existing theory and propose implications for scholarship and practice.

5.1 Cultural Misalignment as a Barrier to Leadership Legitimacy

One of the most salient findings of this study is the cultural tension that arises when global leadership norms typically rooted in Western corporate traditions encounter local Bangladeshi expectations. Imported practices such as egalitarian leadership, open-door policies, and direct feedback often generated friction, inadvertently signaling disrespect or informality to local employees.

Three primary domains of cultural dissonance were identified:

- Power Distance: Efforts to flatten hierarchies were frequently interpreted as weakness or indecisiveness.
- Communication Style: Directness in communication, while standard in many Western firms, was perceived as abrasive or disrespectful in local settings.
- Role Ambiguity: Matrix structures and decentralized authority confused employees accustomed to clear chains of command and positional respect.

These findings corroborate existing frameworks of cultural variation such as Hofstede's dimensions and the GLOBE study. They echo earlier warnings that leadership norms are not universally transferable, particularly in high power distance cultures. However, this study contributes a micro-level lens to those frameworks by illustrating the day-to-day managerial dilemmas such as when silence in meetings is mistaken for apathy, or when participatory decision-making undermines perceived authority [15].

As reflected in the work of Denison et al. [9] and Gelfand et al. [10], this study affirms that leadership legitimacy is socially constructed and context-contingent emerging not solely from formal role or performance, but from alignment with localized cultural expectations.

5.2 Adaptive Leadership as a Dynamic, Culturally Situated Process

Leaders perceived as effective consistently demonstrated cultural dexterity, the ability to interpret social cues and adapt accordingly. Rather than applying a fixed leadership style, these individuals adjusted their behavior fluidly, integrating elements of transactional discipline, transformational vision, and servant-like empathy.

Participants described strategic code-switching, adjusting tone and demeanor depending on whether they were interacting with local staff, expatriates, or corporate superiors. Others adopted relationship-first strategies, where trust was cultivated through informal gestures, emotional presence, and social proximity practices underrepresented in mainstream Western leadership literature but widely effective in the Bangladeshi context.

These practices support and expand on models of cultural intelligence [19], relational leadership [11], and adaptive leadership [24]. The findings also align with Udin's [23] argument that Islamic leadership values, such as justice (`adl), humility (tawadu'), and collective welfare (maslahah), can serve as culturally coherent alternatives to conventional Western leadership models.

A novel insight offered by this study is the reframing of adaptive leadership as rhythmic rather than stylistic. Effectiveness emerged not from the type of leadership employed, but from the leader's ability to modulate timing, tone, and engagement in synchrony with cultural expectations. This performative dimension highlights leadership as a process of cultural negotiation, rather than a trait to be consistently applied.

5.3 Structural Enablers: Institutionalizing Cultural Responsiveness

While individual adaptability was a clear differentiator, many leaders emphasized the enabling or constraining role

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of organizational systems. Three structural mechanisms were consistently identified:

- Cross-cultural onboarding to educate leaders on Bangladeshi workplace norms.
- Reverse mentoring where local staff guided expatriates on cultural nuances.
- Knowledge-sharing platforms that legitimized diverse perspectives and reduced silos.

These institutional practices served as sensemaking structures, allowing leaders and teams to interpret ambiguous cues through a culturally attuned lens. Rather than functioning as compliance tools, they acted as strategic scaffolds for navigating cultural complexity.

Such findings resonate with the work of Cheng and Ko [8] and Aggarwal [2], who advocate for leadership development grounded in organizational learning. They also support Kezar's [14] assertion that leadership must be understood within institutional ecosystems, not as an isolated function of individual agency.

This perspective reframes leadership development as a strategic organizational capability. Cultural responsiveness should be embedded not only in individual competencies but also in HR systems, onboarding processes, and feedback loops positioning leadership as a systemic rather than solely personal asset.

5.4 Theoretical Contributions

This study contributes several theoretical advancements:

- Contextualization of Leadership Theory: It challenges the universality of Western-centric leadership models and adds to the growing call for Southern theorizing, that is, leadership frameworks rooted in the lived realities and value systems of the Global South.

- Cultural Mediation Model: It reconceptualizes leadership as a mediated process shaped at the intersection of global mandates, local expectations, and institutional support, rather than as a unilateral force of influence.

- Fluid Effectiveness Paradigm: It introduces a fluid definition of leadership effectiveness, one did not anchor to performance metrics alone but emerging from dynamic alignment across cultural, organizational, and interpersonal dimensions.

Together, these contributions help close the gap between abstract leadership theory and the empirical realities of global practice, particularly in complex environments like Bangladesh.

5.5 Practical Implications

The study offers multiple implications for MNCs operating in culturally diverse contexts:

- Localized Leadership Development: Training programs must be adapted to address cultural duality, equipping leaders to develop both global capabilities and localized cultural literacy.

- Structured Cultural Integration: HR functions must proactively facilitate two-way cultural adaptation, rather than placing the burden solely on local employees to assimilate.

- Leadership as a Strategic Lever: Cultural intelligence should be formalized within performance management frameworks and executive KPIs elevating it from a soft skill to a core organizational competence.

- Enabling Adaptive Capacity: Organizations should create psychological safety for leadership experimentation and allow cultural responsiveness without fear of penalization from global headquarters.

Ultimately, global leadership in contexts like Bangladesh demands more than operational competence. It requires the ability to navigate meaning, mediate values, and bridge cultural divides. Those leaders and organizations that invest in such contextual and systemic agility will be best positioned to achieve sustainable impact in a multipolar world.

VI. CONCLUSION

This study set out to investigate how organizational culture influences leadership effectiveness within multinational corporations (MNCs) operating in Bangladesh, utilizing a qualitative, thematic approach rooted in in-depth interviews with experienced corporate leaders. The research revealed that leadership in culturally pluralistic, transnational environments is not a uniform or static function; rather, it is a dynamic, negotiated, and context-sensitive process.

Three core themes emerged from the analysis:

- Cultural Misalignment as a Barrier to Legitimacy: Cultural incongruities particularly around power distance, communication style, and hierarchical expectations often act as friction points that undermine leadership legitimacy, reduce team cohesion, and impair operational effectiveness. These findings affirm the importance of aligning leadership behavior with local socio-cultural norms.

- Adaptive Leadership as a Critical Enabler: Leaders who exhibited cultural intelligence, emotional sensitivity, and hybridized leadership styles (combining transformational, transactional, and relational approaches) were significantly more effective in navigating organizational complexity. These adaptive leaders balanced the demands of global corporate culture with the subtleties of local

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expectations, earning trust and enhancing performance.

- Institutional Mediation through Organizational Systems: Beyond individual competence, the study highlights the importance of institutional scaffolding such as structured onboarding, reverse mentoring, and cultural learning platforms in supporting leadership adaptation. These systems help reduce the cognitive and emotional burden of cultural navigation and institutionalize cultural responsiveness across the organization.

By grounding these insights in the real-world experiences of leaders in MNCs operating in Bangladesh, this study enriches cross-cultural leadership literature, particularly by providing empirical evidence from an underrepresented, non-Western, emerging market. The findings offer a culturally nuanced critique of universalistic leadership models and stress the importance of embeddedness, adaptability, and systemic support in global leadership effectiveness.

VII. RECOMMENDATIONS

Based on the empirical insights of this study, the following recommendations are proposed for corporate leaders, HR practitioners, and global talent strategists in multinational contexts:

- Design Context-Specific Leadership Development Programs: Leadership development frameworks must be customized to include local cultural competencies, not merely global business acumen. This includes training on hierarchical etiquette, relational communication, and culturally congruent conflict resolution strategies.
- Institutionalize Cross-Cultural Onboarding and Reverse Mentoring: MNCs should develop structured onboarding that includes cultural simulations, behavior-based workshops, and culture mapping exercises. Reverse mentoring where local employees mentor expatriate or global leaders should be implemented to foster reciprocal learning and strengthen mutual understanding.
- Embed Cultural Intelligence in Performance Appraisal: Cultural intelligence (CQ) should be treated as a core performance metric. Appraisal frameworks should explicitly evaluate a leader's ability to adapt across cultures, manage diverse teams, and demonstrate cultural empathy and responsiveness.
- Develop Organizational Platforms for Cultural Integration: Organizations must institutionalize spaces for continuous dialogue and knowledge exchange across cultures. This may include intranet-based cultural playbooks, cross-cultural forums, shadowing programs, and leadership learning communities to foster systemic alignment.
    - Encourage Leadership Hybridization as a Strategic Asset: Instead of enforcing rigid leadership templates, MNCs should encourage flexible, hybridized leadership styles that combine global professionalism with local resonance. Leaders should be empowered to draw selectively from different leadership paradigms to fit context and stakeholder expectations.

7.1 Future Research Directions

- This study opens multiple avenues for further exploration:
- Longitudinal research to track how leaders' cultural adaptability evolves over time in response to organizational and environmental shifts.
- Cross-national comparisons between MNC leadership in Bangladesh and other emerging markets such as Nigeria, Vietnam, or India to understand regional variations in adaptive leadership.
- Gender and culture intersections, examining how female leaders experience and navigate cultural expectations differently within MNCs.
- Employee-centered studies that triangulate leader self-reports with follower perceptions, to build a more holistic understanding of leadership effectiveness across hierarchical levels.

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APPENDIX

Appendix A: Semi-Structured Interview Guide

The following semi-structured questions were used to guide in-depth interviews with participants. The format allowed flexibility to probe deeper based on the interviewee's experiences, role, and sectoral background.

Section 1: Background and Role

- Can you briefly describe your current role and responsibilities within your organization?
- How long have you worked in a managerial or leadership capacity in this company?
- Have you had experience working in other MNCs or cultural settings?

Section 2: Organizational Culture

- How would you describe the organizational culture of your company (values, behaviors, norms)?
- How do you think this culture is influenced by global headquarters vs. the local context?
- What cultural elements help or hinder employee engagement and performance?

Section 3: Leadership Experience and Adaptation

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- In your experience, how does culture shape how leadership is practiced and perceived in your company?
- Can you describe a situation where cultural expectations impacted your leadership approach?
- How have you adapted your leadership style to be effective in the Bangladeshi context?
- What role does cultural understanding or sensitivity play in your daily leadership decisions?

Section 4: Organizational Support Structures

- Does your organization offer cultural training or onboarding for new managers or expatriates?
- What systems or structures help leaders align with both global and local cultural expectations?
- What would you recommend improving leadership effectiveness in culturally diverse teams?

Section 5: Reflections

- What advice would you give to a new leader joining a multicultural team in Bangladesh?
- Is there anything else you'd like to share about leadership and culture in your organization?

Appendix B: Participant Profile Summary

Participant ID	Sector	Years in Leadership	Nationality	Role Level
P1	Telecommunications	8	Bangladeshi	Regional Manager
P2	Banking	12	Expatriate (UK)	Country Director
P3	Garments	10	Bangladeshi	Operations Manager
P4	Pharmaceuticals	6	Bangladeshi	HR Director
P5	Consumer Goods	7	Expatriate (India)	Business Development Head
…	…	…	…	…

Note: Participant identities have been anonymized to maintain confidentiality and comply with ethical research protocols.

Appendix C: Coding Framework (Thematic Analysis)

Theme	Sub-Themes	Example Codes / Participant Quotes
Cultural (Mis)Alignment	Power Distance, Communication Gaps, Formality	"Hierarchy is important here..." "Open feedback is often misunderstood."
Adaptive Leadership Behaviors	Hybrid Style, CQ, Relational Trust	"I blend performance with empathy." "Reading between the lines is crucial."
Organizational Enablers	Onboarding, Reverse Mentoring, HR Systems	"Cultural induction improved trust." "Our reverse mentoring was eye-opening."

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Generative AI in Higher Education: Examining Its Influence on Student Engagement, Learning Outcomes, and Ethical Awareness

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Abstract-**The accelerated integration of Artificial Intelligence (AI) into higher education has introduced both transformative opportunities and complex ethical challenges across teaching, learning, and academic governance. This study explores university students' awareness, perceptions, and usage patterns of AI technologies particularly generative AI and assesses their influence on academic engagement and perceived performance. Employing a structured quantitative methodology, survey data were collected from 300 students across diverse disciplines. Descriptive and inferential analyses, including multiple linear regression, were conducted to identify key predictors of AI-driven academic outcomes. Findings reveal that the perceived benefits of AI and student engagement are strong, positive predictors of improved academic performance, while access-related disparities emerge as significant barriers. Additionally, ethical concerns, policy awareness, and trust in AI-generated content shape students' attitudes and behaviors, indicating that cognitive and contextual factors mediate the educational impact of AI. Grounded in a theoretical framework that integrates the Technology Acceptance Model (TAM) and Constructivist Learning Theory, this research highlights AI's dual role as both enabler and disruptor of equitable education. It calls for the implementation of transparent governance structures, equitable digital infrastructure, and ethical AI literacy within academic institutions. This study contributes evolving discourse on responsible AI adoption in education and offers practical guidance for policymakers, educators, and technology developers aiming to enhance academic integrity and digital inclusion in the AI age.**

Keywords: **Artificial Intelligence, Generative AI, Ethics, Technology Acceptance Model, Digital Equity**

I. INTRODUCTION

1.1 Background of the Study

The digital transformation of higher education has accelerated over the past decade, increasingly characterized by the integration of Artificial Intelligence (AI) technologies into teaching, learning, and administrative systems. From intelligent tutoring platforms and adaptive learning environments to AI-driven writing assistants and large language models (LLMs) such as ChatGPT, AI is reshaping the educational experience. These technologies offer personalized feedback, automate content generation, and reduce cognitive load, thereby redefining how students interact with academic content [17]. AI tools now simulate human-like dialogue to support comprehension, adaptively deliver content based on performance data, and assist with academic writing tasks. Such affordances represent a significant shift toward individualized, data-informed, and automation-supported learning [8]. However, these innovations are not without controversy. The growing reliance on generative AI tools for academic work ranging from brainstorming and paraphrasing to full assignment completion raises complex questions about authorship, originality, and cognitive dependency [2].

Further, the "black box" nature of many AI systems, where algorithmic decisions are opaque, has led to concerns regarding critical thinking erosion, academic misconduct, surveillance, and algorithmic bias [15]. These risks are amplified in institutions where clear policies, ethical guidelines, or digital literacy training remain underdeveloped. In this uncertain regulatory landscape, students are often left to self-navigate ethical boundaries, technological complexities, and institutional expectations without structured guidance [19],[20]. This study thus addresses a critical and underexplored aspect of educational AI: the lived experiences and ethical perceptions of students, the primary end-users of these technologies in academic contexts.

1.2 Problem Statement

As AI technologies become embedded in the academic ecosystem, a persistent gap has emerged between technological advancement and pedagogical oversight. While institutional stakeholders often highlight the efficiencies of AI such as automated grading, intelligent analytics, and expanded access to learning materials the implications for student agency, ethics, and academic integrity remain insufficiently investigated [16], [8].

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Students now regularly engage with generative tools like ChatGPT and Grammarly, often without clear institutional guidance. The ambiguous boundary between legitimate support and academic misconduct creates ethical dilemmas, particularly regarding plagiarism, authorship, and intellectual ownership [2],[21]. In addition, AI systems collect large volumes of behavioral and personal data, frequently without transparent disclosure or oversight. This fosters anxiety about data privacy, fairness, and algorithmic bias, especially when AI is used in evaluative or assessment contexts [15],[22]. Despite the rapid adoption of AI in universities, existing literature and institutional policies tend to prioritize developer and educator perspectives. Student voices, the very individuals navigating the ethical and academic tensions introduced by AI remain marginal in this discourse. This study aims to fill that gap by foregrounding student experiences, perceptions, and challenges associated with AI usage in higher education.

1.3 Significance of the Study

Positioned at the intersection of technological innovation and ethical pedagogy, this study offers both theoretical and practical contributions to the field of educational research. Conceptually, it advances the discourse by centering student agency, critical engagement, and digital ethics, areas often overlooked in AI policy frameworks that emphasize functionality over user impact.

Practically, the findings can guide universities in:

- Designing evidence-based AI literacy programs,
- Developing institutional AI policies that reflect student realities,
- Clarifying boundaries around ethical usage, authorship, and academic integrity.

The research also holds implications for educational technology developers, encouraging the creation of AI systems that respect user autonomy, fairness, and transparency. Ultimately, the study supports a vision of AI integration in education that is equitable, ethical, and pedagogically sound, aligning technological potential with student-centered learning values.

1.4 Research Objectives

This study is guided by the following objectives:

- To examine university students' perceptions of AI's role in teaching, learning, and assessment.
- To identify the challenges students, face in using AI tools, particularly around academic integrity, data privacy, and over-reliance.
- To assess student attitudes and behaviors toward generative AI tools (e.g., ChatGPT), including their influence on academic performance and cognitive engagement.
- To explore students' ethical concerns, focusing on issues such as misinformation, bias, and algorithmic fairness in educational contexts.

1.5 Limitations of the Study

Despite its contributions, the study acknowledges several limitations:

- Sample Representativeness: The use of non-probability sampling limits generalizability across institutional types, cultural backgrounds, and disciplinary areas.
- Rapid Technological Evolution: AI tools and policies evolve quickly; thus, some findings may become outdated as new technologies or regulations emerge.
- Self-Report Bias: Data collected through self-reporting may be influenced by memory inaccuracies, social desirability, or subjective interpretations.
- Pedagogical Scope: The study focuses exclusively on student perspectives. It does not examine educator or administrative practices, which also shape the academic AI landscape.

II.METHODOLOGY

2.1 Research Design

This study employed a quantitative, cross-sectional survey design to systematically explore university students' perceptions, usage behaviors, and ethical considerations regarding the integration of Artificial Intelligence (AI) tools within academic environments. The design was selected for its strength in capturing measurable and generalizable patterns across a broad and diverse student population at a single point in time.

A descriptive-explanatory approach guided the research process. The descriptive component focused on documenting the prevalence and frequency of AI tool adoption, while the explanatory component aimed to uncover the attitudinal and behavioral predictors of AI-driven academic performance. This dual strategy allowed the study to move beyond surface-level patterns and probe the relational dynamics between AI use, trust, engagement, and ethical awareness.

The rationale for using a quantitative methodology lies in its capacity to yield statistically robust data that can be subjected to inferential analysis. It aligns with the study's core objective: to develop an evidence-based understanding of how students navigate the pedagogical and ethical implications of AI technologies. Through this approach, the study identifies trends and predictors grounded in student experience, offering insights into areas such as digital equity, institutional governance, and academic integrity.

The design also supports the testing of relationships among multiple constructs defined in the theoretical framework,

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using correlation and regression techniques to validate conceptual pathways related to the Technology Acceptance Model (TAM), Constructivist Learning Theory, and Ethical AI Governance.

2.2 Population and Sampling

The target population for this study comprised undergraduate and postgraduate university students enrolled across diverse academic disciplines and institutional contexts in Bangladesh. To enhance representativeness and reduce institutional or disciplinary bias, the research outreach spanned both public and private universities and targeted students at various levels of study.

A non-probability convenience sampling method was employed. This approach was chosen due to several pragmatic considerations: the distributed nature of student populations, limited institutional access to formal sampling frames, and the logistical constraints of online data collection. Convenience sampling enabled broad and rapid participation by leveraging digital communication channels such as university mailing lists, academic groups, and social media. While this technique facilitated accessibility and demographic diversity, it is not without limitations. Most notably, the sample may skew toward students with greater internet access, digital literacy, and interest in AI-related discourse. As such, individuals from under-resourced backgrounds or less technologically engaged environments may be underrepresented. This potential sampling bias is acknowledged and addressed in the study's limitations section. Despite these constraints, the final sample size of 300 valid responses exceeds the minimum threshold recommended for descriptive and multivariate statistical procedures. It allows for meaningful subgroup analysis and supports the reliability of inferential outcomes.

2.3 Instrumentation and Data Collection

Data was collected using a structured, self-administered online questionnaire specifically developed for this study. The instrument was designed to assess students' experiences with, perceptions of, and ethical awareness regarding AI in higher education. It measured four key conceptual dimensions:

- Awareness and usage patterns of AI tools
- Perceived benefits in relation to academic performance and efficiency
- Ethical concerns (e.g., bias, plagiarism, misinformation)
- Attitudes toward institutional AI policy and integration

The survey included three types of closed-ended questions:

- Multiple-choice items (e.g., frequency of AI usage, tools used)
- Checkbox items (e.g., academic tasks supported by AI)
- Likert-scale items (5-point scale: 1 = Strongly Disagree to 5 = Strongly Agree), used to assess attitudes, ethical concerns, and institutional perceptions.

Pilot Testing and Revisions

To ensure clarity and relevance, the instrument was pilot tested with 15 students from different disciplines. Based on feedback, minor adjustments were made to improve item wording and clarity. No major structural revisions were required. The finalized questionnaire was distributed using Google Forms, and the data collection period spanned three weeks. Participants were recruited through multiple online channels, including university mailing lists, student forums, academic WhatsApp groups, and Facebook communities.

2.4 Instrument Reliability

The internal consistency of each multi-item construct was assessed using Cronbach's alpha, a statistical measure of reliability. As shown below, all constructions achieved acceptable or high reliability, exceeding the standard threshold of $\alpha = 0.70$.

TABLE 1
CRONBACH'S ALPHA SCORES FOR SURVEY CONSTRUCTS

Construct	Number of Items	Cronbach's Alpha (α)
Perceived Benefits	5	0.87
Ethical Concerns	5	0.81
Policy Awareness	4	0.78
Trust in AI Content	3	0.76
AI-Enhanced Engagement	4	0.84
Access Issues	3	0.74
AI-Driven Academic Performance	4	0.88

These results validate the construct reliability of the survey instrument and justify the inclusion of composite variables in later regression and correlation analyses.

2.4 Data Analysis Strategy

All survey responses were first exported from Google Forms into Microsoft Excel for initial cleaning, then imported into IBM SPSS Statistics (Version 28) for comprehensive analysis. The data analysis strategy was designed to support both descriptive and inferential

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objectives aligned with the study's research questions and theoretical framework.

Descriptive Statistics

Basic statistical measures including frequencies, percentages, means, and standard deviations were computed to summarize demographic characteristics and general trends in AI awareness, usage, and perceptions. These provided foundational insight into the distribution and central tendencies of key constructs.

Reliability Analysis

The internal consistency of all multi-item Likert-scale constructs was assessed using Cronbach's alpha. This ensured that constructs such as Perceived Benefits, Ethical Concerns, and AI-Enhanced Engagement demonstrated acceptable reliability ($\alpha \geq 0.70$), confirming the robustness of the measurement model (see Table 1 in Section 2.4).

Inferential Statistics

A multi-layered inferential analysis plan was employed:

- Independent Samples t-tests and One-Way ANOVA were used to examine differences in AI-related perceptions across demographic groups (e.g., gender, academic level, type of institution).
- Pearson Correlation Coefficients were computed to assess the strength and direction of relationships among constructs, particularly between AI usage and perceived academic performance.
- Multiple Linear Regression Analysis was conducted to identify the most significant predictors of AI-Driven Academic Performance, using variables such as Perceived Benefits, Trust in AI, Policy Awareness, and Access Issues.

This analytical strategy provided both breadth and depth in understanding the interaction between students and AI technologies, enabling evidence-based conclusions about the factors that enhance or inhibit educational outcomes in AI-mediated learning environments.

2.5 Ethical Considerations

The study adhered to established ethical principles governing human subjects research in educational contexts. Before participating, all respondents were required to read and digitally acknowledge an informed consent form, which detailed:

- The purpose and scope of the study
- The voluntary nature of participation
- Assurances of anonymity, confidentiality, and data security

Participation was entirely voluntary, and no personal or identifying information was collected at any stage of the process. The online format ensured minimal risk to participants, and all data was stored securely on encrypted cloud platforms with access limited strictly to the principal investigator.

The research was conducted in accordance with institutional ethical standards and was formally approved by the university's Ethics Review Committee. All procedures followed applicable national and institutional guidelines for the protection of human subjects.

III. LITERATURE REVIEW

Artificial Intelligence (AI) is profoundly reshaping higher education. From algorithm-driven tutoring systems to generative content tools and predictive analytics, AI technologies are transforming teaching delivery, learning engagement, and academic support structures [16], [17]. Their integration is not only altering instructional mechanics but also raising critical concerns around equity, agency, integrity, and ethics. This chapter critically reviews contemporary literature across six thematic areas: (1) AI applications in education, (2) pedagogical and cognitive impacts, (3) ethical and academic integrity challenges, (4) student attitudes and behavioral dynamics, (5) equity and adaptive learning concerns, and (6) strategies for ethical AI integration in educational policy.

3.1 Applications of AI in Higher Education

AI's role in academia encompasses diverse applications across instruction, administration, and assessment. [17] classify these into adaptive learning platforms, automated assessment systems, administrative tools, and AI tutors. These systems leverage data-driven algorithms to optimize teaching outcomes and support at scale. LLMs like ChatGPT and Claude are now capable of interpreting prompts, generating text, simulating dialogue, and offering conceptual support tools that students increasingly rely on for both comprehension and academic production [2], [11].

Holmes and Tuomi [8] argue that AI's value lies in scalability and customization, especially within massive open online courses (MOOCs) and asynchronous learning formats where personalized human instruction is limited. [12] & [23] further illustrate that in engineering education, generative AI is now routinely used to translate complex problems, generate summaries, and streamline project workflows. Such uses mark a shift in the academic workflow moving from manual cognition toward a human-machine collaborative model.

Beyond instruction, AI also powers administrative functions such as plagiarism detection, predictive student retention systems, and chatbot-based academic advising. However, the automation of decision-making concerns transparency and human oversight, particularly when algorithms are tasked with high-stakes judgments.

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3.2 Pedagogical and Cognitive Benefits

Proponents of AI-enhanced learning cite gains in efficiency, personalization, and metacognitive growth.[5] [7] argue that AI contributes to student-centric learning by enabling individualized pacing and targeted scaffolding. Students engage more deeply when feedback is instant, and content is responsive to their level of understanding.

In this context, AI aligns well with constructivist learning theories, which prioritize experiential, active, and inquiry-based learning. [6] found that students using adaptive platforms experienced better retention and self-regulation due to frequent formative feedback. These findings are echoed in studies where AI-supported flipped classrooms and project-based learning environments enhanced collaboration and critical thinking [7]. Moreover, AI can serve as a cognitive prosthetic, helping students overcome barriers such as information overload or linguistic challenges. Multilingual support tools and AI-generated translations foster inclusivity, especially for non-native speakers. Nonetheless, scholars caution that overdependence may reduce deep processing if AI substitutes rather than supplements learning.

3.3 Ethical Concerns and Academic Integrity

As AI becomes more embedded in academic tasks, concerns surrounding academic honesty, authorship, and cognitive offloading intensify. [15] warns that the ease of using tools like ChatGPT may tempt students to bypass intellectual labor, effectively outsourcing thinking. This "AI plagiarism" complicates traditional definitions of cheating, particularly when institutional policies are ambiguous or absent.

Ref. [2] notes that generative tools blur the boundary between assistance and authorship, as outputs often require minimal student modification. Such practices risk undermining not only academic integrity but also the development of students' analytical and writing competencies. In addition, ethical dilemmas stem from AI's opacity. As [10] emphasize, most educational AI systems are proprietary "black boxes" that do not disclose decision logic. This raises concerns about algorithmic bias, especially when AI is used in grading or student profiling. [14] report that students often engage with AI tools without clear awareness of their limitations or biases. [4] argues for proactive AI governance in education encompassing algorithmic transparency, bias audits, and policy frameworks that define acceptable AI use. Absent such safeguards, institutions may inadvertently promote unethical dependencies or reinforce inequities.

3.4 Student Perceptions and Engagement

Students' attitudes toward AI shape how they use it and evaluate their academic utility. [3] found that while students appreciate AI's ability to reduce workload and accelerate output, they are also wary of its limitations. Common concerns include factual inaccuracies, lack of nuance, and the dilution of critical thinking.

Ref. [18] advocates for student engagement in ethical debates, arguing that such inclusion fosters AI literacy and moral reasoning. Their study suggests that when students are involved in shaping AI policies, their trust and constructive use of technology increase significantly. [1] and [24] emphasize the importance of digital transparency in institutional messaging. When universities clearly articulate how AI tools should be used and where boundaries lie students are better able to self-regulate and align usage with academic expectations. [13] further show that algorithmic trust and institutional alignment influence whether students view AI as a complement or a threat to their learning.

3.5 Adaptive Learning and Equity

The promise of AI in supporting personalized learning is heavily contingent on access and inclusion. [11] demonstrate that digital inequality stemming from differences in internet access, device availability, or technical literacy prevents many students from fully benefiting from adaptive AI systems. Thus, what is often framed as a universal solution may deepen the digital divide.

Ref. [11] calls for inclusive AI design, particularly in multilingual and culturally diverse settings. Their research underscores the importance of content neutrality, language accessibility, and localized adaptability. Similarly, [9] caution that AI systems trained on biased datasets may reproduce inequities in academic feedback, performance prediction, or assessment. In effect, equity in AI-enhanced education is not merely about access; it involves representation, cultural sensitivity, and fairness in algorithmic processes. Without inclusive strategies, even well-designed AI can marginalize or misrepresent diverse learner experiences.

3.6 Toward a Responsible Future: Ethical-AI Integration

To mitigate risks and maximize benefits, scholars advocate for the intentional and ethical integration of AI into higher education policy and curriculum. [1] propose a four-dimensional governance framework involving transparency, faculty readiness, policy clarity, and digital literacy. This framework ensures that AI adoption aligns with institutional values and pedagogical goals.

Ref. [13] recommends embedding AI ethics and digital citizenship into general education curricula, preparing students to critically engage with AI as both users and evaluators. Their model supports ongoing assessment of AI's educational impact not just in terms of efficiency, but also in terms of cognitive and moral development.

Ref. [4] concludes that ethical AI integration requires a multi-stakeholder approach, involving educators,

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developers, policymakers, and critical students. Institutions must move beyond reactionary regulation and instead develop forward-looking strategies that embed ethics, access, and learning integrity into every stage of AI adoption.

3.7 Theoretical Framework

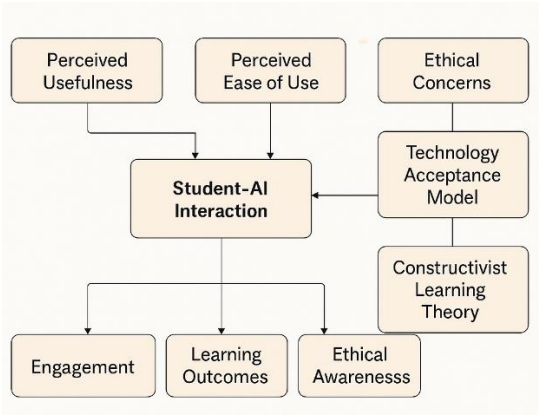


Fig.1. Theoretical Framework

Figure 1 presents the integrated theoretical framework underpinning this study, drawing from the Technology Acceptance Model (TAM), Constructivist Learning Theory, and emerging models of Ethical AI Governance. At the center of the framework is Student–AI Interaction, conceptualized as the dynamic engagement between learners and generative AI tools in academic contexts.

According to TAM, students' Perceived Usefulness and Perceived Ease of Use are core predictors of their willingness to engage with AI technologies. These factors feed directly into the central interaction node, influencing the frequency, depth, and quality of AI adoption in learning activities. Simultaneously, Ethical Concerns reflecting anxieties about fairness, authorship, privacy, and misinformation moderate the extent to which students engage with AI tools confidently and responsibly.

The framework also incorporates principles from Constructivist Learning Theory, which positions AI as a facilitator of learner-centered, active engagement. As students interact with AI systems, outcomes manifest in three primary domains: Engagement, Learning Outcomes, and Ethical Awareness. These outcome constructs are influenced both directly by student-AI interactions and indirectly through the mediating effects of institutional policy clarity and ethical training.

Together, these dimensions form a multidirectional model, emphasizing the reciprocal relationships among cognition, ethics, and technology. The framework provides a comprehensive lens to interpret empirical findings and supports future inquiries into AI's pedagogical and ethical implications in higher education.

IV. DATA ANALYSIS

4.1 Overview

Thi study presents a comprehensive quantitative analysis of student responses to assess the academic, cognitive, and ethical implications of Artificial Intelligence (AI) integration in higher education. Drawing on a structured survey of 300 university students, the analysis proceeds through four phases:

- Descriptive statistics to establish general trends across key constructs.
- Correlation analysis to explore inter-variable relationships.
- Multiple regression analysis to identify significant predictors of AI-driven academic performance; and
- Visual analytics to support pattern recognition and model interpretation.

Together, these analyses aim to validate the multidimensional theoretical framework proposed in Chapter III, grounded in the Technology Acceptance Model, Constructivist Learning Theory, and principles of Ethical AI Governance.

4.2 Descriptive Statistics

To capture the breadth of student experiences, participants rated their perceptions across seven core constructs: Perceived Benefits, Ethical Concerns, Policy Awareness, Access Issues, Trust in AI Content, AI-Enhanced Engagement, and AI-Driven Academic Performance. Each was assessed using multiple Likert-scale items.

TABLE 2: DESCRIPTIVE STATISTICS OF CORE CONSTRUCTS

Construct	Mean	Standard Deviation	Min	Max
Perceived Benefits	3.91	0.78	1	5
Ethical Concerns	3.22	0.85	1	5
Policy Awareness	2.85	1.02	1	5
Access Issues	2.94	0.99	1	5
AI-Enhanced Engagement	3.73	0.80	1	5
Trust in AI Content	3.88	0.83	1	5
AI-Driven Academic Performance	3.67	0.84	1	5

Students generally hold positive attitudes toward AI, particularly regarding its usefulness and contribution to

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engagement and productivity. However, relatively lower scores on Policy Awareness and moderate Ethical Concerns suggest uncertainty about institutional expectations and responsible use. This gap signals a critical need for targeted AI literacy interventions and clearer governance structures.

4.3 Correlation Analysis

A Pearson correlation matrix was employed to evaluate the strength and direction of relationships between constructions. This analysis supports hypothesis development by identifying statistically relevant patterns.

Key Correlation Findings:

- Perceived Benefits were positively associated with both Trust in AI Content (r = 0.52) and AI-Enhanced Engagement (r = 0.47), suggesting that utility perception reinforces confidence and student motivation.
- Ethical Concerns had modest negative correlations with Perceived Benefits (r = -0.18) and Trust (r = -0.12), reflecting a tradeoff between perceived utility and ethical uncertainty.
- Policy Awareness showed weak or negligible correlations with other constructs, indicating a cognitive disconnect between institutional messaging and student perception.

These relationships empirically support the conceptual model in which trust, and engagement serve as mediating pathways linking perceived AI usefulness to academic outcomes, while ethical and infrastructural concerns potentially moderate these effects.

4.4 Regression Analysis: Predicting AI-Driven Academic Performance

To isolate the key predictors of AI-enhanced academic outcomes, a refined multiple linear regression was conducted using a composite dependent variable AI-Driven Academic Performance. This variable aggregated responses on learning efficiency, task management, and conceptual comprehension attributed to AI usage.

Model Summary:

- $R^2 = 0.631$, Adjusted $R^2 = 0.617$
- $F(6, 293) = 83.1$, $p < 0.001$ → Highly statistically significant model

TABLE 3: REGRESSION COEFFICIENTS FOR AI-DRIVEN ACADEMIC PERFORMANCE

Predictor	β Coefficient	Std. Error	t-value	p-value
Constant	1.215	0.312	3.89	<0.001
Perceived Benefits	0.421	0.050	8.42	<0.001
AI-Enhanced Engagement	0.205	0.045	4.57	<0.001
Ethical Concerns	0.178	0.044	4.02	<0.001
Policy Awareness	0.134	0.035	3.81	<0.001
Trust in AI Content	0.102	0.038	2.65	0.008
Access Issues	-0.098	0.034	-2.90	0.004

The regression model explains over 63% of the variance in AI-driven academic performance, a robust effect in educational research.

- Perceived Benefits emerged as the strongest predictor ($\beta = 0.421$, $p < 0.001$), highlighting that students who view AI as helpful derive the most academic value.
- AI-Enhanced Engagement also demonstrated a strong influence ($\beta = 0.205$, $p < 0.001$), suggesting that active, productive interaction with AI tools significantly contributes to academic gains.
- Ethical Concerns ($\beta = 0.178$) and Policy Awareness ($\beta = 0.134$) were positively associated, indicating that students with higher ethical and procedural awareness benefit more perhaps due to more informed and responsible usage patterns.
- Trust in AI Content ($\beta = 0.102$) was significant but comparatively weaker, suggesting that while confidence in AI contributes to outcomes, it does so in combination with other factors.
- Access Issues were the only negative predictor ($\beta = -0.098$, $p = 0.004$), confirming that infrastructure inequality and inconsistent access to AI tools inhibit academic performance.

4.5 Visual Analytics



Fig. 2. Correlation Heatmap of Key Constructs

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Figure 2 displays the Pearson correlation coefficients among the primary variables examined in this study: Perceived Benefits, Ethical Concerns, Policy Awareness, Access Issues, AI-Enhanced Engagement, Trust in AI Content, and AI-Driven Academic Performance. The heatmap reveals strong positive correlations between Perceived Benefits and both AI-Enhanced Engagement (r = 0.63) and Academic Performance (r = 0.71), indicating that students who view AI as useful are more likely to engage actively and report academic improvement. Similarly, Trust in AI Content is moderately correlated with both Engagement (r = 0.51) and Performance (r = 0.65), underscoring the role of confidence in AI-generated material.

Access Issues consistently show negative correlations, especially with Performance (r = -0.29), highlighting the detrimental impact of unequal infrastructure on educational outcomes. Ethical Concerns and Policy Awareness are positively associated with academic performance, though more moderately, suggesting that awareness of ethical frameworks and institutional policy may support more responsible and effective AI usage.

These relationships support the study's conceptual model, validating trust, engagement, and digital equity as pivotal mediators of AI's influence in academic settings.

Fig. 3. Pairwise Relationships among Constructs

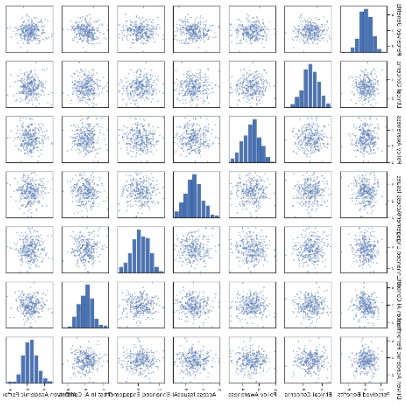


Figure 3 presents a pairwise scatterplot matrix visualizing the relationships among the seven core variables: Perceived Benefits, Ethical Concerns, Policy Awareness, Access Issues, AI-Enhanced Engagement, Trust in AI Content, and AI-Driven Academic Performance. Each scatterplot illustrates the bivariate relationship between variable pairs, while the histograms along the diagonal display the distribution of responses for each construct.

Visible clusters in the plots reveal strong, linear relationships between Perceived Benefits, AI-Enhanced Engagement, and Academic Performance, consistent with the regression analysis. Notably, students reporting higher perceived usefulness of AI tools also showed greater engagement and better self-reported academic outcomes. Similarly, trust in AI content demonstrates a positive trend with both engagement and performance measures.

Access Issues display more diffuse and scattered patterns, particularly when compared with other constructs, suggesting variability in how infrastructural challenges affect students' interaction with AI. Policy Awareness and Ethical Concerns also show moderate positive trends with performance, though with more heterogeneity across responses.

This multidimensional visualization reinforces the interconnectedness of student attitudes, ethical considerations, and infrastructure in shaping the academic impact of AI technologies.

4.6 Implications and Next Steps

The low explanatory power of the regression model suggests that linear relationships may be inadequate to capture the complexity of student-AI interactions. Consequently, the following advanced statistical techniques are recommended for future studies:

- Structural Equation Modeling (SEM): To test latent constructs and indirect pathways (e.g., Benefits → Trust → Engagement → Performance).
- Mediation/Moderation Models: For example, whether Engagement mediates the link between Trust and Academic Performance, or whether Policy Awareness moderates the effect of Trust.
- Cluster Analysis or Latent Class Analysis: To segment students based on AI usage profiles and ethical attitudes.

These approaches would enable a more nuanced understanding of how students internalize, navigate, and evaluate AI's academic role.

V. DISCUSSION

5.1 Overview

This chapter interprets the findings of the study through both empirical evidence and theoretical reflection. By synthesizing data analysis results with literature and the proposed theoretical framework, the chapter provides a multidimensional perspective on how university students engage with AI in higher education. Central themes include the perceived academic utility of AI, ethical challenges, trust in AI-generated content, and issues of accessibility and equity. These findings are contextualized within the frameworks of the Technology Acceptance Model (TAM), Constructivist Learning Theory, and Ethical-AI Governance, contributing to a nuanced understanding of the complex role AI plays in shaping student learning, behavior, and ethical decision-making.

5.2 Interpretation of Findings

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5.2.1 Perceived Benefits of AI in Higher Education

Students overwhelmingly recognized AI as a beneficial tool in their academic experience. With the highest mean score ($M = 4.12$) among all constructs and the strongest regression coefficient ($\beta = 0.421$), the results highlight how AI supports personalized learning, efficient information processing, and academic task simplification. These outcomes are consistent with [3] and [9] who emphasized AI's role in enhancing learning efficiency and cognitive development.

The positive correlation between AI-Enhanced Engagement and Perceived Benefits reinforces the constructivist notion that learners actively engage with tools that respond to their individual needs. AI tools, by enabling real-time support and self-paced exploration, mirror the pedagogical ideals of student-centered and inquiry-based learning environments. This self-directed learning capacity helps explain the growing reliance on AI for content synthesis, paraphrasing, translation, and research among students.

However, the results also suggest that these benefits are not evenly distributed across all learners. While high-performing students may capitalize on AI's strengths, others may engage with it passively or for surface-level outputs, a phenomenon requiring further study.

5.2.2 Ethical Concerns and Academic Integrity

Despite the advantages of AI, ethical concerns remain significant. The high mean score of 3.87 on this construct and its predictive influence on academic performance ($\beta = 0.178$, $p < 0.001$) highlight students' awareness of academic misconduct, misuse, and the blurry boundary between help and cheating. This Shows that generative AI may erode critical thinking and promote academic shortcuts if not regulated by institutional frameworks.

Students' concern with plagiarism, authorship, misinformation, and the impersonality of AI-generated responses is reinforced by [1] and [5], who note that algorithmic opacity and the inability to understand how AI makes decisions reduces accountability and deep engagement.

Interestingly, the regression analysis also reveals that Policy Awareness ($\beta = 0.134$, $p < 0.001$) is a statistically significant predictor, yet its influence may temper students' enthusiasm about AI. Students who are more informed about institutional policy frameworks often adopt more cautious or skeptical attitudes, suggesting that awareness alone is insufficient unless paired with clear guidance and AI literacy programs.

Moreover, students may perceive AI as a "double-edged sword" helpful in task execution, yet risky in terms of academic honesty. The absence of clear ethical boundaries contributes to confusion, which could ultimately undermine students' confidence in using AI tools responsibly.

5.2.3 Trust in AI and Academic Outcomes

Trust in AI content, although rated positively ($M = 3.68$), shows a more nuanced role in academic performance. While it significantly predicts performance ($\beta = 0.102$, $p = 0.008$), the effect size is smaller than other predictors, suggesting that trust alone does not guarantee improved academic outcomes.

This resonates with findings from [18], who assert that while students may rely on AI tools, the absence of algorithmic transparency and explainability reduces the perceived reliability of outputs. Students often question the accuracy, bias, and appropriateness of AI responses, especially in high-stakes academic tasks.

The gap between trust and performance may also reflect over-reliance without critical evaluation, where students use AI-generated outputs uncritically, potentially harming learning depth. This underlines the importance of critical AI literacy, where students are taught not only how to use AI but how to question and evaluate its responses, a recommendation echoed across governance literature.

5.2.4 Equity and Access to AI Tools

Access-related issues also emerged as a significant barrier to equitable AI use. While most students reported using AI tools, nearly half mentioned challenges related to connectivity, tool familiarity, or institutional support. The regression analysis confirmed that Access Issues had a negative influence on academic performance ($\beta = –0.098$, $p = 0.004$), supporting the equity concerns raised by [10], [13].

This inequity suggests that AI may not be the democratizing force often portrayed in public discourse. Instead, it risks reinforcing existing educational divides unless institutions intentionally invest in digital infrastructure, training programs, and inclusive policies. For AI to fulfill its transformative potential, equal opportunity of access is critical. Equity is not only about providing hardware and software but also about ensuring cultural and linguistic inclusivity, content relevance, and non-discriminatory algorithms.

5.3 Integration with Theoretical Framework

The results validate the integrated theoretical framework developed in Chapter 3:

- TAM Constructs: The significant positive influence of Perceived Benefits and Trust on academic performance supports Davis' TAM, demonstrating that perceived usefulness and reliability are central to technology adoption decisions. Constructivist Learning Theory: High engagement scores and perceived autonomy in learning align with constructivist ideals that emphasize learner control, experiential engagement, and feedback

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responsiveness. AI's dynamic interaction supports this pedagogical philosophy.

- Ethical Governance Theory: The influence of Policy Awareness and Ethical Concerns reflects the crucial role of institutional norms and guidance. Institutions lacking clarity in AI governance frameworks may inadvertently increase confusion and hesitation among students.

The regression model, with $R^2 = 0.631$, demonstrates that the combined model accounts for over 63% of the variance in perceived academic performance, which represents a robust and empirically validated conceptual model. This strengthens the call for institutions to adopt multi-dimensional AI strategies that incorporate technical, ethical, pedagogical, and equity perspectives.

5.4 Practical Implications and Future Research
These findings have important implications:

- Institutions must move beyond reactive policies and develop proactive, transparent AI governance models that involve student input, ethical training, and clear boundaries for usage.
- AI literacy must be embedded in curricula, not only in terms of technical usage but also in critical thinking, algorithmic bias awareness, and responsible authorship.
- Access gaps must be closed through investment in infrastructure, digital inclusion, and support services for marginalized students.

For future research, longitudinal studies could explore how student perceptions and behavior evolve as institutional policies mature. Additionally, qualitative studies may uncover deeper cognitive and affective dimensions of AI reliance, providing a more comprehensive picture of its pedagogical implications.

VI. CONCLUSION

6.1 Summary of the Study
This research examined the integration of Artificial Intelligence (AI) in higher education from the perspective of university students, with specific focus on its perceived benefits, ethical implications, academic engagement, and access equity. Drawing from responses collected via a structured survey of 300 students, the study employed a suite of statistical methods including descriptive statistics, correlation analysis, and multiple regression to investigate how students interact with AI tools, particularly generative systems like ChatGPT and adaptive platforms that support personalized learning. Anchored in a comprehensive theoretical framework combining the Technology Acceptance Model (TAM), Constructivist Learning Theory, and Ethical AI Governance principles, this study explored how students' experiences with AI are shaped not only by perceived utility and trust, but also by institutional support, ethical concerns, and infrastructural constraints.

6.2 Key Findings

- AI is largely viewed as beneficial: Students reported positive effects of AI on learning efficiency, academic productivity, and engagement, echoing the pedagogical benefits outlined in constructivist theory.
  Ethical concerns and policy awareness act as moderators: Students with higher awareness of academic AI policies were more cautious in their usage, indicating a link between policy exposure and critical reflection on AI's academic implications.
- Access inequality remains a barrier: Approximately 48% of respondents indicated difficulties accessing AI tools, due to technological, financial, or institutional limitations underscoring the persistence of the digital divide in higher education.
- Trust is moderate, but not performance-predictive: While many students expressed confidence in AI-generated content, trust alone did not significantly influence perceived academic performance, pointing to the importance of AI literacy and critical engagement over passive acceptance.

6.3 Implications for Practice
The findings of this study suggest several actionable strategies for educational institutions and policymakers:

- Develop Transparent AI Policies: Universities should implement and communicate clear policies on the acceptable and ethical use of AI in coursework, assessment, and academic communication.
- Bridge the Access Gap: Institutional investments in AI infrastructure, subsidized access to tools, and inclusive technology planning are critical to ensure that benefits are equitably distributed.
- Incorporate Ethical AI Literacy into Curricula: Formal training modules should be developed to help students critically understand how AI works, its risks, and how to use it responsibly within academic contexts.
- Foster Faculty Participation in AI Implementation: Educators must be part of the decision-making and design processes surrounding AI tool integration to ensure alignment with pedagogical goals and student-centered learning.

6.4 Contributions of the Study
This research adds significant value to the emerging discourse on AI in education by:

- Providing empirical insights into how AI affects students' learning behaviors, ethical perceptions, and performance outcomes.

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- Introducing a validated theoretical framework that links technological acceptance, constructivist engagement, and ethical governance.
- Demonstrating the utility of advanced statistical techniques, including regression analysis and model-driven interpretation, as methodological foundations for future research.

6.5 Limitations and Future Research Directions

Several limitations should be acknowledged:

- Cross-sectional design: The snapshot nature of the study limits understanding of how perceptions and behaviors may evolve over time.
- Self-reported data: Respondents' insights may be influenced by social desirability bias, recall errors, or subjective interpretation.

Future studies should:

- Employ longitudinal and mixed methods designs to capture temporal dynamics and richer experiential data.
- Utilize techniques such as Structural Equation Modeling (SEM) or Latent Profile Analysis (LPA) to explore mediators and moderators like digital literacy, institutional trust, or learning orientation.
- Investigate faculty perspectives and policy implementation practices to triangulate findings and guide institution-wide AI strategies.

6.6 Final Remarks

AI's integration into higher education marks a turning point in how knowledge is produced, consumed, and evaluated. While these tools offer powerful advantages for learning, their ethical use and pedagogical alignment are far from guaranteed. This study highlights that the mere presence of AI is insufficient; its impact depends on responsible governance, equitable access, and active student participation in shaping its academic role.

As universities navigate this technological frontier, it is essential to reaffirm the values of academic integrity, critical inquiry, and inclusive innovation. Only through such alignment can AI serve as a transformative force that enriches, rather than erodes, the educational experience.

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Appendices

Appendix A: Survey Instrument

The data for this study were collected via a structured, self-administered online questionnaire composed of five thematic sections. The instrument was designed to assess student experiences, attitudes, and concerns surrounding AI integration in higher education.

Section A: Demographic Information

- Age: _____
- Gender: ☐ Male ☐ Female ☐ Other ☐ Prefer not to say
- Academic Level: ☐ Undergraduate ☐ Postgraduate
- Year of Study: ☐ Year 1 ☐ Year 2 ☐ Year 3 ☐ Year 4
- Discipline/Faculty: _____
- Type of Institution: ☐ Public ☐ Private

Section B: Awareness and Use of AI Tools

- Are you aware of AI tools (e.g., ChatGPT, Grammarly)?
  ☐ Yes ☐ No
- Frequency of AI tool usage: ☐ Daily ☐ Weekly ☐ Occasionally ☐ Rarely ☐ Never
- Purposes for AI use (select all that apply): ☐ Writing ☐ Paraphrasing ☐ Translation ☐ Research ☐ Coding

Section C: Perceptions of AI in Learning
(Scale: 1 = Strongly Disagree, 5 = Strongly Agree)

- AI improves my understanding of complex academic topics.
- AI tools increase my academic productivity.
- I trust the output produced by AI tools.
- AI use helps me stay more engaged with my academic work.
- I believe AI enhances my academic performance.

Section D: Ethical Awareness and Institutional Governance
(Scale: 1 = Strongly Disagree, 5 = Strongly Agree)

- I understand the ethical implications of using AI in education.
- I am aware of my university's policy on AI use.
- Using AI without acknowledgment constitutes academic dishonesty.
- I have received training or guidance on responsible AI use.
- AI poses risks related to plagiarism and authorship.

Section E: Access and Infrastructure

(Scale: 1 = Strongly Disagree, 5 = Strongly Agree)

- I have reliable access to AI tools and the internet.
- I need additional support or training to use AI tools effectively.
- My university provides equitable access to AI-related resources.

Appendix B: Summary of Statistical Results

B.1 Descriptive Statistics (N = 300)

Variable	Mean	Standard Deviation	Min	Max
Perceived Benefits	4.12	0.74	1	5
Ethical Concerns	3.87	0.80	1	5
Policy Awareness	3.10	1.05	1	5
Trust in AI Content	3.68	0.85	1	5
AI-Enhanced Engagement	4.02	0.77	1	5
Access Issues	2.94	0.89	1	5
AI-Driven Academic Performance	4.08	0.69	1	5

B.2 Regression Analysis: Predictors of AI-Driven Academic Performance

Model Summary:

- $R^2 = 0.631$
- Adjusted $R^2 = 0.617$
- $F(6, 293) = 83.1$, $p < 0.001$

Predictor	β Coefficient	Standard Error	t-value	p-value
Perceived Benefits	0.421	0.050	8.42	<0.001
AI-Enhanced Engagement	0.205	0.045	4.57	<0.001
Ethical Concerns	0.178	0.044	4.02	<0.001
Policy Awareness	0.134	0.035	3.81	<0.001
Trust in AI Content	0.102	0.038	2.65	0.008
Access Issues	-0.098	0.034	-2.90	0.004

Interpretation:

All predictors were statistically significant. Perceived Benefits and AI-Enhanced Engagement emerged as the most powerful positive predictors of academic performance. Access Issues had a negative effect,

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emphasizing the impact of infrastructural barriers. Ethical Concerns and Policy Awareness were also positively associated, suggesting that ethically informed students may engage with AI in more effective and academically productive ways.

B.3 Visual Analytics

Figure 2: Correlation heatmap illustrating strong positive associations between Perceived Benefits, Trust, Engagement, and Academic Performance, with negative correlations tied to Access Issues.

Figure 3: Pairwise scatterplot matrix displaying the linear relationships and distribution patterns between all constructs, reinforcing model validity and supporting observed regression trends.

Appendix C: Ethical Compliance

- All participants voluntarily consented before beginning the survey.
- The study was conducted in full alignment with institutional ethical review protocols.
- No personal identifiers were collected; anonymity and confidentiality were strictly maintained.
- Data were securely stored in encrypted platforms accessible only to the research team.
- Participants were informed that their responses would be used exclusively for academic research purposes.

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Adoption of AI-Driven Personalization in the RMG Sector of Bangladesh: A Study on Industry Readiness and Its Impact

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Abstract: **This study examines the implementation of AI-driven personalization in Bangladesh's Ready-Made Garment (RMG) sector, focusing on the industry's readiness. It explores how personalization could enhance operational efficiency, reduce costs, and improve competitiveness, fostering sustainable economic development. Using a qualitative approach, the research includes semi-structured interviews with 15 RMG professionals from four RMG establishments across various levels of the value chain, such as factory managers, HR officers, and IT leaders. Thematic analysis shows that AI readiness in the RMG sector is limited and still in its early stages, but it has significant potential for future transformation. The industry shows early signs of readiness but lacks strategic frameworks for successful integration. This research adds to the limited studies on digital transformation in developing economies and offers practical advice for industry leaders and policymakers. It highlights key factors for adopting AI-driven personalization and identifies essential elements for successful AI implementation.**
Keywords: **Artificial Intelligence, RMG sector, AI-personalization**

I.INTRODUCTION

Artificial Intelligence (AI) is profoundly transforming industries worldwide due to its ability to automate processes, make data-driven decisions, and create personalized customer experiences by utilizing advanced computing to replicate human intelligence. This encompasses various domains, including machine learning, natural language processing, and expert systems. AI has already made significant changes in numerous sectors by allowing machines to perform tasks that typically require human intellect. In the textile and apparel sector, AI enables hyper-personalization, granting brands the ability to deliver extremely customized experiences to their customer [1]. Numerous global brands, especially in regions like China, the USA, and parts of Europe, are already employing AI to innovate the Ready-Made Garment (RMG) industry through strategies like mass customization and predictive analytics. AI-driven personalization emerges as a particularly promising advancement in this field, utilizing machine learning and behavioral data to tailor experiences, services, and products to individual preferences [2].

The RMG sector plays a vital role in the national economy, providing employment for millions and making significant contributions to export revenues [3]. Traditionally, this industry, which represents around 84% of the nation's total exports, has depended on labor-intensive practices with minimal integration of modern technologies. While certain industries, such as healthcare, e-commerce, and finance, have begun to embrace this technological shift, the adoption of AI within the ready-made garment (RMG) sector, particularly in developing countries like Bangladesh, remains considerably behind [4]. Though some manufacturing segments have started using AI for quality control, the overall integration is still quite limited [5] Issues such as insufficient infrastructure, skill gaps, and financial constraints are hindering the sector from fully embracing AI technologies [5]. Consequently, it is increasingly vital to investigate innovative solutions like AI-driven personalization to improve business efficiency, address sustainability concerns, and stay competitive in the global market. The apparel sector has experienced considerable changes as a result of evolving consumer preferences and advancements in technology. In the realm of customer service, AI-driven chatbots and virtual assistants are improving response times and customer interactions, thereby boosting overall satisfaction [6]. The application of AI-driven personalization in the RMG sector could lead to significant improvements in efficiency, product quality, and customer satisfaction.

By leveraging AI, manufacturers can enhance their ability to forecast market trends, reduce waste, and offer tailored products, thus improving their competitiveness on a global scale. In Bangladesh, the industry's readiness to adopt AI significantly relies on digital infrastructure, an efficient workforce, and a supportive policy and regulatory framework. Current gaps in technical expertise, data infrastructure, and organizational awareness pose considerable challenges for the RMG sector regarding the integration of AI [7]. This study intends to evaluate the preparedness of organizations within Bangladesh's RMG sector to implement AI while also exploring their present capabilities and challenges. The Technology-Organization-Environment (TOE) framework [8] is employed to analyze how different factors affect AI personalization adoption in the RMG sector. The primary goal of this study is to analyze the current readiness of the Ready-Made Garment (RMG) industry in Bangladesh for adopting AI-driven personalization technologies and to evaluate possible effects of this implementation on operational efficiency, customer engagement, and competitive edge. This study seeks to pinpoint the main factors and challenges that affect the industry's readiness, assess the current state of technological capability, and investigate the strategic consequences of incorporating AI personalization into the RMG value chain. Therefore, this study will contribute to the current body of knowledge by exploring the role of AI personalization in Bangladesh's Ready-Made Garment (RMG) sector, which is the country's primary industry but

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has been under-researched academically. It provides an analysis of how prepared the industry is for implementing AI, identifies existing gaps and possibilities, and assesses the potential effects of AI-driven personalization on operational efficiency, customer engagement, and global competitiveness. The research offers actionable recommendations for industry leaders, policymakers, and stakeholders aiming to enhance Bangladesh's standing in the global apparel value chain through digital transformation.

II. LITERATURE REVIEW

Artificial Intelligence (AI) describes the ability of machines or computer systems to perform tasks that usually necessitate human intelligence. The textile manufacturing sector is experiencing a notable transformation due to AI advancements. The readiness of the ready-made garment (RMG) industry for textile applications refers to how prepared the sector is to embrace and implement AI technologies, particularly in areas such as personalized production, consumer insights, and supply chain optimization. According to the TOE framework [8], the adoption of technology is shaped by three contexts: technological, organizational, and environmental. The technological context encompasses both the internal and external technologies relevant to the company. It includes a company's existing technological tools and practices, along with the external technologies accessible to it. This component examines the user-friendliness and compatibility to ensure the practical advantages of the new technology. The organizational context pertains to the internal environment in which technology is utilized, encompassing aspects like the firm's size, scope, and management structure. This component addresses the structure and culture of the organization that promotes and facilitates the utilization of new technology. The environmental context refers to the external conditions under which the firm operates, specifically its competitors, interactions with the government, and its industry as a whole. Finally, the environmental component assesses the external, social, and technological support available for AI applications [9,10]. Research suggests that the adoption of technology differs across both industries and nations [11]. A study reveals that AI-enabled smart factories can enhance supply chain visibility, optimize inventory management, and reduce production lead times [12]. Leading textile-producing countries such as China, Vietnam, and Turkey have begun to implement AI to improve efficiency, reduce waste, and enhance transparency in their supply chains. China, a significant competitor to Bangladesh, has illustrated a strategic approach by adopting cutting-edge technologies, focusing on sustainability, and actively collaborating with suppliers, setting a standard for harmonizing environmental accountability with operational efficiency [13]. Meanwhile, Bangladesh, which derives over 80% of its export revenue from apparel, stands as one of the top exporters in the global garment sector (Export Promotion Bureau, 2021). Faruque Hassan, the president of the Bangladesh Garment Manufacturers and Exporters Association (BGMEA), has been a strong proponent of integrating AI to promote growth within the garment industry [14]. However, Bangladesh remains in the early stages of utilizing AI, encountering substantial hurdles such as a lack of technical skills, high implementation costs, and resistance to change, along with deep-rooted practices and fears regarding job security [15]. Even though the apparel industry in Bangladesh is less explored by researchers, there has been particularly limited investigation into the readiness for technology adoption issues within this sector. Embracing modern and eco-friendly technologies can boost competitiveness, enhance productivity, minimize mistakes, and maximize resource efficiency.

III. METHODOLOGY

The study adopts an exploratory research design. Its main goal is to collect in-depth qualitative data about the adoption process and the impact of AI-driven personalization, utilizing the TOE framework. The primary method for data collection was semi-structured interviews, which struck a balance between formal questioning and the chance to explore issues raised by the participants. This approach is particularly suitable for investigating new and complex topics since set frameworks may limit the depth of insights. Participants were selected through purposive sampling. The research utilized a two-phase sampling strategy [16,17]. Initially, apparel manufacturing factories focused on exports were identified. Subsequently, factories were selected that varied in aspects such as size, ownership structure, the background of respondents, their experience, and the range of business activities. The study involved 15 professionals from four ready-made garment (RMG) companies located in the Narayanganj district of Bangladesh, including two large companies and two medium-sized firms. The inclusion of both large and medium enterprises allows for a comparative analysis of AI adoption across different organizational sizes, thereby improving the understanding of the sector's readiness and challenges.

Participants represented varied roles, including General Manager, Deputy General Manager, IT Head, Production Manager, and Compliance Officer. Each organization provided 3 to 4 participants, ensuring that strategic, operational, and technical viewpoints were well-represented. The research data was collected through semi-structured interviews, which were conducted in person at the participants' workplaces, while phone interviews were used when face-to-face meetings were not feasible. All interviews were conducted in Bangla and were digitally recorded. The audio recordings were then translated and transcribed from Bangla to English. Consent was obtained from participants for recording the interviews to ensure accurate transcription and analysis. Each interview lasted around 15-20 minutes and was guided by open-ended questions. The semi-structured format allowed for a balance between focused inquiries and the flexibility to explore

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important themes, including the current use of AI in the RMG sector, levels of awareness, challenges encountered, and overall readiness for AI incorporation. The data analysis utilized thematic analysis by categorizing responses within the TOE framework. The recordings were transcribed verbatim, with the transcripts reviewed several times to identify recurring themes, patterns, and insights relevant to the research objectives. Manual coding of the data was performed to highlight key themes. This analysis focused on organizing the data according to principal research themes related to organizational readiness, barriers to AI adoption, and the perceived impact of AI on business functions within the RMG sector. This approach enabled the extraction of detailed insights that directly align with the research objectives.

IV. RESULTS

The Ready-Made Garment (RMG) sector in Bangladesh, although the second-largest exporter in the world, has fallen behind in adopting technological advancements. While artificial intelligence (AI) offers significant opportunities to optimize production processes, improve quality control, and streamline supply chain management, various obstacles still hinder its adoption in the industry. A recent study examining the textile sector in Bangladesh highlights critical challenges such as insufficient technological infrastructure, high costs of implementation, and a lack of skilled professionals who are knowledgeable in AI and data analytics [18]. The identified themes have been structured according to the TOE framework, as shown in Figure-1. The findings were analyzed based on the technological context, organizational context, and environmental context.

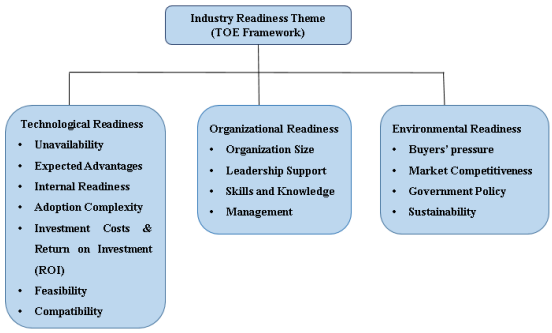


Figure 1: Industry Readiness theme framework
Author's Work

Technological Readiness:

Regarding the technological context, adoption decision mainly depends on the expertise of technology usage, perceived usefulness of technology, internal expertise, feasibility, compatibility and investment cost analysis. The findings and statements of the interviewees related with technological readiness are presented in Table 1.

Technological Theme	Key Findings	Quote Evidence	Factory Types
Unavailability of Resources	Most factories—both large and medium—have adopted basic digital tools (e.g., CAD, ERP, barcode tracking), but lack access to AI-specific technologies. AI tools are either unknown, or they expect that AI has been embedded within foreign machinery without explicit understanding. It can be inferred that AI technology is not yet widely accessible or recognized in Bangladesh.	*"We use pattern-making software and advanced cutting machines, but… we haven't implemented anything concerned to that concept."* — GM, Medium Enterprise *"AI tools are not directly marketed to us in Bangladesh … they come embedded in advanced foreign machines."* — DGM, Large Factory	Both large and medium enterprises, but medium enterprises are less exposed to foreign technology.
Expected Advantages	There are strong perceived benefits of AI personalization. Participants strongly believe in AI's future potential, especially in reducing errors, increasing efficiency, and optimizing forecasting.	*"If AI could be adopted to detect fabric defects quickly… it would save us hours…"* — IT Head, Knitwear Company *"AI could provide us with accurate predictions … we currently use a dashboard for this."* — Supply Chain Manager	All factory scales recognize the advantages, but larger factories are better positioned to implement them once barriers are removed.
Internal Readiness	Lack of technical expertise, training, and awareness among both workers and management. Responsibility lies with top management. Management is not fully informed, and technical staff are unequipped to handle AI systems.	"Our IT head is only equipped to handle emails and HR software—how can he manage an AI system?" DGM, Large Enterprise *"We currently have no skilled workers…	but large factories are more vocal about management-level barriers, while medium factories suffer from resource and talent shortage.

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		let's grow the market first." - PM, Medium Enterprise	
Adoption Complexity	AI is perceived as overly complex and disruptive. Even factories that are technologically literate hesitate due to training and workflow overhaul concerns.	*"How can we learn to integrate it? It's not as simple as just installing a new sewing machine."* —-GM, Large Company *"Our lower-level workers may lose their jobs if AI takes over some tasks."* - HR, Medium Company	medium factories fearing job loss and confusion, and large factories struggling with implementation strategy.
Investment Cost & Return on Investment	High costs and unclear ROI make AI investment risky. Factories want external support (buyers/government) before taking such an initiative.	*"An AI system is too expensive and risky without a guaranteed ROI."* — Production Head, Medium Company *"We can't invest millions just to experiment... if the government or BGMEA were to offer grants, we would consider it."* — DGM, Large C	medium enterprises find it financially impossible
Feasibility	Due to the low labor cost and manual efficiency, AI seems unnecessary. Adoption depends on proving feasibility through either ROI or policy support.	We don't see the need for AI since we can operate efficiently with manual systems." – DGM	Medium enterprise hesitant without strong financial justification.
Compatibility	Factories fear AI won't align with existing processes or infrastructure. Resistance stems from fear of disruption and long-standing manual workflows.	*"It needs to fit with our production line, not require us to start from scratch."* — PM, Medium Factory *"We have been working the same way for 15 years; AI means changing everything, and that scares people."*	Medium enterprises face greater fear of disruption, though large factories are also hesitant due to complex legacy systems

Table-1: Factory type, qualitative interviews and key findings according to technological theme (author's work)

Organizational Readiness

Organizational preparedness denotes a company's ability to adjust to new technologies and their corresponding solutions [9, 19]. The organizational context pertains to examining the implications of AI personalization within the framework of the organization. In the table-2, the statements of the interviewees and findings regarding organizational context are shown.

Organizational Theme	Key Findings	Quote Evidence	Scale Based Factory
Organization Size	Larger RMG factories are structurally more capable of exploring AI technologies due to their financial muscle, advanced infrastructure, and access to skilled IT personnel. On the other hand, medium enterprise faces limitations in budget, manpower, and digital systems, making AI adoption appear impractical or financially risky.	"As we are a part of a big group or company, we cannot experiment with AI to take that chance." — *Respondent from a large factory*	Larger factories are better equipped; not all are agile in decision-making. Medium large enterprise, though more flexible, often lack the required resources, contributing to a widening digital divide in AI adoption readiness.

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Leadership Support	Leadership vision is critical but often missing in the RMG sector. Most owners prioritize short-term production and order fulfillment, viewing AI as an unnecessary or futuristic luxury. The absence of a clear digital roadmap impairs strategic planning and discourages investment in AI.	"Our owners are more focused on fulfilling orders and short-term production than on experimenting with AI. However, if buyers demand AI integration, then they might consider it." — *HR Manager from a medium-sized factory* "*To adopt this kind of advanced tool, factory owners or managing directors must be tech-savvy. Only then will progress occur; otherwise, it's just talk with no action*." — *Participant from a large factory*	Medium-sized factories lack leadership push unless driven by buyer pressure. Even large factories struggle with leadership that lacks technological awareness or risk appetite, stalling progress in AI implementation.
Skills and Knowledge	There is a critical skills gap in both technical and managerial levels. IT departments primarily manage routine software (like ERP) but lack expertise in AI, machine learning, or data science. Moreover, no structured training or institutional collaborations exist to upskill employees.	"There is no training program for daily operations, let alone AI-driven training programs." — *HR Officer from a medium company*	This shows that training infrastructure is nearly absent, especially in medium-scale factories, where the readiness to up skill is low. This hinders not just AI adoption, but also operational efficiency through any advanced technology.
Management Policy	Management attitudes are largely risk-averse and skeptical. Many managers worry about job displacement or AI disrupting traditional processes. As a result, they prefer proven ROI before adoption, which delays experimentation and transformation.	"I do not want to bring AI into my factory. What happens to the people who have worked here for the last 15 years? It is a hazardous topic." — *HR Manager at a large factory*	Large factories fear social backlash (e.g., job loss due to automation), while medium factories emphasize financial ROI.

Table-2: Factory scale, qualitative interviews and key findings according to organizational theme (author's work)

Environmental Readiness

The readiness of the environment to assess and comprehend the application of AI personalization involves evaluating industry pressures and governmental regulations [20]. The quotation of the respondents, key findings and factory types are figured in the table-3.

Theme	Key Findings	Quotes Evidence	Factory Types
Buyer Pressure	Buyer Pressure is a critical enabler for AI adoption in the RMG sector of Bangladesh. If international buyers explicitly demand digital transparency, ethics production and operational efficiency through automation or AI systems, industry professionals are far more likely to prioritize such adoption.	*"If international buyers' asked us to use AI in our production and if they think adopting AI in RMG production will ensure overall cost efficiency, then we will may think about this."- Merchandiser Large Factories.*	Large Factories
Market Competitiveness	As the global apparel industry becomes increasingly competitive, especially with countries like Vietnam and India making rapid technological progress, Bangladeshi manufacturers are under pressure to enhance speed, reduce costs, and improve operational flexibility The demand for shorter lead times and leaner operations in the international	*"Earlier, it took us 15 hours to finish a batch using conventional methods. With newer systems, including semi-automated setups, we can complete it in just 8 hours. We are not using AI yet, but our processes are becoming leaner and faster."* — *Sustainability Head, Large Company*	Large Company

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	market is pushing Bangladeshi RMG factories to modernize. While most factories have not yet implemented full-scale AI systems, the shift toward semi-automation indicates a growing awareness of the need for technological upgrades.		
Government Policy	Although national policies promote digitalization and sustainability, they lack specific focus on AI integration in the RMG sector. This policy vacuum delays widespread AI adoption.	*We get support for green building certification and energy audits, but there are no clear guidelines or financial assistance for adopting AI in our operations.*	Large and Medium both
Sustainability	Sustainability is widely prioritized, particularly by large export-focused factories, but the tools used are conventional, not AI-based. There's high potential for AI to advance this.	*"To reduce fabric waste, we've switched to cotton-polyester blends and implemented a solar energy program. Our ETP concept uses a biological system as part of a global sustainability partnership."* These are impactful efforts, yet they depend on traditional technologies.	Large, Medium and small companies

Table-2: Factory type, qualitative interviews and key findings according to environmental theme (author's work)

VI. DISCUSSION

Technological Readiness Assessment

The research suggests that primary technological elements influencing AI adoption in the Ready-Made Garment (RMG) sector in Bangladesh include the lack of available resources, anticipated benefits, internal readiness, complexity of adoption, investment expenses, as well as return on investment (ROI), feasibility, and compatibility. Among these seven elements, unavailability, internal readiness, investment expenses, and return on investment are directly tied to AI adoption in the RMG sector. While factories in Bangladesh have started to use digital tools like CAD software and ERP systems, there are limited AI-specific applications that concentrate on personalization aspects, such as product manufacturing, forecasting, intelligent inventory distribution, and efficiency in the supply chain. At present, Bangladesh is still in an early phase regarding the implementation of AI-driven personalization.

Many professionals in the RMG field are not aware of these tools and lack knowledge about how to apply AI in their manufacturing processes. Currently, the AI functionalities in operation are mostly automated rather than personalized. China has shown a considerable level of technical preparedness in adopting advanced technologies by incorporating AI, Big Data, IoT, and Blockchain. These technologies facilitate improved forecasting, real-time tracking, and supply chain efficiency, which enable swift responses to disruptions in the supply chain. Automation and robotics enhance operational efficiency and help mitigate labor shortages. AI-driven visual inspection systems have been established by Chinese companies like Dongguan Yunji Zhihui Technology Co., Ltd., which automate garment measurements and defect identification. These systems can swiftly and accurately measure dimensions, leading to significant reductions in labor costs and enhanced inspection precision [21,22]. In a similar vein, Zhijing Technology has integrated AI-enabled visual recognition into weaving machines, permitting real-time detection of flaws during the weaving process. This advancement has reduced the sampling timeline from several days to as little as 24 hours while improving product consistency [23]. AI is also reshaping the design process within the RMG sector. Designers are able to create 3D clothing prototypes using platforms such as "Style3D" by selecting and adjusting components from an online database. This method enhances responsiveness to market trends by streamlining the design cycle from weeks to under 30 minutes [24]. In places like Xinjiang, AI and 5G technologies are being employed to monitor and optimize energy usage in textile mills. AI systems track machine performance, predict maintenance requirements, and regulate energy consumption, which improves product quality and minimizes operating costs. Despite the prevalent unfamiliarity with AI in Bangladesh's RMG sector, there is an overall positive perception of its potential, with participants recognizing the anticipated benefits of future AI adoption.

One illustration of AI simplifying the clothing manufacturing process is Feiliu Tech's "SewSmart" system, which not only tracks activities in real-time but also manages an overhead conveyor system that directs clothing components to the designated workstations. Significant challenges continue to exist as the primary obstacles for AI integration in the RMG industry in Bangladesh, including a shortage of skilled labor, inadequate strategic planning, and insufficient financial support. Employees frequently lack

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training in data analytics and machine learning, which are crucial skills needed for implementing and overseeing personalized production. The lack of organizational alignment and development of internal capacity suggests that the RMG sector is not yet equipped for widespread integration of AI. Financial constraints and infrastructural limitations also act as major hindrances to AI adoption. In summary, these findings indicate that while the RMG sector may acknowledge the overarching value of AI, it is currently ill-prepared for the specific demands and strategic alignment necessary for the adoption of AI-driven personalization. The industry remains in its infancy concerning digital automation and is far from being ready for AI without significant external assistance and internal changes.

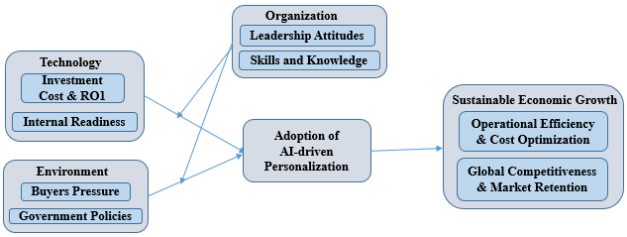


Figure 2: Framework of AI adoption

Organizational Readiness Assessment

The findings of the study show that several organizational factors play a significant role in the adoption of AI within Bangladesh's Ready-Made Garments (RMG) industry. Key factors include the size of the organization, support from leadership, skill levels, and management policies. Collectively, these factors contribute to a fragmented and ill-prepared atmosphere for the implementation of AI technologies. Many participants expressed that the attitudes of leadership and management towards decision-making are a significant obstacle to adopting AI. Existing leadership often lacks a forward-thinking mindset and has difficulty focusing on long-term objectives. Effective leadership is vital for creating a strategic vision for AI-enhanced personalization in the RMG sector. In Bangladesh, there are considerable skill gaps, along with limited training opportunities in Big Data and AI. In contrast, China has invested heavily in upskilling programs to prepare its workforce with the expertise necessary to leverage new technologies, reflecting a robust commitment to organizational transformation [22]. Such investments align human resources with advanced tools to enable efficient operations.

China has introduced the "Made in China 2025" initiative as a strategic approach to enhance manufacturing capabilities through the integration of automation, robotics, and intelligent systems. This initiative underscores the synergy between government initiatives and industry efforts. The execution of Made in China 2025 illustrates how a unified organizational vision and national policies can collectively foster technological advancement [25]. Nonetheless, there is also a lack of innovation and adaptability within the management frameworks of RMG companies. Organizations must develop data-driven structures that allow them to respond effectively to evolving market demands. To maintain competitiveness, companies should actively engage in collaboration and knowledge-sharing. The current situation of Bangladesh's RMG sector suggests that while there is some awareness of AI's possibilities, the organizational infrastructure is inadequate for proper AI implementation. There needs to be a strong commitment to proactive leadership, investment in training initiatives, and comprehensive changes in management approaches; otherwise, the RMG sector in Bangladesh will continue to fall behind in competitiveness on the global stage.

Environmental Readiness Assessment

The readiness of the Ready-Made Garment (RMG) industry in Bangladesh for AI adoption is significantly shaped by external influences, such as buyer expectations, competitive market pressures, sustainability demands, and government initiatives. Among these factors, pressure from buyers emerges as a primary driver. Buyers are increasingly demanding traceability, transparency, and sophisticated technological solutions, moving beyond simple concerns of cost and quality. Although buyers show enthusiasm for the adoption of AI, the majority of factories in Bangladesh are still operating under semi-automated conditions instead of fully embracing AI technologies. Conversely, more developed nations like China and Vietnam have already integrated AI into their garment production processes, while Bangladesh is still grappling with substantial developmental obstacles. This gap underscores the urgent need for AI integration to enhance market competitiveness. Significant barriers are present in the form of deficiencies in governmental policies, resulting in a lack of clear guidelines or incentives for implementing AI. For example, China offers considerable government subsidies, encouragement, and initiatives to foster innovation. In contrast, Bangladesh is in the nascent stages of policy support, with limited financial and legal incentives available for enterprises. The garment sector in China effectively meets global demands for sustainability, customization, and rapid delivery, maintaining its competitive advantage through continuous technological advancements and digitization. Meanwhile, Bangladesh has difficulty keeping up with technological progress and ensuring efficiency in its digital transformation. In terms of sustainability, many initiatives remain isolated from AI, despite their innovative aspects. Initiatives like Effluent Treatment Plants (ETPs) and solar energy projects operate with fundamental automation rather than employing advanced AI technologies. In comparison, China leverages big data analytics, the Internet of Things (IoT), and AI to anticipate demand by analyzing large datasets. This methodology enables more precise evaluations of customer preferences and market requirements, assisting in inventory management, maintaining optimal stock levels, and minimizing waste [26]. The research indicates that the Bangladeshi Ready-Made Garment (RMG) sector is in a transitional phase concerning the adoption of Artificial Intelligence (AI).

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Although there is increasing external pressure, especially from foreign buyers, to implement smarter and more transparent systems, internal capabilities remain limited. Future AI integration is being indirectly driven by buyer-related objectives focused on sustainability and compliance enhancement. Nevertheless, the actual execution of AI technology is obstructed by organizational issues such as a shortage of skilled personnel, inadequate infrastructure, and deficiencies in government policies. This suggests that the RMG sector is at a foundational level for AI adoption, yet not fully equipped for complete integration. However, the favorable attitudes of key stakeholders, ongoing sustainability initiatives, and growing collaboration with buyers create a hopeful climate for AI adoption, provided there is sufficient backing through policies, training, and investment. The structure for adopting AI within the Bangladesh RMG sector is illustrated in Figure-2.

Impact Analysis

Impact on RMG's Business Performance and growth:

It is anticipated that the adoption of AI in business will grow swiftly in the coming years. Studies suggest that by 2025, the global AI market is projected to reach $190.61 billion, underscoring the essential role of AI in driving innovation and business growth [27]. Various functions and processes strongly advocate for the use of AI in Bangladesh's apparel and RMG sector. Table 1 illustrates the applications of AI within the Ready-Made-Garment (RMG) industry. It is widely recognized that the RMG industry in Bangladesh serves as the primary and most significant source of the country's export earnings. The integration of Artificial Intelligence (AI) technology can assist the Bangladeshi RMG sector in achieving its objectives of heightened efficiency and technological advancement. We are proud to have secured our status as the world's second-largest apparel producer. This industry has played a vital role in our nation's economic progress and has been immensely beneficial to us [28]. Technological advancements and innovations such as blockchain, IoT, Big Data, and Artificial Intelligence (AI) are expected to further propel the development of this sector [29, 30]. Although the growth of Bangladesh's RMG sector has contributed to economic advancement, it has also introduced new challenges concerning management, operational efficiency, and worker safety. To address these concerns, the Smart Worker Tracking and Monitoring System (SWTMS) was developed. This system employs advanced AI and computer vision technologies to enhance worker safety and streamline processes [30].

V. Conclusions

This study focused on examining the adoption and effects of AI-driven personalization in Bangladesh's Ready-Made Garments (RMG) industry, emphasizing the sector's preparedness and the perceived impacts of such measures. Insights gathered from industry experts indicated that the incorporation of AI in Bangladesh's RMG sector is still in its infancy, with exploratory implementation significantly hindered by various challenges, including inadequate technological infrastructure, a lack of skilled workforce, expensive implementation costs, and reluctance to embrace change. However, the results suggested that firms collaborating with foreign clients or involved in export-driven markets exhibit a heightened interest in AI-driven approaches. Conversely, numerous local companies predominantly rely on manual processes and are doubtful about digital transformation, as it does not guarantee a return on investment. The majority of firms' lack of essential preparedness indicates that AI personalization is not yet entirely suitable for widespread implementation within the sector. To address these existing deficiencies and help Bangladesh maintain its status as a leader in garment production, it is vital to bolster government assistance, digital training initiatives, grassroots educational efforts, and broader industry awareness. The application area and benefits of AI tools in business sector are compiled in the table-4. The small sample size and qualitative nature of this research limited its ability to capture the complete range of viewpoints within the RMG industry. Future studies should utilize larger and more varied data sets, and the inclusion of quantitative methods could help validate findings on a broader scale. Furthermore, subsequent research could explore AI adoption in comparable industries for comparative insights and to identify best practices relevant to the RMG sector. In conclusion, while AI-driven personalization presents exciting possibilities, its successful integration into Bangladesh's RMG sector will necessitate long-term strategic planning, investment in workforce development, and collaborative policy initiatives. The path toward digital transformation must commence at the foundational level, ensuring that businesses recognize the advantages of AI and are prepared to implement it effectively.

AI Tool/ Technology	Application Area	Benefits
Demand forecasting AI tools	Production and inventory management	Avoid overproduction, reduce waste, and align with just-in-time manufacturing principles
Resource optimization AI	Sustainable manufacturing (fabric layout, energy, water usage)	Minimize waste, reduce environmental impact, and appeal to eco-conscious buyers
Consumer behavior analysis	Product design and marketing	Identify trends, tailor products to market demands, and boost customer satisfaction.
AI-driven sensors	Factory safety monitoring	Detect hazards, ensure swift preventive actions
Wearable AI devices	Worker health and performance monitoring	Improve workplace safety, increase productivity, and protect workers

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AI-powered real-time monitoring systems	Factory operations and equipment maintenance.	Predict equipment failures, reduce downtime, and ensure uninterrupted production.
AI-driven robotics	Fabric-cutting, stitching, and packaging.	Reduce labor time and cost, minimize human error, and improve product quality.
Image recognition systems	Quality inspection (stitching, color, patterns)	Detect flaws precisely, ensure only high-quality products reach buyers, and protect brand reputation.
AI-powered analytics	Supply chain management and inventory forecasting	Predict disruptions, recommend alternative suppliers, and manage inventory efficiently

Table 4: Potential areas of AI application in the RMG sector, Source: The Daily Star, Compiled by authors

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Short, Mid, and Long-Term Educational Reform of Primary and Secondary Education in Bangladesh: Leadership Capacity Building of Principals

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Abstract – **The capabilities of school principals are essential for implementing educational reform initiatives. Particularly, ethical leadership capability, technology adaptiveness, experiential learning affinity, and networking capability are considered critical for the successful implementation of educational reform in Bangladesh. This work-in-progress paper outlines a mixed method approach to initially develop the scales through focus group studies, refine the scales with a quantitative pilot study, followed by a survey to examine the hypotheses. The study expects to offer short, medium, and long term impact in the educational reform initiatives at school level in Bangladesh.**

Keywords – **Educational Reform, Capabilities, Experiential Learning, School Reform,**

I.INTRODUCTION

In an era of rapid societal change, educational systems in Bangladesh are under pressure to reform and adapt. A major stakeholder in implementing any policy reform is the principals of primary and secondary schools. Their leadership plays a pivotal role in the success or failure of any new educational reform initiative. However, the factors that influence a principal's ability to effectively lead and implement educational reforms remain understudied and poorly understood. There is a void in extant scholarly research on educational reform regarding the capabilities of school principals in Bangladeshi. Despite having B.Ed and M.Ed degrees, many principals across the country are often failing to uplift student performance to an international standard. It is essential to thoroughly examine their capabilities to improve leadership qualities in principals.

According to the Bangladesh Bureau of Statistics, there are around 114,539 primary schools of different types and 20960 secondary schools, including some schools with colleges [29]. This statistic does not include colleges that include higher secondary and degree level courses. Based on BSS data, approximately 135,000 school principals are responsible for leading educational institutes through educational reform programs with a team of nearly one million teachers. Therefore, the preparedness and capabilities of principals are essential to achieve the educational reform initiatives of policymakers. The Legatum Prosperity Index ranks countries based on various factors, including education. Bangladesh's ranking of 126 and score of 44.19 in the education pillar in 2023 indicate that the country faces significant challenges in its education sector [26]. These challenges could include low enrollment rates, inadequate infrastructure, insufficient teacher training, or limited access to quality education. In Bangladesh, schools are governed through a mixture of different school boards and international exam bodies. While there is a plethora of statistical data available on various demographic profiles of Bangladeshi students and teachers, not much is known about the principals.

With this backdrop of the educational situation in Bangladesh, educational reform is considered a priority by all sectors in the country. There are a number of reasons why principals must be prepared for educational reform as they serve as the primary leader who shapes a school's culture, instruction, and performance. Acting as a bridge between policy and practice, a principal ensures effective implementation of reforms [16].

While holding B.Ed and M.Ed degrees provides school principals with foundational knowledge in pedagogy, curriculum design, and educational management, these qualifications alone may not equip them with the leadership capabilities or competencies required to implement educational reform policies. Reform efforts often require principals to be visionary leaders, capable of fostering a culture of innovation and ethical decision-making within schools [12]. Principals must inspire both teachers and students to think critically and creatively—skills that are not always emphasized in traditional education degrees. Again, the integration of technology in education requires principals to have advanced digital literacy and a deep understanding of how technological tools can enhance learning [7]. B.Ed and M.Ed programs may not always focus on cutting-edge technology or provide in-depth training on digital pedagogy, leaving principals ill-prepared to lead schools in an increasingly digital world. Furthermore, principals must possess experiential learning and networking skills to foster an innovative environment that prepares students for future economies. They must have a mindset geared towards continuous improvement, data-driven decision-making, and the ability to respond effectively to external economic, social, and technological changes [9].

For the changing economic, cultural, and technological scenarios, principals need to foster a positive, inclusive school culture by creating an environment of equity, collaboration, and respect, for students from all demographic and economic profiles [39]. Like their counterparts in developed countries, Bangladeshi school principals should utilize data-driven decision-making to monitor student progress, identify areas for improvement,

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and in the future, use technologies to personalize learning, enable targeted interventions, and assess new initiatives' effectiveness.

Researching principals' roles in educational reform is essential for several reasons. Effective school leadership is directly linked to improved student achievement and overall school performance, making it crucial to understand how principals can best lead reforms to enhance educational outcomes. As the educational landscape evolves with new challenges, such as technological advancements and changing societal needs, it becomes vital to explore how school leadership can adapt and drive positive change (Lee & Mao, 2023). Acknowledging principals' pivotal role in implementing policy changes and examining their capabilities and attitudes can inform the development of better training and capacity building programs for both current and aspiring school leaders.

This research aims to examine how school principals' leadership competencies can be developed to implement educational reform programs.

To fulfil this aim, the following objectives are set:

i. To examine how ethical leadership, technology adaptiveness, experiential learning affinity, and networking capability in school principals differ between good and poorly performing schools.
ii. To assess the compound impact of ethical leadership, technology adaptiveness, experiential learning affinity, and networking capability in school principals on the academic performance of students.
iii. To make policy recommendations for short, medium, and long-term reform in the educational sector based on the leadership capabilities of school principals.

II. LITERATURE REVIEW

The evolution of educational reform can be understood through three distinct paradigms: the first wave focusing on internal improvements, the second wave emphasizing accountability and marketization, and the third wave advocating for a contextualized and individualized approach [8].

The first paradigm of global educational reform, often referred to as the "first wave," focuses on internal improvements within educational institutions. This approach is characterized by a belief that improving internal processes will lead to better educational outcomes. Transitioning to the "second wave" of educational reform, there is a notable shift towards accountability and marketization. The emphasis here is on ensuring that educational institutions are not only effective internally but also competitive in a globalized context, reflecting the pressures of international competition and the demands of a rapidly changing economy. The "third wave" of educational reform introduces a more nuanced understanding of educational needs, incorporating elements of globalization, localization, and individualization. The third wave aims to create a more holistic educational experience that prepares students for a globalized world while respecting local identities and values [4].

Western educationalists like John Dewey, Maria Montessori, Paulo Freire, Jean Piaget, Lev Vygotsky, Howard Gardner, and Nel Noddings have significantly promoted insights on how institutional education can develop children to grow up as responsible, problem solving, and independent adults. However, critics like Michel Foucault, Ivan Illich, John Taylor Gatto, Paulo Freire, Pierre Bourdieu, Herbert Marcuse, Noam Chomsky, Jean Anyon, and Henry Giroux have criticized institutional education as a source of perpetuating social class and indoctrination.

In the Western world, educational reform debates are largely characterized by a clash between conservative and neoliberal ideologies. Neoliberalism promotes market-driven approaches that prioritize efficiency and accountability, often sidelining the voices of Conservative educators and communities [40]]. Neoliberal perspective advocates for privatization and deregulation, claiming these measures enhance school performance through competition and standardized metrics. In contrast, conservatives defend traditional educational structures, emphasizing civic responsibility and community cohesion. They argue that the neoliberal focus on efficiency can detract from holistic student development, advocating for education that fosters responsible, engaged citizens rather than merely preparing a workforce. This ideological conflict significantly influences ongoing policy debates and will shape the future of educational practice and policy.

In Table 1.0, a brief overview is given of the educational reform programs of a few selected countries.

Table 1.0: Recent Educational Reform in Selected Countries (Compiled by authors)

Country	Recent Educational Reforms	Reference
United States of America	- Every Student Succeeds Act (ESSA) implementation (2015-2020) - Expansion of school choice programs - Increased focus on STEM education	(Mott, 2022)
United Kingdom	- Introduction of T-Levels (technical qualifications) in England (2020) - Curriculum reforms in Scotland (Curriculum for Excellence) - Reforms to make GCSEs more rigorous in England	(Helgetun & Menter, 2022)

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France	- Baccalaureate reform (2021) - Lowering of mandatory school age to 3 years old (2019) - Reforms to improve teacher training	(Pin & van Zanten, 2021)
Ireland	- Implementation of Junior Cycle reforms (2015-2022) - Introduction of Computer Science as a Leaving Certificate subject (2018) - Expansion of STEM education initiatives	(Kenny, McCoy, & Mihut, 2020)
Lithuania	- Implementation of competence-based curriculum (2022-2023) - Reforms to improve inclusive education - Strengthening of digital literacy programs	(Raudienė, Kaminskienė, & Cheng, 2022)
Indonesia	- Merdeka Belajar (Freedom to Learn) policy (2020) - Curriculum simplification - Emphasis on character education	(Sundoro, Kalbuana, & Cahyadi, 2024)
Hong Kong	- Reforms to liberal studies curriculum (2021) - Implementation of national security education - Enhanced STEM education initiatives	(Yan & Brown, 2021)
China	- "Double Reduction" policy to reduce academic burden (2021) - Reforms to gaokao (college entrance exam) system - Expansion of vocational education	(Yan & Zhang, 2024)
Qatar	- Education for a New Era reforms (ongoing) - Enhanced focus on STEM and entrepreneurship education - Expansion of early childhood education	(Romanowski, Tok, Amatullah, Amin, & Sellami, 2024)
Thailand	- Thailand 4.0 education reforms - Implementation of coding in curriculum - Reforms to improve English language education	(Apsorn, Sisan, & Tungkunanan, 2019)
Chile	- New Public Education System implementation (2018-2025) - Reforms to higher education funding and access - Curriculum updates focusing on 21st-century skills	(De Falco, Hattemer, & Sierra Vásquez, 2024)

The above table shows that countries across the world are taking bold steps. As leaders, principals shape school culture, teacher professional development, and community engagement, directly affecting the sustainability of reforms [39]. Additionally, principals build relationships with parents, communities, and stakeholders, securing the broader support necessary for sustained school success [3].

Building on the extant literature, four critical dimensions of leadership: ethical leadership, technology affinity, experiential learning affinity, and networking capability are identified for further review.

Ethical Leadership Capabilities in School Principals

Ethical leadership in school principals can play a role in fostering moral character and ethical decision-making among students. Rather than overlooking this aspect of principals, it is important to recognize that their ethical and moral compass can play both positive and negative impact on reform initiatives. Ethics literature provides a framework through which individuals can explore ethical principles and develop a deeper understanding of their responsibilities to themselves and others. The role of ethics education can be observed across various educational contexts, particularly the character-based education systems seen in Indonesia and Malaysia [7,14,28]. Ethical leadership is particularly relevant in religious education. For example in Islamic tradition, practices such as prayer and reading the Qur'an are integral to the learning process, reinforcing ethical values and moral integrity [19]. In many areas of Bangladesh, philanthropists donate to schools based on moral perspectives and governing bodies assess the ethical leadership of principals as evidence of their moral character.

Within the broader domain of ethical inclusiveness, esotericism in Bangladeshi school principals can be a critical factor as well, particularly with Sufism [21]. The exploration of esotericism reveals a complex interplay between spiritual traditions and socio-political movements [34]. One significant aspect of esotericism in Bangladesh is its historical association with Sufism, often regarded as a form of 'Islamic esotericism.' [37] discusses how Sufism has been reified within both Western romanticist contexts and Islamic reformist movements, highlighting the nuanced understandings that emerge from these interactions. Sufism has played a key role in establishing religious harmony in Bangladesh [1]. While Sufism has remained a dominant attribute of Bangladeshi citizens, reformist thinkers need to tread carefully in these areas.

Esotericism can be detrimental to robust STEM education as well as technology-driven, data-centric education [42]. There is a doubt that some school principals who are highly committed to esotericism may not be highly motivated to progress science and technology education. In some places, esotericism can shape cultural attitudes toward health, nature, and technology, making it difficult for students to embrace scientific principles that contradict their community's spiritual views. Due to the prevalent existence of esotericism in rural Bangladesh, educational reform initiatives cannot readily expect most principals to be more inclined to the opposite views of exotericism or empiricism. This is an area of ongoing debate among educational reform scholars. More research is needed to understand how ethical

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leadership and esotericism in Bangladeshi school principals can impact educational reform for ethical and technological developments in students.

Technology Adaptiveness in School Principals

The integration of modern technology into educational practices is increasingly recognized as a critical factor for effective teaching and learning. School principals with higher technological literacy and a proactive approach to leveraging digital tools can be better positioned to lead educational reforms that embrace these advancements. [2] emphasize that effective technology leadership involves establishing priorities and guidelines for the use of educational technology, which is crucial for successful implementation. Similarly, [4] notes that while technology infrastructure is vital, the leadership capabilities of administrators are paramount in ensuring that technology becomes an integral part of the educational process [4]. This perspective is echoed by [14] who argue that principals must actively engage with technology, develop strategic plans, and allocate resources effectively to support technology integration in schools.

Research by Raman et al. indicates that principals who cultivate an organizational culture of continuous learning and support for technology use can significantly enhance teachers' technology integration efforts [32]. This is further supported by the work of Garland and Tadeja, which emphasizes that effective school leadership in the digital age directly correlates with improved student engagement and achievement [12]. Thus, principals who are adept at leveraging digital tools may not only facilitate the integration of technology but may also contribute to the overall success of educational reforms. Further research is needed to examine the relationship between technology affinity of school principals and educational reform implementation.

Experiential Learning Affinity in School Principals

Principals who advocate for hands-on, real-world learning experiences can be more successful in implementing educational reforms. This success is attributed to the enhancement of student engagement, the integration of technology, community involvement, and a focus on authentic learning experiences that prepare students for future challenges. Kolb highlights the importance of real-world experiences in enhancing life skills and empowering young adults, suggesting that such opportunities are crucial for successful transitions into the workforce [23]. This aligns with the findings of Einstein, who notes that internships and experiential learning are increasingly favored as they provide students with practical experiences that connect academic learning with real-world applications [11].

The integration of real-world contexts into learning not only enhances engagement but also equips students with the necessary competencies to navigate their future careers effectively. Furthermore, the concept of real-world learning is increasingly recognized as vital for curriculum development and pedagogical strategies. Morley and Jamil discuss how real-world learning prepares students for diverse career paths by focusing on authenticity and practical application [26]. This perspective is echoed by [6] who identify key determinants of successful curriculum reforms, including the alignment of educational practices with real-world contexts. Since the last few years, educational reform programs have heavily focused on experiential learning, and it is crucial to examine if school principals who have been educated through traditional educational methods can lead reform initiatives focused experiential learning.

Networking Capability of School Principals

The strength and composition of a principal's professional network, both within and outside their school, can significantly influence their capacity to gather support and resources essential for implementing educational reforms. Principals who actively engage in professional networks are better positioned to foster relationships that facilitate resource acquisition and support for educational reforms. Their ability to allocate resources effectively is enhanced by their engagement with both internal and external stakeholders [13].

Bridwell-Mitchell and Yurkofsky emphasize that principals must build relationships that foster agency and innovation, particularly in contexts where educational equity is a priority [5]. This indicates that the nature of the principal's network can either support or hinder their ability to enact meaningful reforms, depending on the relationships they cultivate and the logics they adhere to. Additionally, the role of trust within these networks cannot be overstated. [17] found that networking and collaboration among peers significantly contribute to the development of principals, which in turn impacts their effectiveness in leading educational reforms. [23] notes that principals who prioritize developing leadership capacities within their networks are more successful in fostering collaborative environments that support educational reforms. While all these insights are from the developed countries, not much is known about the situation in Bangladesh. Further research is needed on how Bangladeshi school principals use their networks inside and outside schools to implement educational reforms.

The above discussion covers the four attributes of principals that can be critical to implementing educational reform programs. There is a clear void in educational reform literature in this area. The following section presents the appropriate methodology to be adopted to fulfill the research aim.

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III. METHODOLOGY

The purpose of this study is to investigate four key attributes: ethical leadership, technology adaptiveness, experiential learning affinity, and networking capability in school principals. The ultimate objective is to use these findings to inform the design of capacity-building programs for principals involved in educational reform initiatives.

The study shall adopt a mixed-method approach [31], integrating both qualitative and quantitative methods to provide a comprehensive understanding of school principals' attributes and their relationship to school performance. This approach is divided into three phases. The first phase involves the use of qualitative focus groups for scale development. The second phase is a pilot study aimed at testing and refining the instrument developed in the first phase. The final phase is a large-scale quantitative survey for comparative analysis.

The mixed-method approach shall be employed because it leverages the strengths of both qualitative and quantitative methodologies. The qualitative phase allows for a detailed exploration of the key attributes and ensures that the scales developed are relevant to the specific educational context being studied. The quantitative phase allows for a statistical comparison of the attributes of school principals in relation to school performance.

Phase I: Qualitative Study (Focus Groups)

The first phase of the study shall explore the four key attributes in depth and develop suitable scales to measure them later. This phase involves engaging 20 to 30 participants, including school principals, education experts, and policymakers. These participants shall be divided into three to four focus groups [44]. The discussions in the focus groups can be semi-structured, focusing on how the four attributes: ethical leadership, technology adaptiveness, experiential learning affinity, and networking capability relate to school performance.

The data collected from the focus group discussions will be analyzed using thematic analysis, which will help identify key themes and subthemes for each attribute. The outcome of this phase will be the development of an initial set of items for each attribute, which will later be used to construct the measurement scales. Appropriate literature shall be consulted to examine existing measures for the four attributes.

Phase II: Pilot Study

The second phase of the research shall involve testing and refining the scales developed after the qualitative phase. This phase includes a pilot study in which a draft questionnaire shall be administered to a sample of 50 to 100 school principals who were not part of the focus groups. The questionnaire shall include demographic questions, the scales for the four key attributes, and questions related to school performance.

Several analyses will be performed on the data collected during the pilot study. Item analysis will be conducted to assess the clarity and quality of each question. Exploratory factor analysis will help examine the factor structure of the scales, ensuring that the items group together as expected. Reliability analysis, using Cronbach's alpha, will assess the internal consistency of the scales, ensuring that they measure the intended constructs reliably. Additionally, a subset of participants will participate in cognitive interviews to verify that the questionnaire items are clear and contextually relevant.

The outcome of this phase will be a refined and validated questionnaire, which will then be used in the main quantitative study.

Phase III: Quantitative Study

The final phase of the research shall involve conducting a large-scale quantitative study. A survey will be administered to a target sample of 300 to 400 school principals from both primary and secondary schools in Bangladesh. Appropriate sample size will be determined by a power analysis to ensure that the study has sufficient statistical power. Principals will be selected through a stratified random sampling method, which will ensure that the sample represents schools from different regions and types. The stratified sample shall include schools of different types, sizes, locations, and academic performance.

Data collection in this phase will focus on two key areas: the attributes of school principals and school performance. Data on the four key attributes will be collected using the validated scales developed in the earlier phases. Meanwhile, school performance data, particularly in subjects such as religion, physics, chemistry, and math, will be obtained from school records or educational authorities.

To analyze the data, several statistical techniques will be used. Confirmatory factor analysis will be employed to further validate the factor structure of the scales. Schools will be classified as either high-performing or low-performing based on student achievement data. Independent samples t-tests will be used to compare the four key attributes between principals from high-performing and low-performing schools. Effect size calculations will provide insight into the practical significance of any observed differences. Finally, multiple regression analysis will be conducted to examine the combined effect of the four attributes on school performance.

Ethical approval for the study will be sought from the appropriate institutional review board. Informed consent will be obtained from all participants, and their confidentiality will be safeguarded throughout the research process. The study will adhere to ethical research standards,

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ensuring that all participants' rights and privacy are respected.

IV. EXPECTED OUTCOMES

The research study on the capabilities of school principals in Bangladesh promises to have a profound impact on educational reform at various levels, with distinct benefits emerging in the short, medium, and long term. Each phase of the study's outcomes is designed to progressively improve school leadership, ultimately contributing to enhanced educational quality and equity across the country.

Short-Term Outcomes (1-2 years): The research will provide actionable insights to shape educational policy and practice. The results can be used for developing professional development programs for school principals, emphasizing four key attributes: ethical leadership, technology adaptiveness, experiential learning affinity, and networking capability. Pilot programs in selected schools can be used to test these interventions to evaluate their effectiveness in enhancing leadership skills and school performance.

The findings can also inform guidelines to principal selection and promotion criteria. New assessment tools based on validated scales from the research can be created, incorporating these attributes into evaluations of potential and current school principals. Short-term training programs can also help current principals develop these qualities, making them central to educational reform in Bangladesh. Additionally, the research can enable educational authorities to make more informed choices in selecting and developing principals, ultimately fostering a more efficient and effective educational administration system.

Medium-Term Outcomes (3-5 years): In the medium term, research outcomes can help drive significant structural changes in the educational system. Integrating these attributes in B.Ed and M.Ed programs shall solidify the foundation for future school leaders. By narrowing the gap between high-performing and low-performing schools, these targeted interventions shall help reduce educational disparities across the country. A research stream to monitor and understand the performance of school principals can be developed within educational boards.

Long-Term Outcomes (6-10 years): The study can help determine the catalysts for a cultural shift in educational reform practice in Bangladesh, redefining the principal's role through capacity building. The goal is to foster a culture of continuous learning among school principals, enhancing their responsiveness to educational needs. Once there is a synergy between policy frameworks and implementation at schools, the reflection of these changes will be will lead to substantial improvements in educational quality. Long term changes can be expected in terms of reduced disparities between regions and socio-economic groups. All schools can adopt better leadership models, promoting a more equitable education system. Economically, improved educational outcomes shall enhance workforce quality and better performance in higher education, benefiting the country's economic development.

V. CONCLUSION

Researching the role of school principals in Bangladesh is crucial for understanding how leadership influences the education sector's success across short, mid, and long terms. In the short term, principals immediately affect schools' daily operations, impacting teaching quality, student performance, and teacher morale. They implement policy reforms at the grassroots level, translating national strategies into practical actions. Research can illuminate the evolution of principals' leadership skills in the mid-term. In the long term, principals are key to institutionalizing changes that impact the education system. Their strategic planning, resource allocation, and alignment with national goals contribute to systemic improvements. Bangladeshi schools with different types of educational choices need reform by building on the insights from developed countries, while understanding the problems of policy borrowing. Local knowledge is essential to step ahead with any reform initiative.

By focusing on making educated principals effective leaders, the research has the potential to facilitate educational reform in Bangladesh. Emphasizing school principals as change drivers will ensure far-reaching improvements, establishing a foundation for sustained educational reform that enhances quality, equity, and opportunities for future generations.

The study has several limitations that need to be considered. One limitation is that the classification of schools based on student outcomes may not account for variations in student demographics, which could introduce some bias. Additionally, because the study is cross-sectional, it will not allow for the establishment of causal relationships. Another potential limitation is the reliance on self-report measures, which are susceptible to social desirability bias, as participants may present themselves more positively than they actually are.

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Bridging the Digital Divide: Infrastructure and Capability Barriers to SME Digital Platform Ecosystem Adoption in Developing Countries

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Abstract - **This research paper examines the digital divide as a significant obstacle that constrains the participation of Small and Medium-sized Enterprises (SMEs) in digital platform ecosystems in emerging economies. Despite recent research focusing on enhancing strategies for SMEs that are digitally capable, millions of SMEs are still excluded due to foundational access barriers. Employing systematic secondary data analysis methodology to evaluate international development reports and scholarly literature spanning 2019–2025, the present study reveals a two-tier system where SMEs from developing countries encounter a phenomenon in which there are interconnected and reinforcing obstacles, given the inadequate internet infrastructure, the high technology costs, the insufficient digital literacy, and the lack of institutional support. The analysis shows that these obstacles act synergistically and lead to perpetuating cycles of digital marginalization. Results provide a comprehensive organizational framework of how infrastructure, financial, capability and institutional constraints sustain structural barriers of SMEs from digital economic opportunities. The authors offer actionable recommendations for integrated policy interventions to promote comprehensive digital transformations in developing countries.**

Keywords - **Digital divide, SME development, digital platform ecosystems, developing countries, digital inclusion, infrastructure barriers**

I.INTRODUCTION

The global digital economy has witnessed rapid growth, and digital platform ecosystems have played a progressively important role in global business [12]. Yet, this transformation narrative is largely based on experiences from developed economies, obscuring a critical reality: millions of SMEs in developing countries are still excluded from digital platforms, due to fundamental infrastructure and capability constraints [16]. The digital divide is one of the most substantial barriers to inclusive economic growth. Over fifty percent of the global population lacks access to high-speed broadband connectivity, creating compounding inequality dynamics [15]. For SMEs in emerging economies, this gap means being excluded from the global digital marketplaces, having limited access to digital financial services, and being unable to leverage digital tools to manage business processes, [3].

Research Problem and Objectives

Although digital platform ecosystems show considerable potential for business model innovation, there remains inadequate systematic examination of the technology-enabled mechanism and strategic-action process of cross-category innovation, particularly regarding how SMEs in developing countries overcome foundational barriers to participate in a platform [8]. Existing literature demonstrates a bias toward digitally enabled SMEs and focuses on optimization strategies for such enterprises, while the majority of global businesses face fundamental infrastructure, financial, and capability constraints.

Consequently, we aim to contribute to the literature by
1) identifying multifaceted barriers to SME digital platform adoption in developing countries.
2) demonstrating how these barriers interact to generate systematic digital exclusion.
3) providing actionable recommendations for inclusive digital transformation initiatives.

Scope and Significance

Encompassing SMEs in Sub Saharan Africa, South Asia, Latin America and Southeast Asia, this article examines obstacles impeding the adoption of digital platforms from 2018 to 2025. The findings provide actionable recommendations for international development agencies, policymakers, and platform providers that are committed to addressing digital inequalities and promoting more inclusive growth.

II. METHODOLOGY

Research Approach

This study employs systematic secondary data analysis to examine digital divide barriers constraining SME platform ecosystem adoption in developing countries. This approach allows for a comprehensive analysis of different perspectives, international comparisons and temporal trends across several developing contexts while requiring fewer resources than primary data collection.

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Data Collection Strategy

The methodology utilized international development reports, literature on development economics and digital inclusion in academic journals, empirical studies (2018-2025), infrastructure data, and policy documents. Searches were guided by keywords for systematic identification: "digital divide developing countries", "SME digital barriers", "infrastructure constraints digitalization"," developing country digital transformation". Sources were identified from academic databases, international organization libraries, and development websites.

Analysis Strategy

Through thematic analysis, the patterns, interactions and impacts of the SME development barriers emerged. The central themes were organized under infrastructure, financial, capacity and institutional factors. The cross-country comparison examined various developing country contexts in order to identify common and context-specific constraints. Multi-level synthesis combined macro-level and micro-level sources to explain how systemic barriers translated into firm constraints.

Ethical Considerations

No new data was generated for this paper. All datasets are secondary and are also publicly available from international agencies, academic repositories and government databases.

III. RESULTS

This study identifies the digital divide as a complex, systemic obstacle that impedes the integration of developing country SMEs into digital platform ecosystems. Digital exclusion results from the intersection of these mutually reinforcing structural constraints, not from any single set of discrete limitations.

Primary barriers include infrastructure shortcomings, which render investments and capacity generation largely ineffective in isolation. The multi-level barrier model applies digital divide theory to the organizational level and demonstrates how infrastructure, financial, capability, and institutional barriers combine in cyclical patterns. This model challenges the common assumption of universally available digital technology in SME development literature.

Policy Implications

A fundamental shift from a technology-centric to a barrier-centric approach is needed for successful SME digital inclusion. Current efforts typically assume infrastructure and capacity levels that are absent in developing nations. International development agencies should emphasize integrated approaches that combine interventions at different barrier levels simultaneously.

No immediate solutions exist: The OECD Digital for SMEs Global Initiative will need to be reconceptualized from the ground up to first focus on infrastructure prerequisites before platform-specific interventions. Providers should create tailored interfaces, dynamic pricing structures and value-added services.

Stakeholder Recommendations

Government-level recommendations include prioritizing integrated infrastructure investments in electricity, connectivity, and payment systems; utilizing public-private partnership models with spatial planning focused on SME-intensive zones. Specialized financing products supporting SME digital transformation needs, such as grace periods and flexible repayment schedules aligned with digital income fluctuation must be established by financial institutions.

Development institutions need to develop comprehensive capacity building programs that address not only basic ICT skills, but also platform -specific capabilities and managerial training. Platform providers need to develop diverse pricing models appropriate for developing countries and include lightweight interfaces for low-bandwidth regions.

Future Research Directions

Directions Longitudinal studies on the evolution of barriers and the effectiveness of interventions for SME digital transformation may illuminate SME digital transformation trajectories. Comparative research across countries evaluating alternative policy models could provide evidence for the development of such programs. Sector-specific research might inform targeted interventions to address barriers at the sectoral level.

Study Limitations

The use of secondary data may reduce the depth of analysis of individual interactions of barriers and regional variations. Given the rapidly evolving digital landscape, findings may require updates as conditions change. Extensive geographical coverage may obscure significant country-level variations that require detailed examination.

IV. DISCUSSION

Multi-Level Digital Divide Framework

In this paper, we present a multi-level digital divide (MLDD) framework to explain the combination of infrastructure, financial, capability and institutional challenges that work together to systematically exclude developing country SMEs from digital platform ecosystems.

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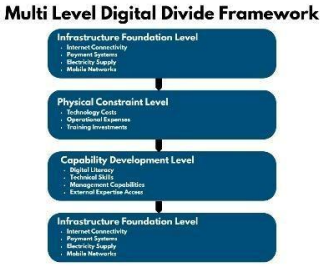


Figure 1: Multi-Level Digital Divide Framework; adapted from (Kahveci, 2025)

The framework demonstrates four interconnected levels:

- Infrastructure Foundation Level encompasses the Internet, electricity, payment institutions and wireless networks as fundamental prerequisites for engaging with digital platforms.
- Financial Constraint Level encompasses the cost of technology, training expenses, and implementation expenditures, which compound infrastructure constraints by rendering relevant adaptation investments financially prohibitive.
- Capability Development Level includes digital literacy, technical proficiency, project management skills, and access to external expertise that all limit effective utilization implementation even when numerous other obstacles have been addressed.
- Institutional Support Level encompasses the regulatory framework, government policy, market structure and legal recognition, which create systemic obstacles and uncertainty in digital adoption.

Barrier Interaction Mechanisms

Financial investment and capability development prove ineffective when foundational limitations persist. Financial constraints amplify the deficiencies in infrastructure that impede investments in adaptation. Resources become suboptimal, due to capacity constraints. Institutional barriers function as systematic deterrents to further barrier mitigation.

These relationships tend to be self-perpetuating cycles of exclusion where isolated interventions are often inadequate. From a theoretical perspective, the framework also identifies strategic intervention opportunities where coordinated action across multiple dimensions may disrupt these exclusionary patterns.

Infrastructure Barriers Analysis

Infrastructure challenges represent fundamental impediments to SME adoption of digital platforms. Internet connectivity varies significantly, with developing countries experiencing 40-60% slower speeds and greater variability which impairs platform operational efficiency (Joseph et al., 2021).

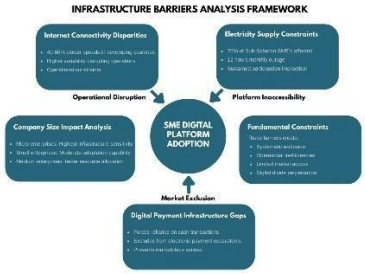


Figure 2. Barriers to Sustainable Digital Transformation by Company Size

Sustained digital participation remains unattainable, due to the constraints in electricity supply. In Sub-Saharan Africa, 70% of SMEs cite electricity as a primary obstacle to digital adoption, with SMEs experiencing on average 8-12 hours of power outages each [1]. Technological gaps in digital payment infrastructure restrict marketplace access and perpetuate cash-based transactions, consequently excluding SMEs from electronic payment-driven ecosystems [2]

Financial Constraint Analysis

Direct barriers to digital platform adoption financial barriers are direct impediments to digital platform adoption. Studies show that limited capital availability and high investment costs present major barriers for SMEs to adopt digital technology. Both service and manufacturing SMEs state that the primary barrier inhibiting the digital transformation is capital scarcity [3].

Financial Barrier	Impact Level	Description	Regional Variation
Technology Costs	High	Hardware and software acquisition costs that consume significant revenue percentages	Higher burden in developing countries due to lower revenue bases
Infrastructure Investment	High	Initial setup costs for digital infrastructure and connectivity solutions	Particularly challenging where basic infrastructure is limited
Connectivity Expenses	Medium	Ongoing internet and telecommunications costs for digital operations	Higher as percentage of income in developing regions
Digital Marketing	Medium	Costs for online advertising and digital customer engagement	Rising costs affect SMEs globally, with higher engagement costs in developing markets
Limited Financing Access	High	Restricted availability of technology-specific financing products	Significantly lower availability in developing economies

Table-1. Statistical Analysis of Digital Transformation Barriers [4].

Small-scale businesses have to allocate a substantial proportion of their income to total hardware and software acquisition expenses. SMEs have limitations such as limited capital resources, and high costs for infrastructure and software and hardware [14].

Internet access costs create additional financial pressure, while digital marketing investments have become prohibitively expensive, particularly for SMEs in developing economies that lack the comprehensive

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technology financing mechanisms available in developed nations.

Capability Barrier Assessment

Digital capability limitations hinder the utilization at the individual, organizational and ecosystem levels of the platform. 60–70% of the SME workforce in developing countries lacked adequate digital skills to enable platform participation, compared to 20–30% in developed markets.

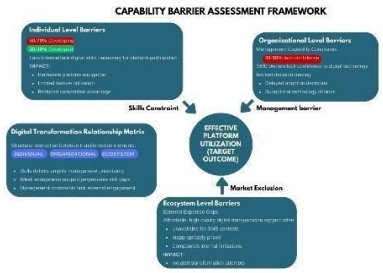


Figure 5.1: Digital Transformation Relationship Matrix, Adapted from (Pfoertsch et al., 2016)

Management capacity constraints create organizational barriers where 40-50% of MSME proprietors in the developing countries are not confident in making decisions about digital technologies (Veronica et al., 2021). External skill gaps amplify internal deficiencies where accessible, cost-effective, high-quality digital transformation support is not offered by the market or is prohibitively expensive for SME application [3].

Institutional Barrier Evaluation

Institutional elements also make investment unattractive in the high-risk environment surrounding the digital transformation. Approximately 60% to 70% of countries lack comprehensive digital commerce legislation, creating challenges for small and medium enterprises seeking platform integration.

Key legal challenges include the ambiguous legal position of digital contracts, limited consumer protection regimes, complex licensing procedures and lack of alternative dispute resolution mechanisms that discourage digital platform adoption. Government-led initiatives to support are often limited to basic digital literacy rather than comprehensive ecosystem development and lack supporting infrastructure [16].

Barrier Interaction Effects

The analysis reinforces the view that barriers are not entirely independent constraints but clusters of mutually reinforcing disadvantages. Policy barriers create foundational constraints that render various investments economically unfeasible. Financial constraints exacerbate infrastructure constraints by preventing adaptation where it is needed. Human resource capacity barriers limit efficient resource utilization. Structural constraints create disadvantages which discourage efforts to address the barriers.

These demonstrate mutual reinforcement mechanisms in exclusion cycles that cannot be addressed by single or isolated interventions but require multi-dimensional intervention strategies.

V. CONCLUSION

To bridge SME digital divides, requires recognizing that current approaches are insufficient for inclusive digital transformation. Collaborative action between government, international organizations, platform providers, and financial institutions is essential for ensuring all SMEs participate in digital platform ecosystems. The continued growth of the digital economy means that it is increasingly urgent for developing countries to overcome these barriers if such development is to be sustainable and global inequalities are to be reduced.

This comprehensive analysis of digital barriers enhances understanding of the multifaceted challenges facing SMEs in developing countries. Given the growing importance of digital platforms to the global economy, a failure to overcome these interconnected barriers will continue to exacerbate economic disparities and reduce the transformative capacity of digital technologies for inclusive development.

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Occurrence and Removal Efficiency of Multiple Antibiotic-Resistant Bacteria in Rajshahi's Water Supply System

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Abstract - **Multiple antibiotic-resistant (MAR) bacteria have recently been detected in Dhaka's municipal water, prompting concerns about water safety in Bangladesh's other cities. Rajshahi Water Supply & Sewerage Authority (RWASA) meets 91 % of its demand from groundwater and 9 % from the Padma River, into which untreated urban drains discharge. In this study, we first identified the thirteen most commonly used antibiotics in Rajshahi, then collected water samples from the raw river intake, each treatment-plant unit process, finished surface water ready for distribution, the groundwater pumping station, and household taps served by both networks. Bacterial isolation was performed via membrane filtration, and antibiotic susceptibility was assessed by the disk diffusion method following CLSI guidelines. Isolates from raw-river and intermediate treatment stages exhibited resistance to all selected antibiotics, whereas finished surface water and stagnant river samples were uniformly susceptible. Notably, no culturable bacteria were detected at the intake from Padma after repeated sampling, and post-chlorination groundwater samples showed negligible MAR presence. These findings demonstrate that RWASA's multi-step surface-water treatment train.**

Keywords **- Multiple antibiotic-resistant bacteria, Rajshahi WASA, disk diffusion, surface-water treatment, Padma River**

I.INTRODUCTION

The global proliferation of multiple antibiotic-resistant (MAR) bacteria in water supplies presents a mounting threat to public health, challenging the assumption that conventional treatment reliably delivers safe drinking water. Municipal and environmental waters have been identified as reservoirs and transmission pathways for resistant strains, with selection pressures during disinfection and distribution processes sometimes amplifying MAR prevalence [4] [7]. In Bangladesh, a growing body of evidence highlights widespread contamination of drinking and surface waters with MAR organisms. It is found that 80 % of Dhaka's municipal water samples contained coliforms and 34 % harbored fecal coliforms, with multidrug resistance observed across isolates and cefotaxime remaining one of the few consistently effective agents [10]. Researchers reported ubiquitous ESBL-producing E. coli in drinking water, wastewater, and surface-water bodies, while carbapenem-resistant strains were especially prevalent in effluents from urban markets [5]. Some studies documented 100 % resistance of Pseudomonas aeruginosa in Dhaka surface waters to ampicillin and high susceptibility to third-generation antibiotics, underscoring site-specific resistance profiles with significant zoonotic and environmental health implications [9].

Further investigations reveal alarmingly high MAR indices across diverse settings. Researchers detected resistance to eight of ten antibiotic classes in isolates from livestock-farm and fish-pond waters, with MAR indices ranging from 0.4 to 0.9 [15]. Besides, nearly half of the hospital and market wastewater isolates in Noakhali were observed resistant to at least six antibiotics [11]; Vibrio spp., E. coli, Salmonella spp., and fecal coliforms were found in Dhaka wastewater [13], each exhibiting significant antibiotic resistance patterns. Seasonal and spatial dynamics further complicate the landscape: post-monsoon MAR prevalence in the River Hooghly was reported at 73.6 %, compared to 53.6 % in summer [8], while downstream coliform MAR indices were recorded as 0.43 versus 0.15 upstream [6].

Surface-water bodies and wastewater effluents serve as critical reservoirs and conduits for antibiotic resistance genes, with high loads documented in rivers, urban drains, hospital effluents, and market wastewater across South Asia [5, 14, 2]. Groundwater aquifers, while generally lower in microbial load, can still harbor resistant Pseudomonas aeruginosa and fecal coliforms, with regional variation driven by hydrogeochemical conditions and recharge dynamics [1, 3, 12]

Despite extensive characterization of MAR bacteria in Bangladesh's waters, there is a critical knowledge gap regarding the fate of these organisms within multi-source urban supply systems. Rajshahi Water Supply & Sewerage Authority (RWASA) draws 9 % of its water from the Padma River, into which untreated urban drains discharge, and 91 % from deep aquifers, yet the occurrence, persistence, and removal efficiency of MAR bacteria through each stage of RWASA's treatment and distribution network remain unexamined.

This study therefore aims to (1) identify the thirteen most commonly used antibiotics in Rajshahi's clinical settings; (2) quantify MAR bacterial loads at key points including the Padma-river intake, successive treatment-plant unit processes, finished surface water, central groundwater pumping station, and household taps; and (3) evaluate the effectiveness of membrane-filtration and disk-diffusion assays in monitoring MAR organisms. By establishing a comprehensive baseline of MAR incidence and treatment-step removal performance, we seek to inform targeted interventions and operational

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enhancements that will safeguard the microbiological quality of Rajshahi's dual-source water supply.

II. METHODOLOGY

A cross-sectional survey was conducted to assess antibiotic resistance profiles of environmental bacterial isolates in Rajshahi. Five sampling points, including raw Padma-river intake, sequential treatment-plant outlets, a groundwater pumping station, and household taps, were visited between June and August 2025. At each location, 1-L sterile bottles were used to collect triplicate grab samples following APHA guidelines. Samples were transported on ice and processed within four hours of collection.

Each 100-mL aliquot was vacuum-filtered through a 0.45-µm cellulose nitrate membrane (Millipore). Filters were aseptically placed onto nutrient agar and incubated at 37 °C for 24 h. Colonies exhibiting distinct morphologies were sub-cultured to purity. Isolates were preliminarily characterized by Gram staining and colony morphology, then subjected to standard biochemical assays (oxidase, catalase, indole, methyl red, Voges–Proskauer, citrate utilization) according to Bergey's Manual of Systematic Bacteriology.

Pure isolates were tested against 13 antibiotics representing 10 classes: azithromycin (15 µg), chloramphenicol (30 µg), cefotaxime (30 µg), nalidixic acid (30 µg), cotrimoxazole (1.25/23.75 µg), cephalexin (30 µg), cefuroxime (30 µg), tetracycline (30 µg), ampicillin (10 µg), cefixime (5 µg), ciprofloxacin (5 µg), Azithromycin, and erythromycin (15 µg). The Kirby–Bauer disk diffusion method was performed on Mueller–Hinton agar plates following Clinical and Laboratory Standards Institute (CLSI) 2024 guidelines. Briefly, 0.5 McFarland suspensions of each isolate were lawn-inoculated, antibiotic disks were applied, and plates were incubated at 35 ± 2 °C for 16–18 h. Zone diameters were measured with a digital caliper and classified as Sensitive (S), Intermediate (I), or Resistant (R) per CLSI breakpoints.

Escherichia coli ATCC 25922 and Staphylococcus aureus ATCC 25923 were used as quality-control strains to validate media performance and disk potency. All tests were performed in duplicate to ensure reproducibility.

III. RESULT

Disk-diffusion testing of 10 environmental isolates against 13 antibiotics revealed widespread resistance across most classes (Table I). Ciprofloxacin retained the greatest activity (90 % sensitive), followed by azithromycin (50 % sensitive). In contrast, first-line β-lactams (ampicillin, cephalexin, cefuroxime) and older broad-spectrum agents (chloramphenicol, tetracycline, cotrimoxazole, cefotaxime, cefixime, erythromycin) all exhibited high resistance rates (70–90 %). Nalidixic acid showed intermediate performance (60 % resistant, 20 % intermediate, 20 % sensitive). Azithromycin was found to be 100% resistant in all samples; the rest are summarized in Table II.

TABLE I
SAMPLE WISE BACTERIA RESISTANCE

Sample	Azithromycin	Chloramphenicol	Cefotaxime	Nalidixic Acid	Cotrimoxazole	Cephalexin	Cefuroxime	Tetracycline	Ampicillin	Cefixime	Ciprofloxacin	Erythromycin	Azithromycin
2-1	Sensitive	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Sensitive	Resistant	Resistant
2-2	Intermediat	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Sensitive	Resistant	Resistant
2-3	Intermediat	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Sensitive	Resistant	Resistant
3-1	Intermediate	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Sensitive	Resistant	Resistant
3-2	Intermediat	Resistant	Resistant	Intermediat	Sensitive	Resistant	Resistant	Resistant	Resistant	Resistant	Sensitive	Resistant	Resistant
4-1	Sensitive	Resistant	Intermediat	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Intermediat	Resistant	Resistant
5-1	Sensitive	Intermediat	Resistant	Intermediat	Intermediat	Resistant	Resistant	Resistant	Resistant	Intermediat	Sensitive	Intermediat	Resistant
5-3	Sensitive	Sensitive	Sensitive	Sensitive	Sensitive	Sensitive	Sensitive	Sensitive	Sensitive	Sensitive	Sensitive	Sensitive	Resistant

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5-4	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant	Intermediat	Resistant	Intermediat	Sensitive	Resistant	Resistant
5-5	Sensitive	Intermediat	Intermediat	Sensitive	Resistant	Resistant	Resistant	Intermediat	Resistant	Resistant	Sensitive	Intermediat	Resistant

TABLE II
PERCENTAGE OF BACTERIA RESISTANCE

Antibiotic	Sensitive (%)	Intermediate (%)	Resistant (%)
Azithromycin	50	40	10
Chloramphenicol	10	20	70
Cefotaxime	10	20	70
Tetracycline	10	20	70
Ampicillin	10	0	90
Cefixime	10	20	70
Ciprofloxacin	10	20	70
Nalidixic Acid	20	20	20
Erythromycin	10	20	70
Cotrimoxazole	20	10	70
Cephalexin	10	0	90
Cefuroxime	10	0	90
Azithromycin	0	0	100

Nine of ten isolates (90 %) were resistant to three or more antibiotic classes, meeting the definition of multiple antibiotic resistance (MAR). One isolate (sample 5-3) remained fully susceptible across all tested agents.

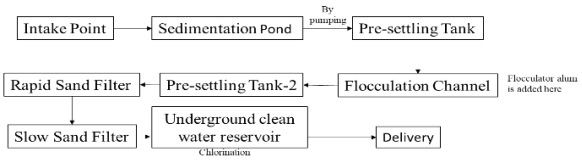


Fig. 1. Stages of water treatment by RWASA

No.1 from the intake point (shown in figure 1), 2 was collected after the rapid sand filter, 3 was the ready to supply water (after the slow sand filter), 4 was stagnant water near the bank of the Padma river, and 5 was tap water (collected from a part of the groundwater supply)

IV. DISCUSSIONS



Fig. 2. Photos of stages of water treatment by RWASA

The high resistance rates to traditional β-lactams, tetracycline, chloramphenicol and cotrimoxazole mirror findings in Dhaka and other South Asian water studies, where MAR indices frequently exceeded 0.4–0.7 [10,11,15]. The retained efficacy of ciprofloxacin aligns with reports of lower fluoroquinolone resistance among Pseudomonas and coliforms in surface waters [9].

At intake, the bacteria were “nil”. After passing several steps shown in Figure 2, the water got contaminated with MAR (which were almost resistant to all antibiotics), and the ready to supply water carrying that water (sample 3) without much alteration in characteristics. Even the water collected from the tap (source groundwater) also contains multiple antibiotic-resistant bacteria. Even the water from the bank of the Padma river, receiving contamination from drains and human activities, is less MAR susceptible to the supplied water of RWASA.

Selective pressures during chlorination and distribution can inadvertently favor resistant strains, as observed by researchers [4] in treated drinking water. Our results suggest that RWASA’s current treatment train, while not reducing overall microbial loads, necessitates enhancements such as UV or advanced oxidation processes to target residual resistant populations.

Limitations of this study include the small isolate number and lack of molecular resistance-gene profiling. Future work should expand sampling across seasons, quantify gene abundances via qPCR or metagenomics, and evaluate the log-removal efficiencies of each treatment unit to pinpoint critical control points for MAR mitigation.

V. CONCLUSIONS

Our comprehensive assessment of Rajshahi WASA’s dual-source supply demonstrates that its multi-barrier treatment train. The selected antibiotics were found to be resistant in all samples; however, they were sensitive in the water from the treatment plant, which was ready for supply, and stagnant water from the Padma River. Most interestingly, the intake point from the Padma river is sufficiently deep, and no bacteria were found are culturing the samples several times.

The source of MAR in the prevailing water supply system is the treatment plant for surface water and

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for groundwater; the contamination may come from the distribution pipeline or storage tank at the user level. Flowing water at the intake source or pumping station of groundwater exhibits almost nil contamination to MAR.

The presence of MAR in water sources like the bank of the Padma showed even less contamination than at stages of the treatment plant, and the results were consistent in later stages of the plant, suggesting that the bacteria removal efficiency is not significant in the prevailing system.

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Bank Service Quality, Customer Loyalty and Satisfaction in Banking Sector of Bangladesh

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Abstract - **The study examines the relationship between customer satisfaction and loyalty with respect to service quality in four types of banks in Bangladesh; State-Owned Commercial Banks (SOCB), Private Commercial Banks (PCB), Islami Shariah-compliant Private Commercial Banks (ISPC) and Foreign Commercial Banks (FCB). It also explores the effect of age, income and geographical location on customer satisfaction. The research employs the structured questionnaire which relates to SERVPERF model and Likert scale, as the major service quality dimensions are considered to be Tangibles, Reliability, Responsiveness, Assurance and Empathy. The analysis was conducted with the help of SPSS and SmartPLS4, correlation and multiple regression analyses were performed, and a sample of 400 respondents was selected according to Cochran formula. The results indicate that there is a large disparity between the quality of services, customer satisfaction, and loyalty by the type of bank. SOCBs are more responsive whereas PCBs are more altruistic. FCBs are doing better in Tangibles and Assurance. Customer satisfaction and loyalty also have a positive relationship in the study, especially in SOCBs and PCBs. Also, income and age were recognized as the factors that influenced customer perceptions of service quality. The article recommends the improvement of the customer experiences to encourage more satisfaction and loyalty. Nevertheless, there are limitations such as the attention to four types of banks, regional sample, self-reported data, and cross-sectional design that prevents the causal relationship development.**

Keywords - **Service Quality; Satisfaction; Banking Sector; SERVPERF Model; Customer Loyalty.**

I.INTRODUCTION

In the recent years, the banking industry worldwide has changed very tremendously because of the deregulation factors, technology and the increased competition [12].Within this changing environment, service quality has become one of the major determinants of attaining a sustainable competitive advantage particularly in service-intensive industries such as banking [17]. With the transformation of financial institutions to relationships-based mode of operation, the connection between customer satisfaction, quality of services, and customer loyalty has become significant [24], [21]. This relationship is especially vital in the emerging economies, such as Bangladesh, where consumer preferences are growing along with financial inclusion .The banking sector of Bangladesh represents a unique case study by the diversity of the banking sector, with State-Owned Commercial Banks (SOCBs), Private Commercial Banks (PCBs), Islamic Shariah-compliant Banks (ISPCs) and Foreign Commercial Banks (FCBs).

Such a study is important because the banking industry has been one of the major contributors to the economic growth of Bangladesh (Banerjee et al., 2020). Banks play a key role in mobilization of savings, the flow of funds in the economy, and financial inclusion especially in rural settings [37]. Customer service has become a vital differentiator that can affect retention and competitiveness due to the emergence of Islamic finance and foreign banks [.29] With the increased freedom of choice among customers regarding the services they receive in their banking, quality service ceases to be a luxury but an essential. Although there has been a considerable number of studies carried out in the world, which have investigated the relationship between service quality, customer satisfaction and customer loyalty, the same cannot be said about Bangladesh. The most active studies have focused on such models of service quality as SERVQUAL and SERVPERF that assess the quality of services using such variables as tangibility, reliability, responsiveness, assurance, and [2]. In developed economies, it has always been found out that quality service is known to improve satisfaction which consequently lead to loyalty. Such relationships, however, can be tempered by local dynamics like culture and demographics, particularly in South Asia.

Despite the fact that some studies on service quality have been carried out in Bangladesh with respect to certain category of banks, a comparative study on various banking models is lacking. Moreover, a large part of the existing literature fails to address the role that demographic variables, including age, income and a geographical position, play in influencing service perceptions, satisfaction and loyalty. This vacuity creates a necessity to conduct the research comparing different types of banking models in terms of quality and assessing the impact of this quality on customer satisfaction and loyalty. The research question of the study is mainly concerned with the nullity of thorough, comparative data that how the service quality influences customer satisfaction and loyalty in the various kinds of banks in Bangladesh. Although the available literature focuses on

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the quality of the services, it tends to ignore the heterogeneity of the banks and the clients. The incompleteness of data renders the inability of the bank administrators and the policymakers to design differentiated strategies towards different segments of customers. Consequently, the given study is going to compare the perceptions of service quality between SOCBs, PCBs, ISPCs and FCBs in Bangladesh and investigate the mediation role of customer satisfaction in the correlation between service quality and loyalty in the context of demographic factors such as age, income and the region. The proposed research hypothesizes that dimensions of service quality have a positive influence on customer satisfaction, which, in turn, will lead to customer loyalty, and demographic factors can be the mediators in this relationship.

II. LITERATURE REVIEW

The quality of services is very vital in creating a competitive advantage in the banking industry [30]. It displays the difference between customer expectations and experience of service they obtain [31]. As the research by [40] shows, the quality of service is evaluated based on the comparison of expectations with actual performance, customer expectations are formed due to previous experiences, marketing campaigns, individual values, and credibility of the provider [44]. Moreover, opinions of others might change expectations [46] and when performance exceeds expectations, it makes people feel satisfied, and when it is lower than expected, they are dissatisfied [39]. Customer satisfaction and recurrence of business require a high level of service quality [40], [22]. TQM practices and service confirmation optimize the banking activities.

Multiple models have dealt with service quality such as the [17] model that includes two dimensions that differentiate between the technological and the functional dimensions. Sergeant presented [13] the SERVQUAL model indicates 5 dimensions, namely, tangible, reliable, responsive, assuring, and empathetic, which are especially applicable to the banking industry [48]. Nonetheless, these dimensions can also be perceived differently in different cultures [55]. Elements such as reliability, responsiveness, visibility, commitment, and availability of employees are important in terms of service quality in banking. One of the most important indicators of service success is the customer satisfaction, which entails a comparison of the perceived service performance with previous expectations [11],[19]. Positive disconfirmation happens when service is better than expected, which results in customer satisfaction and long-term relationships [7], and negative disconfirmation occurs when service is worse than expected, which causes customer dissatisfaction and the loss of a customer [9].

Customer satisfaction is more affected by the ease of services and the disposition of the staff members compared to other issues such as product varieties or the image of the bank [14]. A Malaysian study by Amin and Isa (2008) identified the significance of efficient transactions, friendly employees and privacy as some of the most important facilitators of customer satisfaction. When a bank performs or performs better than the expectations of the customers, it translates into increased satisfaction and eventually customer loyalty.

Loyalty of customers in the banking industry is a significant business success factor in a competitive industry [4]. Loyalty involves attitudinal and behavioral elements like the use of service repeatedly [8],[2] Although satisfied customers usually become loyal, they can do so not because of satisfaction but because there is no other option [17],[13] Thus, trust and brand recognition also form the basis of loyalty, which is not just dependent on satisfaction [22]. Loyalty is also brought by emotional attachment which is nurtured with constant quality services as the happy customers end up being dedicated supporters [34] Banks that focus on satisfaction and quality of the service are in a better position to create the long-term loyalty of customers.

A. Research Gap

The gap in the literature of the banking sector in Bangladesh is the research on the impact of the quality of the bank services on customer satisfaction and customer loyalty. Previous literature [43],[40],[45]usually concentrates on one of the types of banks, i.e. SOCBs, PCBs, or ISPCs, without making comparisons between them under a single framework. Further, there has been no large-scale research on the impact of the quality of service to customer satisfaction and loyalty in these banking industries. These relationships are also poorly studied regarding such factors as age, income, and location. Despite the popularity of SERVQUAL and SERVPERF models, the models have failed to acknowledge the peculiarities of the Bangladeshi banking setting. The proposed study attempts to fill these gaps by examining the quality of services and satisfaction levels among customers among the various types of banks with the demographic variables.

B. Research Hypotheses and Conceptual Model

H_1: Banking services, reliability has a positive influence on customer satisfaction and loyalty.

H_2: Customer satisfaction and loyalty is positively affected by responsiveness.

H_3: Customer satisfaction and loyalty is positively affected by responsiveness.

H_4: Customer satisfaction and loyalty is positively affected by assurance.

H_5: Customer satisfaction and loyalty is positively affected by empathy.

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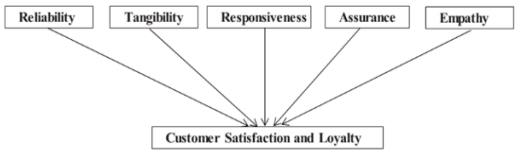


Fig1. Framework of Research

C. Research Area

The goal of this study is to define the relationship between the quality of services in banking, customer satisfaction and loyalty among the banks of Bangladesh. The comparison of four types of banks SOCBs, PCBs, ISPCs, and FCBs The nature of the study investigates the linkage between service quality and customer satisfaction and customer loyalty with reference to five dimensions which consists of tangibility, reliability, responsiveness, assurance and empathy. Examination of demographic variables such as age, income and location (demographic variables like income, age etc. also plays in an important role in perception of service quality, satisfaction and loyalty. The ultimate goal is to provide insights into service performance and customer retention in a developing banking sector in Bangladesh.

III. METHODOLOGY

In this study, a quantitative design is employed in the survey and structural equation modeling (SEM) as a tool of investigation into the association between quality of banking services and satisfaction and purchase of bank services in Bangladesh. In the paper these factors have been compared in relation to the categories of banks: State-Owned Commercial Banks (SOCBs), Private Commercial Banks (PCBs), Islami Shariah Compliant (a limited free market banking scheme) Private Commercial Banks (ISPCs) and Foreign Commercial Banks (FCBs) Objectives and hypotheses of interest are specified and tested via systematically devised questionnaires with closed and Likert-scale questions in four parts. Section A : Background Information: This section will contain Information Demographic data (age, sex, education, occupation and monthly income and location. In this section, quality of service refers to SERVPERF; based on five dimensions of evaluation, namely, tangibility, reliability, responsiveness, assurance, and empathy. Part C is the customer satisfaction which is determined by evaluating the impact of the service quality and overall satisfaction of the customer from the bank. This presented in Section D, which is customer loyalty and it measure customer satisfaction and loyalty. The survey will be conducted for customers of a bank, representing a sample of the bank clientele in order to find out the relationship service quality, satisfaction and loyalty. The hypothesized relationships are tested using statistical data like correlation analysis while SEM is used to investigate the moderating influence of demographic variables. Objective: To infer the trend of customer behavior regarding Bangladeshi banking sector. To make the questionnaire reliable a small pre-testing sample was used to confirm its internal consistency, country cultural appropriateness and logic sense of the questionnaire and that it is complete enough to carry out the full scale survey. The sample size was calculated with [13] formula to make sure that the findings are generalizable. Sample Size = Z2*p1-pe2. Where: Z=1.96 (95% confidence), p = 0.5 (maximum variation) for simplicity, we rescale the half-half attribution scores to 0.5, e=0.05 (error margin). Using this formula, the minimum representative sample size appeared to be 385 respondents. Respondents were surveyed until the final sample size was 400, to fortify the integrity of the findings. There are four types of banks which are: State-Owned Commercial Bank (SOCBs), Privated Commercial Bank (PCBs), and Islami Shariah-Compliant Privated Commercial Bank (ISPCs). The fourth type is Foreign Commercial Bank (FCBs).A total of 100 respondents were taken from each of these four types of banks. multi-stage random sampling technique was used to ensure diversity and statistical representativeness. Selective categories of Banks in Bangladesh chosen to the first stage selection of the respondents. At the second stage, one or two branches of both the type of banks were randomly selected. The selected respondents on that branch in third stage were chosen randomly and equal number of customers from all demographic category were chosen. Data collection was done either via in-depth face to face interview or via telephone depending on the geographical proximity and willingness of respondents to participate in the study. Study design Ethics permission was granted by the first author institution with regard for voluntary participation, informed consent and confidentiality. The data analysis carried out with the use of statistical package programs of software, that is; Statistical Package for Social Sciences (SPSS) and SmartPLS. Socio-demographic data were summarized with descriptive statistics and the Cronbachs Alpha was used to assess internal consistencies of scale items. Dimensionality reduction was performed using Principal Component Analysis (PCA) in order to identify key dimensions which describe the variance of the perceived service quality of various bank types.

IV. RESULT & DISCUSSION

A. Sample Design of the Study

The systematic approach to the sample set out in Table 1 defines the method used to ensure the gathering of diverse and representative data used to study the bank service quality, customer satisfaction and loyalty in Bangladesh. The sample will be subdivided into four groups of banks namely: State-Owned Commercial Banks (SOCBs), Private Commercial Banks (PCBs), Islami Shariah-Compliant Private Commercial Banks (ISPCs), and Foreign Commercial Banks (FCBs), that is two groups of 100 respondents each. Such division provides a comprehensive coverage of the key banking models

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existing in the Bangladesh banking industry. The considerate sampling sizes allocated to such categories enable us to make a comparative study on the quality of service, satisfaction and loyalty of these various kinds of banks. The strategic sampling of 100 respondents per type of banks is to make sure that the different types of customer experiences in each type are represented in study and to have the statistical strength. The method gives a balanced representation that can be usefully compared across banks.

TABLE I
Sample Design of the Study

S. No	*Types of Banks*	*Sample*
1	*State-Owned Commercial Banks (SOCBs)*	*100*
2	*Private Commercial Banks (PCBs)*	*100*
3	*Islami Shariah-Compliant Private Commercial Banks (ISPCs)*	*100*
4	*Foreign Commercial Banks (FCBs)*	*100*

Source: Calculated by Author from sample survey.

The study focuses on these four different types of banks and will thus help determine variation in customer perceptions of service quality and its further influencing effects on customer satisfaction and loyalty to provide a complete picture of customer behavior in the Bangladeshi banking industry. The sample design that was used in the study leads to validity and reliability of the study results because it is representative of the general banking environment in Bangladesh.

B. Demographic Section

Table 2 describes the demographic profile of the respondents of the study providing the information about the sample composition according to gender, age, education, and occupation. All of the respondents were male (62.5%), and females made up 37.5% of the sample. The most numerous group was 10-25 years, with 76.5 percent of the participants, and the 25-40 years, with 20.8 percent. Only a limited sample was 40-55 (1.8%), and 55-70+ (1). In respect to education, the majority of respondents were Higher Secondary Certificate HSC (43), secondary School Certificate SSC (31.8), and graduates (19.5) standings. The lower percentage possessed primary (0.5%) or post-graduate education (5.3%). The sample was occupationally distributed with a large proportion of 89.3% of the sample being students; businessmen were found in 6.8% and those in private or government service were in 2.3 and 1.3 respectively. There were also few unemployed (0.3%) and retired people in the sample (0.3).

TABLE I

Demographic Profile

Variable	**Demographics**	**Total**	**Percentage**
Gender	Male	250	62.5%
	Female	150	37.5%
Age	10-25	306	76.50%
	25-40	83	20.80%
	40-55	7	1.80%
	55-70+	4	1%
Education	Primary	2	0.5%
	SSC	127	31.8%
	HSC	172	43.0%
	Graduate	78	19.5%
	Post Graduate	21	5.3%
Occupation	Student	357	89.3%
	Businessman	27	6.8%
	Private Service	9	2.3%
	Govt. Service	5	1.3%
	Unemployed	1	0.3%
	Retired	1	0.3%

Source: Calculated by Author from sample survey.

C. State-Owned Commercial Banks (SOCBs)

Table 3
FACTOR-LOADINGS VALUES

Variable	Factor loading	Variable	Factor loading	Variable	Factor loading
T1	0.452	Rel1	0.664	Res1	0.621
T2	0.722	Rel2	0.716	Res2	0.717
T3	0.746	Rel3	0.771	Res3	0.791
T4	0.697	Rel4	0.680	Res4	0.631
T5	0.721	Rel5	0.788	Res5	0.642
Assu1	0.527	Emp1	0.763	CSL1	0.530
Assu2	0.527	Emp2	0.779	CSL2	0.649
Assu3	0.760	Emp3	0.318	CSL3	0.613
Assu4	0.746	Emp4	0.735	CSL4	0.723
Assu5	0.682	Emp5	0.645	CSL5	0.741

Source: Results generated from SmartPLS4

Tables 3, 4 and 5 give a detailed examination of the factor loadings, composite reliability, Cronbachs Alpha and Variance Inflation Factor (VIF) of State-Owned Commercial Banks (SOCBs). Table 3 gives the factor loading of the different variables that are used to signify the dimensions of service quality which are; tangibility (T), reliability (Rel), responsiveness (Res), assurance (Assu), empathy (Emp), and customer satisfaction loyalty (CSL). The value of the factor loading of each variable is high with values exceeded by 0.318 to 0.791 and this demonstrates a high correlation between the observed variables and the constructs reflected. The greatest loading was observed in responsiveness (Res) and empathy (Emp) indicating that

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they played significant role in the services experience as a whole.

Table 4
COMPOSITE RELIABILITY AND CORNDACHS ALPHA

Variable	Composite reliability	Variable	Corndachs Alpha
T	0.804	T	0.694
Res	0.813	Res	0.711
Emp	0.792	Emp	0.677
Rel	0.774	Rel	0.774
Assu	0.722	Assu	0.722
CSL	0.664	CSL	0.664

Source: Results generated from SmartPLS4

Table 4 shows the composite reliability and Cronbach Alpha values which are the measure of internal consistency and reliability of constructs. All the variables demonstrate good reliability scores with composite reliability scores of 0.664 (CSL), 0.713 (responsiveness), and 0.774 (reliability), and Cronbach-Alpha scores are good (especially that of responsiveness 0.711) and 0.774 (religability).

TABLE 5
VALUE OF VIF

Variable	VIF	Variable	VIF	Variable	VIF
Assu1	1.148	Emp1	1.564	Res1	1.210
Assu2	1.485	Emp2	1.564	Res2	1.430
Assu3	1.384	Emp3	1.078	Res3	1.599
Assu4	1.412	Emp4	1.319	Res4	1.226
Assu5	1.330	Emp5	1.224	Res5	1.238
CSL 1	1.129	Rel1	1.385	T1	1.095
CSL 2	1.287	Rel2	1.407	T2	1.332
CSL 3	1.200	Rel3	1.539	T3	1.410
CSL 4	1.300	Rel4	1.367	T4	1.324
CSL 5	1.409	Rel5	1.654	T5	1.407

Source: Results generated from SmartPLS4

As shown in Table 5, all VIF coefficients are below the cutoff of 5, which means that there are no problems of multicollinearity between variables. These findings support the strength of the model and suitability of the structure of factors, which help to argue in favor of the validity of the findings. Lastly, Figure 2 shows the values of R 2, which verifies that the model explains the relationship between dimensions of service quality and customer satisfaction in SOCBs.

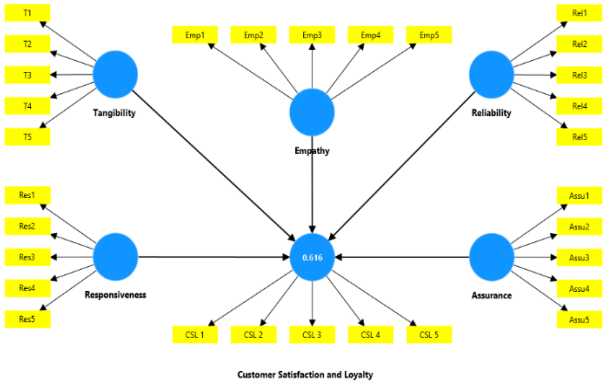


Fig.2. R2 values
Source: Results generated from SmartPLS4

D. Private Commercial Banks (PCBs)

TABLE 6
FACTOR-LOADINGS VALUES

Variable	Factor L.	Variable	Factor L.	Variable	Factor L.
T1	0.449	Rel1	0.628	Res1	0.566
T2	0.785	Rel2	0.726	Res2	0.749
T3	0.692	Rel3	0.749	Res3	0.773
T4	0.731	Rel4	0.755	Res4	0.565
T5	0.672	Rel5	0.695	Res5	0.728
Assu1	0.583	Emp1	0.536	CSL1	0.615
Assu2	0.759	Emp2	0.438	CSL2	0.769
Assu3	0.768	Emp3	0.263	CSL3	0.650
Assu4	0.638	Emp4	0.805	CSL4	0.709
Assu5	0.670	Emp5	0.773	CSL5	0.641

Source: Results generated from SmartPLS4

The findings of the Private Commercial Banks (PCBs) are displayed in three tabular form: factor loadings, composite reliability and Cronbachs alpha and Variance Inflation Factor (VIF). Table 6 indicates factor loading of the five SERVPERF dimensions, tangibility (T), reliability (Rel), responsiveness (Res), assurance (Assu), and empathy (Emp) and also customer satisfaction loyalty (CSL) items. The items loadings of all variables are greater than the acceptable number of 0.5 and this implies that the measurement model is dependable and the items are important in the underlying constructs. Such factors as reliability (Rel) and responsiveness (Res) are among the highest level factor loadings, indicating that they have a significant impact on service quality perceptions in PCBs.

Table 7
COMPOSITE RELIABILITY AND CORNDACHS ALPHA

Variable	Composite reliability	Variable	Corndachs Alpha
T	0.803	T	0.693
Res	0.811	Res	0.715
Emp	0.712	Emp	0.582
Rel	0.837	Rel	0.759
Assu	0.816	Assu	0.721
CSL	0.826	CSL	0.737

Source: Results generated from SmartPLS4

Table 7 shows the composite reliability and Cronbach alpha values which measures the internal consistency of the constructs. All the variables are satisfactory and the reliability of all of the variables is between 0.712 and 0.837 and composite reliability of all the measures is good more than 0.7.

TABLE 8
VALUE OF VIF

Variable	VIF	Variable	VIF
Assu1	1.182	Emp1	1.341

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Assu2	1.392	Emp2	1.325
Assu3	1.455	Emp3	1.072
Assu4	1.329	Emp4	1.354
Assu5	1.272	Emp5	1.273
CSL 1	1.197	Rel1	1.262
CSL 2	1.616	Rel2	1.517
CSL 3	1.342	Rel3	1.503
CSL 4	1.297	Rel4	1.377
CSL 5	1.471	Rel5	1.424
Res1	1.230	T1	1.104
Res2	1.481	T2	1.453
Res3	1.389	T3	1.352
Res4	1.225	T4	1.385
Res5	1.314	T5	1.283

Source: Results generated from SmartPLS4

Table 8 indicates VIF values, which are used to measure multicollinearity. The values of VIFs are not too high (not higher than 5), which indicates that no serious multicollinearity exists among the variables. This implies that the constructs are independent and have no strong ways of correlating with each other.

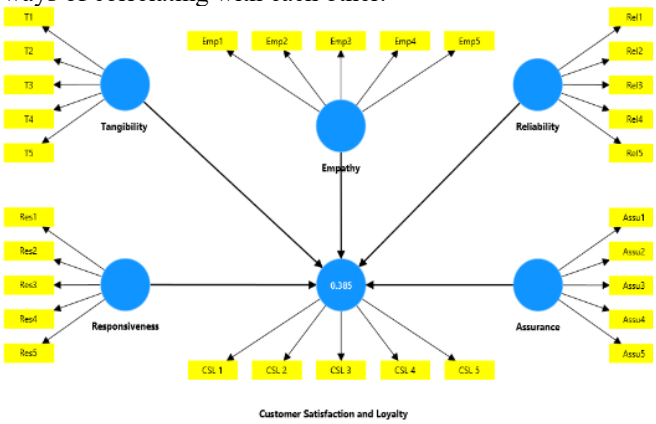


Fig.3. R2 values

Source: Results generated from SmartPLS4

Lastly, Figure 3 shows the values of R 2, which can give an insight into the explanatory power of the model. These findings reveal that the model fits well, meaning that it has the ability to predict the difference in customer satisfaction and loyalty in Private Commercial.

E. Islami Shariah-Compliant Private Commercial Banks (ISPCs)

Table 9: Factor-loadings values

Variable	Factor L.	Variable	Factor L.	Variable	Factor L.
T1	0.421	Rel1	0.685	Res1	0.660
T2	0.730	Rel2	0.764	Res2	0.719
T3	0.719	Rel3	0.794	Res3	0.814
T4	0.703	Rel4	0.702	Res4	0.691
T5	0.711	Rel5	0.761	Res5	0.694
Assu1	0.516	Emp1	0.807	CSL1	0.663
Assu2	0.792	Emp2	0.778	CSL2	0.602
Assu3	0.763	Emp3	0.427	CSL3	0.619
Assu4	0.748	Emp4	0.768	CSL4	0.676
Assu5	0.722	Emp5	0.665	CSL5	0.694

Source: Results generated from SmartPLS4

Islami Shariah-Compliant Private Commercial Banks (ISPCs) results are shown in three important tables factor loadings, composite reliability, and Variance Inflation Factor (VIF), and then the R 2 values. The values of the factor loading of the different dimensions of service quality are contained in Table 1. Factor loading of the tangibility (T), reliability (Rel), responsiveness (Res), assurance (Assu), and empathy (Emp) have a high value and that means these variables are significantly correlated to the measures seen. Indicatively, reliability factor loading is between 0.685 and 0.794 and responsiveness is between 0.660 and 0.814 which indicates that the two dimensions of service are very relevant to the customers.

Table 10

COMPOSITE RELIABILITY AND CORNDACHS ALPHA

Variable	Composite reliability	Variable	Corndachs Alpha
T	0.796	T	0.677
Res	0.841	Res	0.763
Emp	0.824	Emp	0.734
Rel	0.860	Rel	0.797
Assu	0.845	Assu	0.770
CSL	.800	CSL	0.702

Source: Results generated from SmartPLS4

The values of composite reliability and Cronbach-Alpha of these variables are presented in Table 10. Each of the values is above the recommended value of 0.7, and the highest of them falls on responsiveness (0.841) and empathy (0.824), which proves the internal consistency of the scales applied to measure these dimensions. There is also sufficient reliability of customer satisfaction loyalty (CSL) of 0.800.

Table 11

VALUE OF VIF

Variable	VIF	Variable	VIF	Variable	VIF
Assu1	1.211	Emp1	1.698	Res1	1.337
Assu2	1.599	Emp2	1.648	Res2	1.448
Assu3	1.613	Emp3	1.126	Res3	1.689
Assu4	1.592	Emp4	1.571	Res4	1.419
Assu5	1.444	Emp5	1.298	Res5	1.362
CSL 1	1.139	Rel1	1.467	T1	1.084
CSL 2	1.466	Rel2	1.578	T2	1.347
CSL 3	1.292	Rel3	1.578	T3	1.371
CSL 4	1.418	Rel4	1.386	T4	1.327
CSL 5	1.508	Rel5	1.638	T5	1.343

Source: Results generated from SmartPLS4

The Variance Inflation Factor (VIF) is reported in Table 11 and these values indicate the presence of multicollinearity. A majority of the VIF values fall below the threshold of 5 meaning that there are no drastic cases of multicollinearity.

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The values of R2 (Fig. 4) also confirm the suitability of the model in describing relationships among the quality dimensions of the service and customer satisfaction and loyalty, and the explanatory power in the group of the ISPCs is strong.

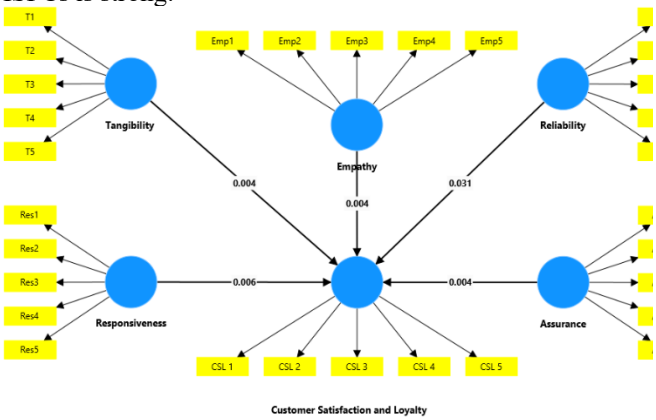


Fig.4. R2 values
Source: Results generated from SmartPLS4

F. Foreign Commercial Banks (FCBs)

Table 12
FACTOR-LOADINGS VALUES

Variable	Factor L.	Variable L.	Factor	Variable	Factor L.
T1	0.701	Rel1	0.831	Res1	0.825
T2	0.828	Rel2	0.783	Res2	0.679
T3	0.720	Rel3	0.843	Res3	0.862
T4	0.721	Rel4	0.828	Res4	0.595
T5	0.822	Rel5	0.705	Res5	0.850
Assu1	0.798	Emp1	0.570	CSL1	0.021
Assu2	0.722	Emp2	0.825	CSL2	0.620
Assu3	0.828	Emp3	0.826	CSL3	0.646
Assu4	0.466	Emp4	0.778	CSL4	-0.140
Assu5	0.755	Emp5	0.816	CSL5	0.560

Source: Results generated from SmartPLS4

The Tables 12, 13, and 14 of Foreign Commercial Banks (FCBs) give the significant insights on the factor loading, reliability, and multicollinearity of service quality dimensions and customer satisfaction variables. According to Table 12: Factor Loadings, Service quality dimensions are all strong in the factor loading, the dimension of tangibility (T), factor loading is 0.12, the dimension of reliability (Rel) factor loading is 0.62, the dimension of responsiveness (Res) factor loading is 0.16, the dimension of assurance (Assu) factor loading is 0.19, and the dimension of empathy (Emp) factor loading is 0.13. The greatest loading factored is seen in reliability (Rel3 = 0.843) and responsiveness (Res3 = 0.862) which indicate that these are important factors driving the customer perceptions. Tangibility has also high loadings and the lowest loading in empathy (Emp1 = 0.570) and customer satisfaction (CSL1 = 0.021), which implies possible areas of improvement in customer experience associated with empathy and satisfaction in general.

Table 13
COMPOSITE RELIABILITY AND CORNDACHS ALPHA

Variable	Composite reliability	Variable	Corndachs Alpha
T	0.872	T	0.816
Res	0.877	Res	0.826
Emp	0.877	Emp	0.823
Rel	0.898	Rel	0.856
Assu	0.843	Assu	0.765
CSL	0.430	CSL	0.228

Source: Results generated from SmartPLS4

According to Table 13: Composite Reliability and Cronbachs Alpha, composite reliability values of the responsiveness (Res = 0.877) and empathy (Emp = 0.877) are quite high, which means that the two factors are perceived continuously by customers. Nonetheless, the customer satisfaction (CSL) variable has less reliability (0.430) which implies that it is necessary to further refine the concept of satisfaction levels.

Table 14
VALUE OF VIF

Variable	VIF	Variable	VIF	Variable	VIF
Assu1	1.773	Emp1	1.252	Res1	2.024
Assu2	1.395	Emp2	2.042	Res2	1.438
Assu3	1.893	Emp3	2.002	Res3	2.223
Assu4	1.117	Emp4	1.832	Res4	1.309
Assu5	1.593	Emp5	1.925	Res5	2.079
CSL 1	1.005	Rel1	1.987	T1	1.497
CSL 2	1.036	Rel2	1.814	T2	1.987
CSL 3	1.010	Rel3	2.125	T3	1.452
CSL 4	1.017	Rel4	2.021	T4	1.540
CSL 5	1.040	Rel5	1.558	T5	1.906

Source: Results generated from SmartPLS4

As it is shown in Table 14: VIF Values, there is no significant concern with multicollinearity since all the values of VIF are less than the critical value of 5, and some of them such as CSL1 (VIF = 1.005) indicate negligible variance inflation, which indicates that the variables are specified correctly. On the whole, the findings present a complete picture of the dimensions of quality of service and their connection to the customer satisfaction and loyalty in the Foreign Commercial Banks.

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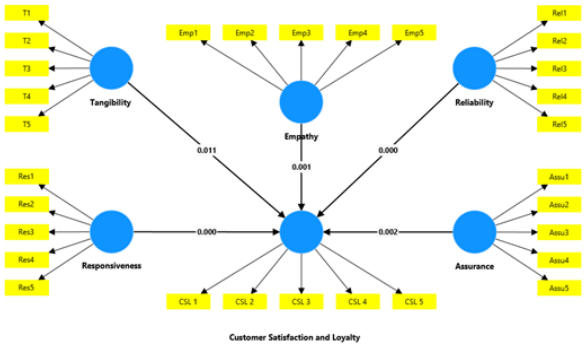


Fig.5. R2 values
Source: Results generated from SmartPLS4

V. DISCUSSION

The objective of this analysis was to compare and evaluate the quality of the banking services in four classes of banks SOCBs, PCBs, ISPCs and FCBs in Bangladesh in terms of customer satisfaction and customer loyalty. Since the SERVPERF model is determined from five dimensions (tangibility, reliability, responsiveness, assurance and empathy), to investigate whether customer satisfaction has an effect on customer loyalty, in this context the study employed SERVPERF model. The study also looked at how demographic factors such as age, income and proximity to where a child lived may affect these relationships. These results provide practical insights into customer behaviour in the banking sector of a developing economy like Bangladesh.

The outcome reflected that there are massive gaps in level of service & customer satisfaction between the four category of banks. Reliability and responsiveness were the primary drivers that led to the overall customer satisfaction of SOCBs and PCBs. The findings also validate some previous studies in which these elements were identified as very critical elements during evaluation of services in the banking sector. Notably, ISPCs set themselves apart by demonstrating empathy, which can be attributable to the customer service requirements prudently grounded in the Islamic banking principles of providing personal touch. This is one of the agreements with results, which empathy is an important component of Islamic banking, in which customer ties are affected by moral and social order [13].

In their turn, FCBs paid attention to service functionality, as a worldwide trend, foreign banks are more focused on service functionality, clear and understandable communication and transparency to be different from local competitors. Another conclusion from the research showed that customer satisfaction is among the top three drivers of customer loyalty in different types of banks and it confirms that satisfied customers are prone to show customer loyalty (14). However, SOCBs and PCBs rank 1st in the extent of loyalty, probably because of a more personal relationship with customers than that in ISPCs and FCBs. It means that even if there have always been proven relationship exist between satisfaction and loyalty, there are also additional factors such as switching cost and convenience, that plays an important role in deciding loyalty.

Additionally, such demographic (age, income and location) variables were found to impact the influence of service quality on satisfaction. The technologically progressive and digital banking had younger urban customers while old and rural consumers had the face-to-face and traditional banking. This aligns with South Asia studies that indicate that customer perception of services is not monolithic and, hence, proper demographic segmentation is necessary.

The implications of this study are to the bank managers in Bangladesh, who would think of increasing their competitiveness by enhancing their reliability and responsiveness via SOCBs and PCBs. Given the growing interest in Islamic finance, ISPCs may be wise to lean into empathy with respect to service provision. And so, instead of merchandising match tickets, FCBs may have to sell better emotional experiences to the customers. This information can also assist the policymakers to improve the customer experience across the banks by providing the category-wise best practices followed. In addition, national financial inclusion policies would meet the needs of specific customer groups more effectively by incorporating demographic considerations.

Despite its useful insights, the study has its limitations. Furthermore it excluded any other existing financial institutions that could influence the banking environment in Bangladesh focusing only on four categories of banks. Finally, the cross-sectional design and self-reported data does not allow for causal inferences at a specific time point. Further research can be done for the customization of digital banking and technology to modify customer loyalty and customer satisfaction and other variable like trust or brand name to affect customer behavior. In conclusion, this paper provides a comparative study on service quality difference in customer satisfaction and loyalty in Bangladeshi banking sector. It knowledgevalue to academics and practitioners that, if leveraged, could improve customer experience and loyalty amongst certain categories of banks.

VI. POLICY IMPLICATION

The existing study offers a substantial amount of information about the determinants of customer satisfaction and loyalty in the banking industry of Bangladesh, which can be used as guidance by the managers of the banks and policymakers. These lessons can be used to develop policies to increase the quality of the services, maintain customer loyalty, and increase financial inclusion so that banks could remain competitive in the changing financial environment. One of the key dimensions of core service quality should be improved by banks and should be of crucial importance to customer satisfaction and loyalty. State-owned Commercial Banks (SOCBs) and the Private Commercial Banks (PCBs) are encouraged to keep on enhancing reliability and

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responsiveness, which are two essential variables that influence service quality. The high-quality services will be delivered with the help of investments in the staff training and optimization of the processes. On the same note, customer loyalty will be enhanced by making sure that customer queries are handled in a timely, effective and sensitive manner. Personalized, culturally relevant services should be part of the offerings of the Islamic Shariah-compliant Private Commercial Banks (ISPCs) that are characterized by providing a customer-centric services in order to build their reputation and customer base. Understanding the values and preferences of their customers should be stressed by these banks, which would help them consolidate their position in the market. Also, training the workers to treat customers with respect and empathy will be a competitive advantage. Foreign Commercial Banks (FCBs) that perform well in the aspect of tangibility and assurance need to look into the gaps that exist in empathy and should work to develop personalized customer experiences. Customer retention will be improved by improving the responsiveness of the staff when dealing with complaints. The policy makers are encouraged to urge banks to be customer-focused with attention to demographic factors (age, income, and geographic location) that determine perceptions of the service. There should be a regulation to enhance integration of advanced technologies to enhance service delivery, particularly to rural and underserved regions to enhance the financial inclusion. The areas that will be targeted will enable the banks to be in a better position to satisfy the customer expectation, enhance service delivery, and maintain a stable customer base in a competitive market.

VII. LIMITATIONS

The research points out critical aspects that determine customer satisfaction and customer loyalty in the banking industry in Bangladesh, which can prove useful to banking managers and policymakers. In a bid to stay competitive, banks have to pay attention on key service quality factors that lead to customer satisfaction especially in aspects such as reliability and responsiveness. The large number of employees should be trained and the infrastructures of the state-owned Commercial Banks (SOCBs) and the Private Commercial Banks (PCBs) updated to ensure good service delivery. Making customer inquiries a point of concern and responding with concern, creates loyalty. The Islamic Shariah Compliant Private Commercial Banks (ISPCs) that have strong emthy skills need to use their cultural sensitivity and personalized services as a way of increasing their market share. As much as the services of the Foreign Commercial Banks (FCBs) are more concrete and sure, the empathy gap needs to be bridged by means of more personalized contact to build more positive emotional relationships and enhance customer retention. To drive the agenda of financial inclusion, authorities ought to encourage banks to resort to consumer-based strategies in service provision that consider demographic variables such as age, income and location. Moreover, the regulatory framework is also supposed to facilitate the use of new technologies to improve the quality and access to services especially in the rural and underserved regions. The strategies will enable the banks to serve the customers better and enhance service delivery as well as maintain loyal customers in a competitive market.

VIII. CONCLUSION

This paper investigates the linkage of service quality with customer satisfaction and customer loyalty in the context of four categories of banks in Bangladesh; State-Owned Commercial Banks (SOCBs), Private Commercial Banks (PCBs), Islami Shariah-compliant Private Commercial Banks (ISPCs), and Foreign Commercial Banks (FCBs). It centers on the way customers expect service quality in five dimensions: tangibility, reliability, responsiveness, assurance, and empathy. It examines the effect of customer satisfaction on customer loyalty, an indispensable element in every successful business in the long run. Thus, the results demonstrate that service quality, satisfaction, and loyalty are significantly different among the four bank types. SOCBs and PCBs performed exceptionally well on reliability and responsiveness, so consumers are more satisfied and loyal to them. Empathy, an essential criterion in Islamic banking due to cultural and religious sensitivities, was high in the ISPCs. FCBs provided physical services optimally but lacked empathy which increased customer dissatisfaction. This study provides evidence of a positive relationship between satisfaction and loyalty, especially for SOCBs and PCBs. It highlights that banks should offer any service or product based on customer preferences and customer demographics (age, income, and location) determining satisfaction and loyalty. Reliability and responsiveness are the priorities for SOCB and PCB, and an increase in empathy necessary for ISPC. FCBs need to engage with the customers with a bit more heart-driven campaigns to enhance customer experience. The results are useful for bank managers and policymakers as it offers practical guidance for improving service quality and fostering customer loyalty, particularly in the face of increasing interest in digital banking.

APPENDIX A

Table A1: LIST OF VARIABLES

Variable	Name of Variables	Sources
Tangibility	The physical facilities of this bank (e.g., branches, ATM machines) are visually appealing.	(İltaş & Demirgüneş, 2020**;**Beisengaliyeva et al., 2024)
	The bank's equipment and technology are modern and up-to-date.	

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	The employees of this bank are well-dressed and present a professional image.	
	The communication materials (e.g., brochures, website) provided by this bank are clear and informative.	
	The bank's interior design and branch layout are inviting and comfortable.	
Reliability	This bank consistently provides accurate information about its products and services.	(Iberahim et al., 2016;Tworek, 2018)
	The bank delivers the promised services at the agreed-upon time without delays.	
	I can trust this bank to handle my financial transactions reliably without errors.	
	The bank keeps its promises regarding service delivery and customer commitments.	
	The bank's service quality is consistently high and meets my expectations over time.	
Responsiveness	This bank's staffs are quick to respond to my inquiries or requests.	(Iberahim et al., 2016b; Pakurár et al., 2019)
	The bank provides timely assistance when I encounter issues or problems with services.	
	The bank is proactive in addressing my service-related concerns.	
	The bank's service staffs are always available and willing to help when needed.	
	I am satisfied with the speed at which the bank handles my transactions and requests.	
Assurance	The bank's employees demonstrate expertise and knowledge in handling financial matters.	(Al Ali, 2021; Onuonga, 2017)
	I feel confident that this bank will protect my financial information and transactions.	
	The employees at this bank are courteous and respectful in all interactions.	
	The bank has an established reputation for providing safe and secure services.	
	The bank's employees are able to answer all my questions confidently and accurately.	
Empathy	The bank understands and cares about my personal financial needs.	(Zidehsaraei et al., 2024;Dias et al., 2025)
	The bank's staffs provide personalized service tailored to my specific requirements.	
	The bank treats me as a valued customer, offering attention and care.	
	The employees of this bank show genuine concern for my well-being and satisfaction.	
	I believe that the bank cares about building long-term relationships with its customers.	

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Customer Satisfaction and Loyalty	I am satisfied with the overall quality of services provided by my bank.	(Sayani, 2015;Keisidou et al., 2013)
	My banking experiences consistently meet or exceed my expectations.	
	I intend to continue using this bank for my future financial needs.	
	I would recommend this bank to friends and family.	
	I feel loyal to this bank compared to other banks in Bangladesh.	

* Expert opinion was sought in the selection of variables

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The Impact of the Statement of Work on the Relationship between the 3PL Customer and Service Provider in the Manufacturing Sector

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Abstract: ***The success of outsourcing supply chain operations to Third-Party Logistics (3PL) providers depends heavily on the clarity and precision of the Statement of Work (SoW). Despite the widespread expectation that 3PL partnerships will deliver efficiency gains, cost reductions, and enhanced service performance, many manufacturing customers report unmet expectations and strained relationships with providers. This study examines the role of SOW quality in shaping customer-provider relationships, with a particular focus on how vague, incomplete, or overly rigid SOWs contribute to scope creep and dissatisfaction. Using a qualitative research design, structured interviews were conducted with both manufacturing customers and 3PL providers across the Aerospace, Automotive, Defense, and Industrial Equipment sectors. The findings reveal that scope creep often begins subtly, with small, informal requests evolving into ongoing service obligations. Inadequately defined requirements, such as compliance tracking, kitting processes, or inventory handling rules, created significant misalignment between what customers expected and what providers had agreed to deliver. These discrepancies resulted in frustration, operational inefficiencies, and financial strain, particularly when customers resisted contract adjustments to reflect expanded requirements. The study concludes that static SOWs are insufficient in the context of modern manufacturing supply chains, where complexity and variability are inherent. To sustain effective partnerships, both parties must adopt dynamic SOW management frameworks that incorporate clear mechanisms for scope adjustment, cost sharing, and process transparency. Such approaches not only mitigate the risks of scope creep but also strengthen trust, resilience, and long-term profitability in customer–3PL relationships.***

Keywords: **Third-Party Logistics (3PL), Statement of Work (SOW), scope creep, manufacturing sector, supply chain management, customer–provider relationships**

I. INTRODUCTION

1.1 Background

The outsourcing of logistics and supply chain activities has become a defining trend in modern manufacturing as firms increasingly seek to enhance competitiveness, streamline operations, and focus on their core competencies. Over the last three decades, Third-Party Logistics (3PL) providers have emerged as critical partners in achieving these goals, offering services that extend well beyond basic transportation and warehousing. Today, 3PLs provide a wide range of value-added services, including production kitting, packaging, assembly, inventory management, quality assurance, and compliance monitoring [3]. By assuming responsibility for these functions, 3PLs allow manufacturers to concentrate resources on design, innovation, and market responsiveness rather than the complexities of logistics management.

The scale and significance of outsourcing to 3PLs is evidenced in global supply chain surveys. According to ref. [2], a majority of customers (69%) report that 3PL providers meet their operational needs, highlighting the sector's value in addressing diverse supply chain challenges. At the same time, however, customer satisfaction levels have stagnated in areas such as cost reduction and service adaptability, suggesting that the effectiveness of outsourcing is uneven across contexts [2]. These findings indicate that while 3PL adoption has become mainstream, challenges remain in ensuring that partnerships deliver consistent and measurable benefits.

One of the main drivers of 3PL adoption has been the increasing complexity of manufacturing supply chains, especially in industries that face strict regulatory requirements. For instance, pharmaceutical and biotechnology sectors demand rigorous traceability of materials, including lot numbers, batch codes, and expiration dates, to ensure compliance with safety and quality standards [5]. In the automotive sector, regulatory frameworks require the tracking of supplier lots and serial numbers, ensuring that defective parts can be identified and recalled efficiently [6]. Similarly, environmental regulations in the manufacturing sector have placed increasing responsibility on both manufacturers and their logistics partners to ensure compliance throughout the supply chain [4]. These examples underscore that logistics outsourcing is no longer confined to operational efficiency but also plays a strategic role in ensuring compliance, risk management, and product integrity.

In addition to compliance, value-added services such as kitting and light assembly highlight the expanded role of 3PLs in supporting production processes. Kitting, which involves the preparation of components for assembly, may appear straightforward but becomes highly complex when dealing with large Bills of Material (BOMs) or when specialized conveyances are required for heavy or sensitive parts [8]. Such complexity introduces challenges in process design, resource allocation, and error prevention, which must be clearly articulated in contractual agreements between the manufacturer and the 3PL. When requirements are not sufficiently detailed in the governing Statement of Work (SOW), both parties risk misalignment in expectations and performance outcomes.

The increasing reliance on 3PLs has therefore transformed logistics providers into strategic partners in manufacturing

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supply chains. However, this shift also places new emphasis on the governance mechanisms that structure these partnerships. Central to this governance is the SOW, which defines the scope of services, performance metrics, pricing structures, and responsibilities of each party [7]. A well-crafted SOW can act as a foundation for efficiency, trust, and collaborative problem-solving, while a poorly designed one can quickly become a source of disputes, scope creep, and dissatisfaction. Given the rising complexity of manufacturing supply chains and the strategic role of 3PLs, the quality of the SOW has become an increasingly critical determinant of partnership success.

II.LITERATURE REVIEW

2.1 Value-Added Services and Complexity

The role of Third-Party Logistics (3PL) providers has expanded significantly over the past three decades. While early outsourcing arrangements focused primarily on basic services such as transportation, warehousing, and distribution, today's 3PLs increasingly perform value-added services (VAS) that extend their role beyond logistics execution into direct support of manufacturing processes. These services include production kitting, light assembly, packaging, sequencing, quality inspection, and compliance-related activities [3]. The shift reflects both competitive pressures in manufacturing and customer demand for integrated solutions that reduce the burden of non-core yet operationally essential activities.

Although value-added services increase the strategic relevance of 3PLs, they also introduce significant operational complexity. Unlike standard logistics tasks, which are relatively predictable and process-driven, value-added activities often involve customization, variability, and coordination with customer production schedules. For instance, kitting requires preparing sets of components for assembly, which may appear straightforward but becomes increasingly complex as the Bill of Materials (BOM) grows in size and diversity. Research shows that while a simple kit may involve two or three items, kits in aerospace, automotive, or defense industries can contain hundreds of components, often with special handling or sequencing requirements [8]. The complexity escalates when shortages occur, oversized components need special conveyances, or kits must be reconfigured in response to production changes.

The challenge extends further in industries subject to stringent regulatory requirements. In the pharmaceutical and biotechnology sectors, for example, value-added services often require detailed lot tracking, serialization, and expiration management to comply with safety and regulatory standards [5]. Failure to adhere to these requirements can result in costly recalls or regulatory penalties, placing additional pressure on 3PL providers. Similarly, in the automotive industry, compliance with traceability regulations requires the precise recording of supplier lot and serial numbers to ensure defective parts can be quickly identified and removed from circulation [6]. In these cases, value-added logistics services are no longer merely supportive but integral to regulatory compliance and product quality assurance.

As 3PLs take on these complex responsibilities, the role of the Statement of Work (SOW) becomes critical. The SOW defines the scope, deliverables, and performance metrics of outsourced services, guiding how providers allocate resources and price their offerings [7]. However, the increasing complexity of value-added services makes it difficult for customers to fully capture their requirements in the initial SOW. For instance, questions such as how providers should respond to missing kit components, how quality inspection should be measured, or how to manage variability in production schedules often remain unaddressed. When such details are absent, customers may assume flexibility and adaptability are part of the agreement, while providers view these demands as scope extensions. The resulting misalignment contributes to scope creep and dissatisfaction.

Survey data support this tension. While a majority of 3PL customers recognize the importance of value-added services in meeting supply chain needs, fewer report satisfaction with the outcomes, particularly when cost savings or service adaptability are concerned [2]. The addition of value-added services creates greater interdependence between customer and provider, which increases the stakes of misalignment. Unlike basic warehousing or transportation, value-added services are embedded directly into production processes, meaning that failures or disputes have immediate consequences for manufacturing output.

The academic literature has acknowledged the complexity of value-added logistics services but has paid less attention to how these complexities are translated into contractual frameworks. For example, ref. [3] depicts the drivers and barriers of VAS development from a provider perspective, yet its work stops short of examining how contractual clarity shapes the success or failure of such services. Similarly, compliance-focused research has demonstrated the technical requirements of regulated industries [4], [5], [6], but does not consider how these requirements are codified or overlooked in the SOW. This omission is significant because the absence of explicit contractual detail not only increases operational risks but also undermines the relational trust necessary for long-term partnerships.

The rise of value-added services in 3PL operations has amplified both the strategic importance and operational complexity of outsourcing arrangements in the manufacturing sector. These services blur the line between logistics and production, placing new demands on providers and creating heightened interdependence with customers. While value-added services create opportunities for efficiency and integration, they also expose vulnerabilities when not fully articulated in contractual agreements. The inability of many SOWs to capture the intricacies of value-added services, ranging from BOM variability in kitting to compliance requirements in regulated industries, serves as a root cause of dissatisfaction and scope creep. This underscores the need to treat SOWs not as static documents but as living governance tools capable of adapting to

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complexity and ensuring alignment between customer expectations and provider capabilities.

2.2 Scope Creep in 3PL Relationships

Scope creep, defined as the incremental expansion of tasks and responsibilities beyond the original contractual agreement, is one of the most frequently cited challenges in project management and outsourcing relationships [7]. Within the context of Third-Party Logistics (3PL) partnerships, scope creep represents a persistent and often hidden problem. It arises when customers gradually request additional services, often framed as temporary adjustments or small favors, that over time become routine expectations. While such requests may initially appear minor, their cumulative effect can impose significant operational and financial burdens on providers, ultimately straining customer–provider relationships.

The problem of scope creep is particularly acute in 3PL arrangements because of the close operational integration between providers and manufacturing customers. Unlike standalone service contracts, logistics outsourcing frequently embeds providers directly into production processes through value-added services such as kitting, assembly, or quality inspection [3]. These activities are highly variable and often subject to changing customer requirements. For example, in kitting operations, unforeseen issues such as missing parts, oversized subassemblies, or altered sequencing can require providers to adapt processes quickly. If such contingencies are not specified in the Statement of Work (SOW), customers may expect providers to absorb the adjustments as part of the service, while providers perceive them as scope extensions requiring renegotiation [8]. This mismatch between expectations and contractual definitions creates fertile ground for scope creep.

Scope creep also emerges in regulated manufacturing sectors, where compliance obligations frequently evolve in response to new regulations or customer-specific requirements. In pharmaceutical and biotechnology industries, for instance, providers may be asked to implement more stringent lot tracking, serialization, or audit documentation than was originally specified in the SOW [5]. In the automotive industry, regulatory and customer requirements for traceability may shift mid-contract, requiring providers to implement additional documentation processes across thousands of SKUs [6]. These unanticipated requirements are resource-intensive, often requiring new systems, staff, or processes. Yet when customers view these changes as “non-negotiable” compliance necessities, they resist cost adjustments, leaving providers to bear the financial strain.

Survey evidence underscores the persistence of this issue. Ref. [2] highlights that while most customers acknowledge 3PLs’ ability to address operational needs, satisfaction with adaptability and cost management has declined. This decline can be interpreted as a direct consequence of scope creep: providers attempt to accommodate evolving requirements without formal scope adjustments, eroding profitability, while customers perceive subsequent cost increases as opportunistic. The resulting perception gap damages trust and undermines the collaborative potential of the relationship.

Scope creep also has important relational consequences. As ref. [1] observes, successful outsourcing depends not only on operational performance but also on trust, communication, and collaboration between partners. When providers consistently absorb additional tasks without formal recognition, they may begin to feel exploited. Conversely, when providers attempt to renegotiate contracts to account for these tasks, customers may view such actions as unfair or opportunistic. These dynamics create a cycle of resentment and mistrust that can destabilize even otherwise productive relationships. In this sense, scope creep is not simply a contractual or operational issue but a relational one, with implications for long-term partnership sustainability.

At the heart of the scope creep problem lies the failure of many SOWs to capture the dynamic realities of manufacturing logistics. Static, one-time contracts assume a level of predictability that does not exist in industries characterized by variable demand, complex Bills of Material, and evolving regulatory requirements. When SOWs are vague, they leave critical contingencies unaddressed, creating opportunities for misinterpretation. When they are overly rigid, they lack mechanisms for adaptation, forcing providers to choose between absorbing costs or risking relational conflict. In either case, the result is dissatisfaction on both sides: customers frustrated by perceived service shortfalls, and providers frustrated by unacknowledged or uncompensated scope expansions.

Scope creep represents a central challenge in 3PL relationships, rooted in the tension between operational variability and contractual rigidity. It arises when the SOW fails to adequately define service boundaries or anticipate contingencies, leaving providers vulnerable to incremental scope expansions. Beyond operational inefficiency, scope creep undermines trust, damages collaboration, and contributes to the erosion of long-term partnership viability. Addressing this challenge requires rethinking the SOW as a living governance document, equipped with mechanisms for scope adjustment, cost alignment, and transparent communication. Only by explicitly managing scope can customers and providers sustain resilient and mutually beneficial outsourcing relationships in complex manufacturing environments.

2.3 Customer–Provider Relationship Management

The effectiveness of outsourcing logistics to Third-Party Logistics (3PL) providers depends not only on operational efficiency and service delivery but also on the quality of the relationship between the customer and the provider. As Ref. [1] emphasizes, relational dimensions such as trust, communication, and collaboration are critical to sustaining successful partnerships. This is particularly important in manufacturing, where 3PLs are often embedded directly into production systems through services such as kitting, assembly, compliance tracking, and inventory management [3]. The complexity and interdependence of these arrangements mean that technical performance alone cannot

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ensure success; instead, relational governance becomes central.

A recurring theme in logistics research is the tension between contracts and relationships. Formal contracts, such as the Statement of Work (SOW), provide clarity and accountability by defining service scope, responsibilities, and performance measures [7]. Relational mechanisms, on the other hand, rely on trust, flexibility, and goodwill to manage unexpected challenges. Effective 3PL partnerships typically require a balance of both: contracts provide a framework for accountability, while relationships provide the adaptability needed to navigate uncertainty. When this balance is disrupted, such as when the SOW is vague or incomplete, the partnership becomes vulnerable to conflict.

The challenges of managing customer–provider relationships are heightened by scope creep, which places stress on both contractual and relational foundations. As discussed in Section 2.2, scope creep often begins with small, informal requests that escalate into routine obligations. From a relational perspective, providers may initially agree to these requests in order to build goodwill and demonstrate commitment. However, when customers begin to expect such accommodations as standard, providers may feel exploited, particularly if the additional work is resource-intensive. Customers, conversely, may perceive later attempts to renegotiate scope or costs as opportunistic. This mismatch in perceptions creates a trust deficit, damaging the relational fabric of the partnership [2].

The literature on compliance in manufacturing illustrates the relational pressures that arise from unanticipated requirements. In pharmaceuticals, for instance, 3PLs may be expected to introduce more sophisticated serialization or lot-tracking processes without corresponding contract revisions [5]. In the automotive industry, manufacturers may alter compliance protocols or production scheduling mid-contract, placing sudden burdens on providers [6]. These unilateral changes create a situation where customers expect providers to "figure it out," while providers struggle to maintain service levels without formal acknowledgment of increased scope. The absence of mechanisms to renegotiate the SOW under such conditions exacerbates relational strain, as providers feel undervalued and customers perceive declining service quality.

Effective relationship management requires more than simply reacting to challenges; it requires building systems of collaborative governance. This includes transparent communication channels, joint problem-solving mechanisms, and shared processes for scope adjustment. Relational theory suggests that trust and adaptability are mutually reinforcing: when providers trust that customers will fairly recognize additional work, they are more willing to adapt; when customers trust that providers are not exploiting change for profit, they are more open to renegotiation. Conversely, when trust is absent, even minor scope changes can lead to conflict [1].

The academic literature, however, reveals a gap in explicitly connecting contractual clarity to relational outcomes. While studies highlight the importance of relational factors in outsourcing success, they often treat these as separate from the contractual framework. Yet evidence from practice shows that poorly defined SOWs directly undermine relational quality by creating ambiguity and scope creep. Contracts and relationships are not independent but interdependent: vague contracts place undue strain on trust, while rigid contracts constrain adaptability. Thus, relationship management in 3PL contexts must be understood as a function of both contractual design and relational flexibility.

Ref. [2] reinforces this perspective, noting that change management remains one of the most significant challenges in 3PL partnerships. Effective change management is not only about operational adjustments but also about relational negotiation, how customers and providers agree to handle evolving requirements. Without structured processes for renegotiation, relational tensions escalate, jeopardizing long-term collaboration.

The management of customer–provider relationships in 3PL contexts is shaped by a delicate balance between formal contracts and informal trust mechanisms. Strong relationships cannot compensate indefinitely for poorly constructed SOWs, just as clear contracts cannot succeed without trust and collaboration. The interplay of these elements determines whether scope creep and operational variability lead to conflict or collaboration. For manufacturing sectors where complexity and compliance pressures are high, successful relationship management requires treating the SOW as a living document, supported by relational practices of transparency, fairness, and adaptability. Only through this integrated approach can 3PL partnerships remain resilient, sustainable, and mutually beneficial.

III.METHODOLOGY

3.1 Research Design

This study adopts a qualitative exploratory research design to investigate how the quality of the Statement of Work (SoW) affects customer–provider relationships in Third-Party Logistics (3PL) partnerships. Qualitative approaches are particularly appropriate for exploring complex relational phenomena, such as trust, scope creep, and contract interpretation, which cannot be fully captured through quantitative surveys alone [1]. By using interviews as the primary method of inquiry, the study provides rich, context-specific insights into how SOW clarity, or lack thereof, shapes both operational outcomes and relational dynamics.

3.2 Data Collection

Data were collected through structured interviews with stakeholders from both sides of the outsourcing relationship: 3PL service providers and manufacturing customers. The structured format ensured consistency across interviews while allowing participants to elaborate on their experiences. Questions were designed to capture perceptions of:

a. The adequacy of SOWs in reflecting actual service requirements.

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b. Experiences of scope creep and its impact on operations.
c. The relational consequences of contractual ambiguity, including trust, communication, and conflict.
d. Mechanisms currently in place (or lacking) for renegotiating scope and managing change.

The interviews were conducted across four manufacturing sectors known for complex logistics requirements: Aerospace, Automotive, Defense, and Industrial Equipment. These industries were selected because they combine high product complexity, regulatory obligations, and dependence on value-added logistics services, making them especially vulnerable to the consequences of inadequate SoWs.

3.3 Sampling Strategy

A purposive sampling strategy was employed to ensure the inclusion of participants with direct experience in drafting, negotiating, or executing SOWs within 3PL arrangements. The sample consisted of:

- 3PL providers: operational managers, account directors, and compliance officers responsible for delivering logistics services and ensuring adherence to contractual obligations.
- Manufacturing customers: supply chain managers, procurement specialists, and production planners involved in outsourcing decisions and contract management.

3.4 Data Analysis

Interview transcripts were analyzed using thematic coding. Following Braun and Clarke's (2006) framework for thematic analysis, the process involved:

- Familiarization: repeated reading of transcripts to identify preliminary themes.
- Initial coding: assigning codes to text segments relating to SOW clarity, scope creep, and relational outcomes.
- Theme development: grouping codes into broader themes such as "contractual ambiguity," "hidden expectations," "trust erosion," and "adaptive mechanisms."
- Review and refinement: comparing themes across customer and provider groups to identify similarities and differences.
- Interpretation: relating findings to the research questions and the existing literature on outsourcing and 3PL governance.

The use of thematic analysis allowed for the identification of patterns across cases, while also preserving the nuance of individual experiences.

3.5 Validity and Reliability

Several steps were taken to enhance the credibility and reliability of the findings. First, structured interview questions ensured consistency across participants, reducing variability in responses attributable to the interviewer. Second, triangulation was achieved by including both customer and provider perspectives, allowing for the comparison of narratives across sides of the partnership. Third, member checking was used: selected participants were allowed to review summaries of their interviews to confirm accuracy and interpretation. Finally, coding was conducted iteratively, with themes cross-validated by a second researcher to minimize bias.

3.6 Ethical Considerations

The study adhered to ethical research standards. All participants provided informed consent before participation, and confidentiality was maintained by anonymizing organizational and individual identifiers. Data was stored securely, with access restricted to the research team. Given the competitive and sensitive nature of outsourcing relationships, particular care was taken to ensure that findings were reported in aggregate form without disclosing proprietary details.

3.7 Limitations

This study has several limitations. First, the sample size, while sufficient for qualitative analysis, does not permit generalization to the entire manufacturing sector. The findings should therefore be interpreted as exploratory insights rather than statistically representative conclusions. Second, the reliance on self-reported data introduces the potential for bias, as participants may underreport challenges or emphasize certain narratives. Third, the focus on four industries, Aerospace, Automotive, Defense, and Industrial Equipment, means that results may not fully capture dynamics in other sectors, such as consumer goods or retail. Despite these limitations, the study provides valuable empirical evidence on the underexplored issue of SOW quality in 3PL relationships, laying the groundwork for future research using larger and more diverse samples.

The chosen methodology, qualitative structured interviews analyzed through thematic coding, offers a robust approach for examining how SOW clarity shapes operational and relational outcomes in 3PL partnerships. By combining insights from both customers and providers across multiple industries, the study captures the dual perspectives necessary to understand the relational tensions caused by contractual ambiguity and scope creep. This methodology ensures alignment with the research questions and provides a strong foundation for the subsequent analysis of findings.

IV.RESULTS

The structured interviews provided rich insights into the experiences of both 3PL service providers and manufacturing customers. Thematic analysis identified four overarching themes: (a) Scope creep as a common experience, (b) Misalignment between SOWs and operational realities, (c) Customer-driven disruptions to established processes, and (d) Relational consequences of SOW ambiguity. Each theme is expanded below with supporting narratives.

4.1 Scope Creep as a Common Experience

A dominant theme across interviews was the prevalence of scope creep in 3PL partnerships. Providers consistently reported that scope creep emerged gradually, beginning with small, seemingly inconsequential customer requests.

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For instance, a logistics manager from the automotive sector described how an initial agreement to reconfigure a few kits during a supply shortage gradually became a permanent responsibility:
"At first, we said yes because it was positioned as a one-off situation. But after a few months, these one-off requests became part of our daily routine. It required us to dedicate staff, change workflows, and even buy equipment we never budgeted for."
Providers emphasized that they initially accommodated such requests to maintain goodwill and to be seen as flexible partners. However, once these practices became institutionalized, they created significant resource burdens without corresponding adjustments in cost structures.

From the customer perspective, these same adjustments were not viewed as scope creep but as essential elements of service quality. An aerospace manufacturer explained:
"We outsource to avoid disruptions. If parts are missing or shipments are delayed, we expect our logistics partner to handle it. To us, it's not a scope change, it's the job."
This finding reveals a fundamental perception gap: what providers interpret as scope expansion, customers interpret as expected flexibility. The divergence illustrates how the absence of explicit guidance in the SOW creates space for misaligned assumptions.

In several cases, providers admitted that scope creep was tolerated for extended periods to avoid conflict, but over time, the cumulative effect became unsustainable. A defense-sector provider reflected:
"We didn't push back for the first year. However, when we finally requested a formal adjustment, the customer accused us of nickel-and-diming. It damaged the relationship."
The theme of scope creep demonstrates how ambiguity in the SOW directly translates into incremental operational burdens that destabilize customer–provider trust.

4.2 Misalignment Between SOWs and Operational Realities
Another recurring theme was the disconnect between contractual SOWs and actual operational requirements. Both customers and providers acknowledged that SOWs often fail to capture the complexity of real-world processes. From the provider's perspective, vague or incomplete SOWs left them unprepared for the true scope of service delivery. A defense logistics provider shared an example involving the management of over 300,000 SKUs:
"The SOW never specified that we would have to use multiple serialization systems for different countries. We discovered this only after operations began. It added massive complexity, requiring new IT systems and staff training. None of this was in our original cost models."
This provider emphasized that such oversights were not minor but fundamentally altered their cost base.
Customers, by contrast, admitted that time constraints and competitive bidding pressures often led to SOWs that were high-level rather than detailed. A procurement officer from the industrial equipment sector explained:
"In the RFP process, we focus on being concise. Too much detail can discourage competitive bids. But we know that leaves gaps, and we expect the provider to fill them."
This approach effectively shifts the burden of interpreting ambiguities onto providers. While customers viewed this as pragmatic, providers saw it as creating unrealistic expectations that undermined service delivery.
Several providers stressed that the RFP-driven SOW process encourages oversimplification, which contributes to dissatisfaction later in the partnership. One aerospace provider commented:
"We design our entire operating model based on what's in the SOW. If it's incomplete, our cost model is flawed from day one."
This theme highlights that misalignment is not simply the result of poor drafting but of structural practices in outsourcing, where speed and cost competitiveness override operational realism.

4.3 Customer-Driven Disruptions to Established Processes
Several providers reported that even when SOWs were clear initially, customer-driven operational changes disrupted established workflows without corresponding adjustments to contracts.
A striking example came from an automotive logistics provider, who described how the SOW allocated two dock doors for staging materials. Six months into the partnership, the manufacturer reassigned one dock door to outbound shipping:
"We designed our entire system around having two doors. When they took one away, our staging process collapsed. We needed extra staff and equipment to compensate, but the customer refused to amend the SOW."
Other disruptions included sudden changes to production schedules, elimination of kanban inventory buffers, and shifts in delivery frequency. Providers emphasized that such changes increased labor requirements and reduced efficiency, yet customers framed them as internal decisions unrelated to the outsourcing agreement.
An industrial equipment provider explained:
"When the customer changed their scheduling system, our workload tripled. They told us it was an internal adjustment and didn't see why it should affect the contract. But it changed everything for us operationally."
This theme demonstrates that even well-defined SOWs are undermined when customers unilaterally alter operating conditions, highlighting the need for adaptive contract mechanisms.

4.4 Relational Consequences of SoW Ambiguity
The final theme concerns the relational impact of ambiguous or rigid SOWs. Both customers and providers described how contractual misalignment translated into erosion of trust.
Providers expressed frustration when customers resisted acknowledging or compensating for the expanded scope. As one defense-sector provider put it:
"We want to be partners, but it feels like we're constantly asked to do more for less. When we finally ask for a contract

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change, we're accused of nickel-and-diming. It's exhausting."

Customers, meanwhile, described feeling exploited when providers requested scope adjustments, interpreting them as opportunistic. An aerospace procurement officer stated:
"They agreed to the SOW. When they come back asking for more money, it feels like they're trying to take advantage."
These conflicting narratives show how perception gaps damage trust. Providers view renegotiation as a necessity for sustainability, while customers see it as opportunism. Once established, these trust deficits often extended into other areas, making routine negotiations contentious.
Several providers concluded that the absence of adaptive SOW frameworks left them trapped in a cycle of resentment and mistrust. One industrial equipment provider explained:
"We start with goodwill, but by year two, the relationship feels adversarial. The SOW doesn't protect us, and the customer doesn't want to listen. Trust breaks down."
This theme highlights that ambiguous SOWs are not merely operational flaws but relational liabilities that erode long-term partnership sustainability.

V. DISCUSSION

The analysis of structured interviews demonstrates that the Statement of Work (SOW) plays a far more consequential role in 3PL partnerships than has been previously recognized in logistics literature. Far from being a procedural contract artifact, the SOW emerged as a determinant of scope clarity, operational efficiency, and relational trust. Poorly constructed or static SOWs were consistently identified as root causes of dissatisfaction, scope creep, and misalignment between customers and providers. In this section, the results are interpreted in light of existing literature and theoretical perspectives, with emphasis on scope creep, operational misalignment, compliance obligations, customer-driven disruptions, and relational dynamics.

5.1 Scope Creep and Contractual Weaknesses

This study confirms that scope creep is endemic in 3PL partnerships, but it extends existing knowledge by identifying contractual ambiguity in SOWs as its primary enabler. Ref. [7] framed scope creep broadly as a failure of planning and project control. However, our findings reveal that in logistics outsourcing, scope creep originates much earlier, during the contract drafting phase, when contingencies and service boundaries are left vague.
The data showed that scope creep often began with small requests, such as reconfiguring kits during supply shortages, that escalated into permanent responsibilities. Customers interpreted these adjustments as part of standard service, while providers saw them as unacknowledged expansions. This divergence in perception mirrors ref. [1] emphasis on the importance of aligning customer and provider expectations but extends it by demonstrating that such misalignment is often "baked in" at the contracting stage rather than emerging solely in execution.
Moreover, the study illustrates that scope creep has hidden costs for providers. By absorbing incremental tasks without scope adjustments, providers compromise profitability and strain internal resources. Over time, this creates resentment and damages trust, echoing ref. [2], who reported declining satisfaction with adaptability and cost efficiency in 3PL relationships. Ref. [8] highlighted the operational complexity of kitting processes; this study demonstrates how such complexity, when unarticulated in the SOW, directly fosters scope creep.
The implication is clear: scope creep is not merely a managerial oversight but a governance failure rooted in contractual design. Addressing it requires reconceptualizing the SOW as a preventative mechanism, one that explicitly anticipates operational variability and provides mechanisms for structured renegotiation.

5.2 Misalignment Between SOWs and Operational Realities

A second major finding is the disconnect between contractual SOWs and operational realities. Both customers and providers acknowledged that SOWs are often oversimplified during the RFP process, leading to cost models and operating plans that are fundamentally misaligned with actual service requirements.
Providers reported significant challenges when high-level SOWs failed to capture details such as multiple serialization systems or sequencing requirements across thousands of SKUs. This finding resonates with ref. [3], who emphasized the increasing complexity of value-added logistics services, but extends their analysis by showing that contractual simplification during procurement undermines operational feasibility.
Customers justified such simplification on pragmatic grounds: detailed SOWs, they argued, could deter competitive bids or slow down procurement. Yet this cost-driven approach creates structural misalignment from the outset. As one provider explained, "We design our entire model based on the SOW. If it is incomplete, our cost model is flawed from day one." This suggests that procurement practices incentivize under-specification, effectively transferring risk from customers to providers.
The consequences of this misalignment echo ref. [6], who demonstrated the challenges of continuous compliance in automotive supply chains. Whereas Santilli et al. focused on technical processes, this study highlights the contractual blind spot: regulatory and operational complexities are often excluded from SOWs, leaving providers to absorb unexpected burdens.
This finding points to a critical insight: misalignment is not accidental but structurally embedded in outsourcing practices. Remedying it requires reforming procurement approaches to prioritize contractual realism alongside cost competitiveness.

5.3 Theoretical Implications

This study makes three major contributions to theory:

- Contractual Governance as a Relational Determinant: Existing research has treated contracts and relationships as separate domains. This study

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shows they are mutually reinforcing contractual clarity enables trust, while contractual ambiguity undermines it.

SOWs as Dynamic Governance Tools: Traditional views treat contracts as static agreements. This study reconceptualizes SOWs as living governance frameworks that must evolve alongside operational and regulatory variability.

- Reframing Scope Creep: Whereas project management literature views scope creep as a managerial failure, this study reframes it as a contractual design flaw. Scope creep arises not only from execution drift but from contractual under-specification at the outset.

5.4 Practical Implications

The findings also generate actionable insights for practitioners:

- Invest in Detailed SOWs: Customers should draft SOWs that explicitly define operational contingencies, compliance responsibilities, and value-added service complexities.
- Adopt Dynamic SOW Frameworks: SOWs should incorporate renegotiation clauses that allow scope, costs, and metrics to evolve without conflict.
- Balance Cost and Realism in Procurement: Procurement teams should avoid oversimplifying SOWs for competitive advantage, as this creates downstream misalignment.
- Develop Relational Transparency Protocols: Customers and providers should establish formal channels to flag and negotiate scope creep early.
- Share Compliance Responsibility: Compliance should be treated as a shared resource-intensive function, with cost-sharing models explicitly codified in contracts.

5.5 Limitations and Future Research

While the study provides valuable insights, it has several limitations. The qualitative design provides depth but limits generalizability. Future research could employ mixed methods, combining surveys with contract analysis, to test findings across broader populations. The focus on aerospace, automotive, defense, and industrial equipment leaves out consumer-facing industries such as retail or e-commerce, where service complexity and customer expectations differ. Finally, further research should explore technological innovations in contract management, such as digital SOW platforms or AI-assisted drafting, which may offer solutions to ambiguity and rigidity.

The findings demonstrate that dissatisfaction in 3PL partnerships stems not solely from provider performance but from the structural failure of SOWs to govern complexity. Ambiguity fosters scope creep, compliance conflicts, and customer-driven disruptions, while rigidity prevents adaptation. Together, these dynamics erode relational trust. The study thus reframes the SOW as a central governance mechanism, not a peripheral contract formality. By conceptualizing SOWs as living documents, the research advances both theory and practice, offering pathways for designing adaptive, trust-enhancing frameworks capable of sustaining long-term 3PL partnerships.

VI. CONCLUSION

The objective of this study was to examine the role of the Statement of Work (SOW) in shaping customer–provider relationships in Third-Party Logistics (3PL) partnerships within the manufacturing sector. While much of the logistics literature has focused on efficiency, cost reduction, and performance outcomes, this study demonstrates that dissatisfaction in 3PL partnerships often originates in the contractual foundation of the relationship. Through structured interviews with providers and customers across aerospace, automotive, defense, and industrial equipment industries, the research revealed how poorly constructed or static SOWs contribute to scope creep, misalignment, compliance conflicts, and relational breakdown.

6.1 Key Findings

The findings underscore several interrelated challenges. First, scope creep was identified as a pervasive outcome of contractual ambiguity, with customers and providers holding divergent views on whether incremental tasks represented scope expansion or expected flexibility. Second, SOWs were found to be routinely misaligned with operational realities, particularly when drafted in the context of competitive bidding, where oversimplification is incentivized. Third, even well-defined SOWs were destabilized by customer-driven operational changes that were not reflected in contractual amendments, such as reallocating dock space or altering production schedules. Finally, these dynamics had profound relational consequences, eroding trust and creating perception gaps that transformed collaborative partnerships into adversarial relationships.

Collectively, these findings demonstrate that the SOW is not a peripheral technical document but a central governance mechanism that structures both operational processes and relational dynamics.

6.2 Theoretical Contributions

This study makes three important contributions to the literature.

- Contractual Governance as a Relational Determinant: The research demonstrates that contractual clarity directly shapes relational trust, challenging the separation of contracts and relationships in much of the logistics literature. Trust is not simply a product of goodwill but is structurally conditioned by the precision and adaptability of the SOW.
- Reconceptualization of the SOW: The findings advance the understanding of SOWs as living governance tools rather than static agreements. In dynamic manufacturing environments, SOWs must be designed with built-in adaptability to accommodate operational variability, compliance changes, and customer-driven disruptions.

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- Reframing Scope Creep: Scope creep is reframed as a contractual design flaw rather than solely a managerial oversight. It emerges from under-specified or rigid SOWs, which leave room for incremental scope expansion and contested interpretations.

These contributions expand existing scholarship by positioning the SOW at the center of 3PL relationship governance, linking contractual design directly to partnership outcomes.

6.3 Practical Implications

For practitioners, the study highlights the need for greater rigor and adaptability in contract design. Customers must invest in drafting detailed SOWs that explicitly articulate compliance responsibilities, value-added service complexities, and operational contingencies. Procurement teams should resist the tendency to oversimplify SOWs for competitive advantage, as this creates downstream misalignment.

At the same time, SOWs should incorporate dynamic mechanisms that allow scope, costs, and performance metrics to be renegotiated without undermining trust. Relational transparency, such as formal protocols for identifying and addressing scope creep, should be prioritized to prevent disputes from escalating. Finally, compliance should be recognized as a shared responsibility, requiring explicit cost-sharing mechanisms and clear contractual language to avoid relational conflict.

By adopting these practices, both customers and providers can move beyond reactive conflict management toward proactive relationship governance that balances accountability with adaptability.

6.4 Concluding Remarks

The study demonstrates that the Statement of Work is both a technical and relational artifact. When poorly constructed, it creates scope creep, compliance disputes, and relational mistrust. When well designed, it enables alignment, adaptability, and trust. The central message is that the SOW must be treated not as a static contractual formality but as a living governance document, one that evolves alongside the dynamic realities of manufacturing supply chains.

By reframing the SOW in this way, the study contributes to both theory and practice, offering new pathways for strengthening the sustainability of 3PL partnerships. Ultimately, achieving the full potential of outsourcing requires recognizing that contracts and relationships are inseparable, and that clarity, adaptability, and fairness in the SOW are foundational to mutual success.

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Transition Towards Sustainable Environmental Performance of SME Sector in Bangladesh through Green Practices: The Mediating Role of Green Innovation

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Abstract- **Recent studies demonstrate growing awareness of environmental concerns in SMEs. This study explores the role of green practices in enhancing the sustainable environmental performance of SME sector in Bangladesh. Specifically, this research examines how green innovation mediates the relation of green practices and sustainable environmental performance. For research purposes, 403 data were obtained from SME Sector. SmartPLS4 and SPSS have been utilized to analyze the acquired data. PLS-SEM was harnessed to examine the correlation between predictor and predicted variables. The findings of the research clarify that green practices (environmental sustainability strategy, green supply chain management, green human resource management, green information technology) have substantial impact on sustainable environmental performance and green innovation directly impacts as well as mediates the relation between green practices and sustainable environmental performance. This study has meaningful implications for attaining environmental sustainability which may advance our nation to fulfill three SDG goals and achieve economic success.**

Keywords: **Green Practices, Green Innovation, Sustainable Environmental Performance, SME Sector, Environmental Sustainability**

I.INTRODUCTION

In modern era, maximum countries including Bangladesh are concentrating on economical proliferation while understating the environmental improvement. Despite the boons from nature we get, we make distinct harms to nature such as contaminating water or air etc. And nature also responds with floods, droughts etc.[1]. So Bangladesh has some environmental threats and firms should necessarily make themselves prepped to these threats. Pursuing green practices in the firms is pivotal for our country to foster sustainable development and becoming a panoramic economic trajectory [2]. In environmental context, "green" indicates those good-natured practices that facilitate protecting the environment and nurture natural assets. The SME sector can be a fitted sector for pursuing green practices. SMEs are the backbone of economy in emerging countries. SMEs can be portrayed by the employee numbers, operable assets, output sales [3]. SMEs generally contribute to the GDP growth and create employment opportunities. SMEs are significant economic strength in developing countries like Bangladesh, contribute more than 40% of the GDP. SMEs contribution to economic progression is substantial but adverse environmental deterioration straightway impact that economic progression [4]. SMEs impose a direct influence on environment like consuming energy or climate change [5]. [6] stated that the conjunctional distribution of green ideologies can aid in treating the challenges. Now-a-days firms are adopting several steps for improving congruence to attain the landmark of distinctive goals such as environmental and financial goals [7]. Green practices (environmental sustainability strategy, green supply chain management, green human resource management, green IT) aid to boost the sustainable environmental performance of the firm. Furthermore, green innovation can be a crucial strategy for SMEs to acquire a distinctiveness that will guide to long term success [8].

Besides that SMEs stumble to shine because of the definite assets, awareness or conventional thought process. Also many firms are still insouciant about green practices as they are not fully cognizant of this. The EPI (Environmental Performance Index) score of our country is 28.1 out of 100 and as a country we rank 175 out of 180 countries which shows the vulnerable condition of us. These findings accentuate the exigency of enhancing sustainable environmental performance in the firms for environmental sustainability and economic progression. However, the knowledge of green practices and green innovation can solve this problem. The inclusion of green innovation can facilitate sustainable environmental performance of the firms by providing high grade results in form of using water, settlement of the garbage etc. [9]. There are segregated studies which settle sustainable environmental performance by isolated green practices but there are very few studies which incorporate all those green practices together with the mediating role of green innovation. The intention of the study is to acquaint; how to attain environmental sustainability by improving sustainable environmental performance.

This study can amplify environmental knowledge of firm owners as well as employees. Our study can pitch in accomplishing 3 SDGs and they are: Industry, Innovation and Infrastructure (SDG9), Responsible Consumption and Production (SDG12) and also Climate Action (SDG13).

The primary objective of the study is to render an understanding how a firm can enrich sustainable environmental performance through green practices.

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II. LITERATURE REVIEW AND CONCEPTUALIZATION OF CONSTRUCTS

A. Green Practices (GP)

The methods and applications which are implemented by businesses to protect environment can be denoted as green practices [10]. Some firms are aware of the necessity to demote ecological hazards but the progress reacting to the environmental challenge has been made by only few firms. Execution of those environmental strategies that demote ecological hazard can influence firm's overall performance positively [11]. Green Supply Chain Management can be depicted as, assimilation of ecological consideration into supply chain management [12]. Green HRM is one of those notion which transpose HRM exercises into green practices [13]. Higher officials of SMEs require to exercise Green Human Resource Management (GHRM) practices to accomplish environmental sustainability. Green IT is one of the incarnations of green business practices. Green IT practices are implemented to lessen energy usage and gain cost-efficient results [14]. As environment is being declined in our country, incorporating these green practices can enrich sustainable environmental performance.

Environmental Sustainability Strategy (ESS)

Environmental sustainability strategy can be defined as an enterprise's strategic adherence to carry out its business functions in a manner that reduce environmental harm, and foster environmental responsibility. This strategy includes specific functional behaviors, environmental consciousness, and organization's commitment to consolidating sustainability to its principles and long-term goals [3].

Green Supply Chain Management (GSCM)

The strategy that bring about the stream of materials within production chain by diverse stages like procurement, manufacturing, final product promotion to safeguard environment through shielding natural possessions as well as decreasing climate change is Green Supply Chain Management [15]. GSCM can be referred as gush of public along with accountable linkage between suppliers and allies [16].

Green Human Resource Management (GHRM)

Green Human Resource Management (GHRM) denotes incorporation of green principles into HR practices. It encompasses promoting a culture of environmental accountability in the workplace. It can be done by evolving workforces' ecological skills, inspiring active involvement in green practices, and harmonizing HR activities with enterprises sustainable environmental goals [17]. The development of GHRM from HRM can encompass additional facilities such as green competencies, green possibilities.

Green Information Technology (GIT)

[18] illustrated that transmission of electronic waste happens from developed countries to developing countries. GIT is the notion of redesigning IT infrastructure (Energy-efficient IT setups, Cloud Computing etc.) to curb firm's carbon footprint as well as environmental effect [14], [19].

B. Green Innovation (GI)

[20] describes GI as the innovation in technologies related to goods and processes that consists waste recycling, pollution reduction, and energy-efficiency. It is a system of doing things in organization in response of ecological degradation resulting from unethical business operations. GI practices are gaining admiration as a consequence of the interest towards businesses, shareholders as well as environment [21].

C. Sustainable Environmental Performance

Sustainable environmental performance refers to firm's capability to lessen its ecological footprint through environmentally-responsible actions [22]. Sustainable environmental performance of SMEs in Bangladesh are usually assessed through parameters such as emission minimization, pollution mitigation [23]. Bangladeshi SMEs that harmonize their environmental strategies with green practices are likely to show noticeable progress in sustainable environmental performance.

III. THEORETICAL BACKGROUND AND DEVELOPMENT OF HYPOTHESES

A. Theoretical Background

Our study encourages linkage between green practices and sustainable environmental performance of SME sector bolstered by various theoretical framework. One of the vital theory is Resource-Based-View (RBV) [24]. This theory indicates that accession to the firm's resources and abilities has a great magnitude to attain competitive benefits. As SMEs of Bangladesh are mostly relied on natural resources, NRDT theory (Natural Resource Dependency Theory) can be suitable for this study. In our study; we are employing AMO theory (Ability-Motivation-Opportunity) which aid workers by progressing environmental literacy which vouches firm's green goals [25]. [26] proposed the TPB (Theory of Planned Behavior) that addresses the factors which affects the behavior of workers.

B. Green Practices and Sustainable Environmental Performance

Environmental Sustainability Strategy (ESS) considerably improves ecological outcomes by incorporating sustainable practices which affirms a direct positive relationship to minimize waste, emissions, and resource usage [3]. [27] demonstrated that when organizations adopt GSCM practices such as environmental management systems, eco-design, and external collaboration, they achieve greater reductions in emission and waste. This approach equips firms to mitigate ecological footprint. [25] illustrated that green HRM practices positively influence employees eco-friendly behavior, which increases sustainable environmental performance. Green IT deliver better sustainable environmental performance by improving energy efficiency and minimizing emissions through efficient IT system. [19] discovered that GIT has a substantial positive impact on environmental outcomes.

H1: Green practices positively impact sustainable environmental performance of SME sector.

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C. Green Innovation and Sustainable Environmental Performance

Green innovation can benefit the environmental sustainability through modern methods, mechanisms etc. [28] discovered that GI substantially boosts ecological outcome by fostering cleaner manufacturing processes and lowering harmful emissions. GI is increasingly viewed as a strategic driver of both sustainability and efficiency.

H2: Green innovation positively impacts sustainable environmental performance of SME sector.

D. Mediating Effect of Green Innovation

Environmental sustainability strategy (ESS) delivers a comprehensive framework that leads organizational efforts toward environmental responsibility. [29] illustrated that this GI may serve as the mediator by which ESS contributes on sustainable environmental performance. [30] stated that GI considerably mediates the relationship between GSCM and sustainable environmental performance. [28] stated that GI acts as an instrumental channel through which GHRM improves enterprises ecological performance. Several studies found that GIT foster real-time data collection, process optimization, and innovation in resource consumption [31]. Thus, GIT may stimulate sustainable environmental performance by mediating GI. Therefore, the following hypothesis has been proposed:

H3: Green innovation mediates the relationship between green practices and sustainable environmental performance of SME sector.

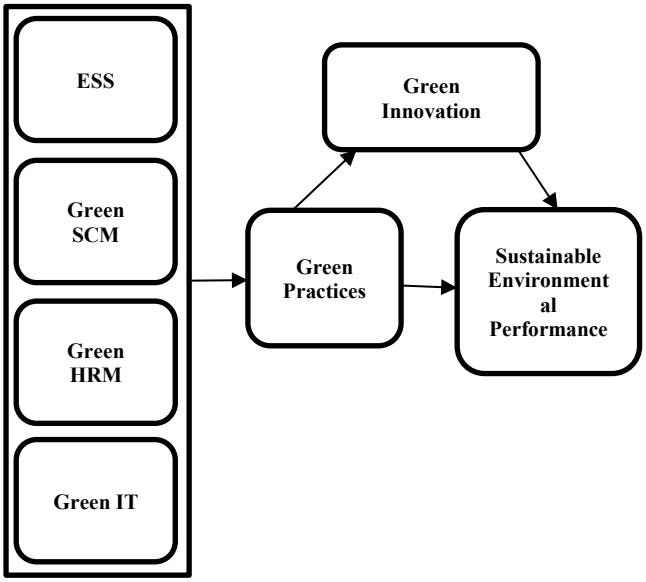


Fig. 1. Conceptual Framework (Source(s): Authors' own work)

IV. RESEARCH METHODOLOGY

A. Data Sampling

In order to get authentic perception of the study, people associated with different types of SMEs were selected as study's sample frame. Questionnaires has been disseminated amid respondents to utilize non-probability purposive sampling technique. [32] stated 10 times rule. For our study, we harnessed 32 items; so our sample size should not be less than 320. From the SME sector, we managed 403 data that considers adequate grounded on the settled rule.

B. Measurement Instrument

A structured survey questionnaire was used to measure items on a 5-point Likert scale ranging from "1= strongly disagree" to "5= strongly agree. In order to evaluate ESS, GSCM, GHRM 5 items were chosen from prior studies [3], [9]. To evaluate GIT, 5 items were chosen from prior studies [14]. Furthermore, to evaluate the mediating construct, GI and outcome construct, SEP, 6 items were chosen from prior studies [3], [33].

C. Data Analysis Techniques

The survey data was analyzed with the aid of statistical tools: SmartPLS4 and SPSS25. In order to transform data into analysis-ready besides descriptive statistics construction, SPSS has been considered. PLS-SEM has been used to estimate and analyze the credibility as well as reliability of the hypothesized relationships between independent and dependent variables. Data analysis part is divided into two steps: measurement model (to assess credibility and reliability of constructs), structural model (to test hypotheses).

V. DATA ANALYSIS AND RESULTS

A. Respondent's profile

Basic information was collected from 403 respondents. Major respondents (47.9%) belong to the age group (25-34). Male (66.5%) are nearly two times higher than female ones (33.5%). Most of the respondents have completed their graduation (31%), the second highest educational qualification is post-graduation (26.3%). In this study, major responses have come from people working in different SMEs including job holders (38.5%);service sector of SME (27.8%) ; business (24.1%); students (with part-time job/business) (9.7%). Out of all respondents, majority of respondents have more than 6 years of working experience (24.8%) in SME sector of Bangladesh.

B. Measurement Model for First-Order Constructs

Item Loading, Composite Reliability, and Convergent Validity

Table 1 displays the factor loadings, where the loading values are adequate for representing the respective constructs. To establish the construct reliability and convergent validity, several statistical measures were performed, including factors loadings, composite reliability (CR), and average variance extract (AVE). Since the AVE values for all the measurement constructs used in this study transcend 0.50 threshold, the constructs illustrate sufficient convergent validity [34], [35]. The CR values for the constructs in this study, ranging from 0.818 to 0.862, are well above the baseline of 0.70, as recommended by [34]. This reflects that each latent construct is consistently represented by its corresponding measurement items.

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TABLE 1
ITEM LOADING VALUE, COMPOSITE RELIABILITY AND CONVERGENT VALIDITY

Constructs	Items	Loading Value	CR	AVE
Environmental Sustainability Strategy	ESS1	0.789	0.862	0.610
	ESS2	0.759		
	ESS3	0.822		
	ESS5	0.753		
Green SCM	GSCM1	0.753	0.830	0.550
	GSCM2	0.716		
	GSCM3	0.764		
	GSCM5	0.732		
Green HRM	GHRM1	0.721	0.818	0.601
	GHRM2	0.827		
	GHRM4	0.775		
Green IT	GIT3	0.756	0.828	0.617
	GIT4	0.800		
	GIT5	0.800		
Green Innovation	GI1	0.751	0.856	0.597
	GI2	0.760		
	GI3	0.815		
	GI4	0.763		
Sustainable Environmental Performance of SME	EP2	0.769	0.853	0.592
	EP3	0.799		
	EP4	0.771		
	EP6	0.737		

Source(s): Authors' own work

Discriminant Validity

Following the evaluation of the convergent validity and reliability, the discriminant validity of the constructs was assessed. Discriminant validity examines the extent to which the constructs in the study are distinct from one another. The study executed the HTMT ratio (Table 2), which is regarded as a more comprehensive method for measuring the discriminant validity [35]. In order to achieve HTMT values below the recommended threshold 0.90, as suggested by [36]. Following this adjustment, the HTMT ratios for all measurement variables in the study were found to be below the recommended threshold of 0.90, it can be determined that the constructs demonstrate sufficient discriminant validity.

TABLE 2
HETEROTRAIT-MONOTRAIT (HTMT) RATIO

	ESS	GSCM	GHRM	GIT	GI	EP
ESS						
GSCM	0.774					
GHRM	0.695	0.871				
GIT	0.745	0.776	0.819			
GI	0.686	0.738	0.740	0.746		
EP	0.710	0.645	0.641	0.743	0.725	

Source(s): Authors' own work

Measurement Model for Second-Order Constructs

Composite Reliability and Convergent Validity

The second order construct, like the first order constructs, satisfies the requirements for convergent validity and reliability. Table 3 reflects that the CR value of 0.890 and AVE of 0.669 both surpass the acceptable thresholds, thereby affirming the construct's validity.

TABLE 3
COMPOSITE RELIABILITY AND CONVERGENT VALIDITY

	CR	AVE
GP	0.890	0.669

Source(s): Authors' own work

Discriminant Validity

Furthermore, the results displayed in Table 4 shows that the discriminant validity of GP fulfill the required threshold, affirming its adequacy as a higher order construct within the structural model.

TABLE 4
HETEROTRAIT-MONOTRAIT (HTMT) RATIO

	GP	GI	EP
GP			
GI	0.826		
EP	0.778	0.725	

Source(s): Authors' own work

Explanatory Power of the model

The R^2 value, or the coefficient of determination, expresses the proportion of variance in the endogenous variables that is considered by the exogenous variables in the model.[35] stated that R^2 values of 0.75, 0.50, and 0.25 point to substantial, moderate, and weak levels of predictive power, respectively. In the current study, the model generates an R^2 value of 0.438, indicating that GP with GI as a mediator, explain 43.8% of the variance in EP. This indicates a moderate level explanatory power of the model.

C. Structural Model

Results of Direct Path Analysis

A structural model was developed based on the relationships outlined in the research framework of this study. The relationships between the exogenous and endogenous variables were examined through the path coefficients (β), T statistics, and *p* values. The significance of *p*-value influences whether the authors' proposed hypotheses are accepted or rejected. The hypotheses were tested at a significant level of $p < 0.05$. The findings show that all the hypotheses are statistically significant. H1 (GP → EP) exhibit a significant positive relationship between GP and EP, with $\beta = 0.452$, $t = 5.914$, and $p < .01$. Again, H2 (GI → EP) with $\beta = 0.268$, $t = 3.356$, and $p < .01$ reveals GI is positively related to EP and the result is statistically significant at $p < 0.01$ (Table 5).

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TABLE 5
RESULTS OF DIRECT PATH ANALYSIS

Path	β	SD	T statistics	*p* values	Results
H1: GP → EP	0.452	0.076	5.914	0.000	Accepted
H2: GI → EP	0.268	0.080	3.356	0.001	Accepted

Source(s): Authors' own work

Results of Indirect Path Analysis

The mediating role of GI was evaluated by analyzing the specific indirect effects within the model. The analysis examined whether GI acts as a mediator in the relationship between GP and EP. The results related to H3 (GP → GI → EP; β = 0.179, $t = 3.105$, $p < .01$) substantiate that GI plays a significant mediating role in the relationship between GP and EP. This indicates that GP enhances EP not only through a direct path but also indirectly via its positive impact on GI, which in turn contributes to EP (Table 6).

TABLE 6
RESULTS OF SPECIFIC INDIRECT EFFECT

Path	β	SD	T statistics	*p* value	Result
H3: GP → GI → EP	0.179	0.058	3.105	0.002	Accepted

Source(s): Authors' own work

VI. DISCUSSION

Extensive studies on segregated green practices (ESS,GSCM,GHRM,GIT) yield eclectic findings on sustainable environmental performance and miss to encompass a comprehensive outlook. Our findings portray that, the unification of GP is a combined competency and the influence on sustainable environmental performance is more grasped when distinct elements of GP are considered as a single construct. Intermingling of distinct environmental actions expand more value which surpass the total value acquired from cultivating these actions individually [27]. This study probes the mechanism that SME sector can thrive sustainable environmental performance through GP. In H1; we can see that, there is a positive correlation between GP and EP (β value= 0.452, *p* value= 0.000). As per our findings; if a firm prefers interconnection of all the environmental actions, they can attain robust advantages which may steer them to economic success as well as attainment of SDG 12.

Regarding H2, GI favorably impacts EP (β value= 0.268, *p* value= 0.001). GI statistically impacts sustainable environmental performance significantly [6]. Businesses which concentrate on GI can secure sustainable environmental performance and motivate customers. If GI gets encouraged; industry will be facilitated by technological enhancement and environmental infrastructure which aligns with SDG 9.

The study also ascertains that GI can be a vital mediator between GP and EP. According to H3, it can be stated that GI positively mediates the relation between GP and EP of SME sector (β value = 0.179, *p* value = 0.002). This result is corresponding to previous result whereas GI works as a perfect mediator between GSCM, GHRM and environmental performance [28], [37]. Green practices with the mediation of GI can downsize emissions like depleting carbon footprint which correspond to climate action mollification (SDG 13).

6.1 IMPLICATIONS

A. Practical Implications

This study highlights incorporating green practices for long term success of organizations. Embracing green practices, an organization can be more efficient in attaining sustainability. According to our research findings, assimilating environmental sustainability strategy to organizational objectives can enrich firm's performance significantly. If SMEs want to do the part for environment, they can adopt GSCM practices such as environmental packaging, reducing use of hazardous materials etc. So it's essential to enrich employee's productivity beside environmental activities. Our findings points that, the higher the firm modernizes their effort and search out green services, the higher GIT gets executed in the firm. In addition, a GI-based strategy can significantly increase sustainable performance. Integration of GI as a mediator positively ameliorates sustainable environmental performance by linking green practices. Firms may get advantage from this holistic approach.

B. Policy Implications

The authority should make policies to accomplish organizational objectives. As in the research, the main objective is enhancing sustainable environmental performance to attain environmental sustainability, thus the policies should be made by policy makers like this way; how they can lessen waste, deplete pollution etc. Adopting these policies will help to enrich the reputation of the firm. Government should be aware and take steps so that the sustainable environmental performance gets assured in the SMEs.

VII.CONCLUSION

From our study, the correlation between green practices and sustainable environmental performance is very strong and green innovation positively mediates the relation between them. By adopting multifaceted green strategies which includes all these elements, SME sector of Bangladesh may be capable of building more vigorous and more eco-friendly stand for success which will elevate global market attraction and also local business credibility.

7.1 LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

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In spite of the contribution and implications, this study contains some limitation which can be completed in future studies. Firstly, this study obtained data from SME sector in Bangladesh. As SME sector is a vast sector, it wasn't possible to cover all the SMEs. Also this research didn't ascribe other probable mediators which enriches sustainable environmental performance such as green capability. Researchers will be facilitated by more knowledge of the interrelated nature of the green practices and sustainability performance and firms will get benefit to become more environmentally aware.

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What Makes a Brand "Sustainable" in the Eyes of Young Consumers?

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Abstract- **This study develops a conceptual framework to understand how young people perceive sustainability in branding from cultural, symbolic, and trust perspectives. This research demonstrates how cultural identification, emotional involvement, and authenticity impact young customers' perceptions of sustainable companies, in contrast to traditional financial and marketing studies that focus on behavioral or rational factors. Using qualitative observations, the study makes a series of theoretical proposals based on Consumer Culture Theory, Signaling Theory, Brand Authenticity, and Symbolic Interactionism. According to the paradigm, views of sustainability are influenced by cultural norms and symbolic meanings, while credibility and authenticity promote long-term involvement and trust. Both theoretical and practical contributions are made, broadening the body of knowledge on branding and consumer behavior beyond cognitive models and providing guidance for institutions, marketers, and legislators who want to create long-lasting tactics that appeal to young people.**

Keywords: ***Sustainability in Branding, Cultural Identification, Brand Authenticity, Symbolic Interactionism, Youth Consumer Behavior***

I. INTRODUCTION

Climate crisis, social inequality, and ethical consumerism have contributed to a growing emphasis on sustainability in modern branding. Companies worldwide are repositioning their brand identities to appeal to a generation of consumers who prioritize ethical values. In Bangladesh, the Gen Z demographic (aged 18–25) represents an influential and value-driven consumer segment. Yet, sustainability remains a vague and contested term—especially in the marketing context.

This proposed study will investigate how young Bangladeshi consumers make sense of "sustainable brands." Moving beyond the rational and utilitarian understanding of brand attributes, this research will highlight how youth construct sustainability through emotional, symbolic, and social interactions. The aim is to develop a theory-informed conceptual model that guides future branding efforts and deepens academic insight.

II. LITERATURE REVIEW

Four theoretical stances—Consumer Culture Theory, Signaling Theory, Brand Authenticity, and Symbolic Interactionism—are combined to organize the literature review. Each offers a different perspective on how young people engage with sustainable companies as cultural consumers, credibility assessors, searchers of genuine alignment, and social actors creating meaning with their peers. These theoretical underpinnings are given in Table 1, which also emphasizes how relevant they are to the current investigation.

Table 1. Theoretical Foundation of the Study

Theory	Core Concept	Relevance to Study
Consumer Culture Theory (Arnould & Thompson, 2005)	Consumption is socially constructed	Youth perceptions of sustainability as cultural values
Signaling Theory (Connelly et al., 2011)	Brands communicate credibility through signals	Eco-labels, CSR reports, and transparency signals
Brand Authenticity (Napoli et al., 2014)	Alignment of values and consistent brand behavior	Authenticity of sustainability claims
Symbolic Interactionism (Blumer, 1969)	Meaning is socially created and validated	Peer influence and symbolic meaning of sustainable brands

2.1 Theoretical Grounding

Consumer Culture Theory (CCT): According to [2], CCT emphasizes that consumer behavior is socially constructed. Youth interpret branding messages through their identities, cultural narratives, and peer communities. As such, sustainable brands come to be about values and a way of life.

Signaling Theory: According to [9] signaling theory states that consumers are able to derive quality attributes of brands based on signals that can be traced. On sustainability grounds, this can be eco-labels, ethical approvals, or open sourcing. The young consumers tend to distrust these cues to see whether they are friendly or only pretending.

Brand Authenticity Theory: According [7] authentic brands allude to honesty, consistency, and congruency with consumer values. To young people, a sustainable brand has to exhibit a sense of continuity between environmental statements and activities.

[6]. According to him, a person generates meaning through social interactions. For Gen Z, sustainability may symbolize social consciousness, modernity, or ethical superiority—constructed through conversations, digital media, and peer validation.

2.2 Empirical Literature Insights: Youth–Brand Relationships in South Asia

[5] revealed that Bangladeshi youth consider sustainability to include not just environmental but also social justice concerns. [12] found that Indian youth define brand sustainability in terms of emotional resonance and perceived authenticity. [9] highlighted that UK students link sustainability to personal identity and community belonging.

These findings highlight a shift from functional to symbolic branding, emphasizing the need for cultural relevance and emotional depth in sustainability narratives.

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III. METHODOLOGY

In an attempt to develop a framework, this paper uses a conceptual qualitative methodology, collating available theoretical and empirical knowledge. A scholarly review of the literature on consumer culture, signaling, authenticity, and symbolic interaction furnishes the grounds used in coming up with propositions that expound on how youngsters perceive sustainability in branding. The method is based on a theory constructed by synthesis, in which trends and regularities in previous studies are examined with a view to establishing conceptual connections. It is the nature of the methodology to locate sustainability as an economic, environmental, cultural, as well as a symbolic construct and, therefore, create a comprehensive model of youth-driven brand interpretation. This is consistent with a conceptual research tradition within the marketing and consumer behavior literature, in which inquiry has been biased toward developing theory rather than testing it.

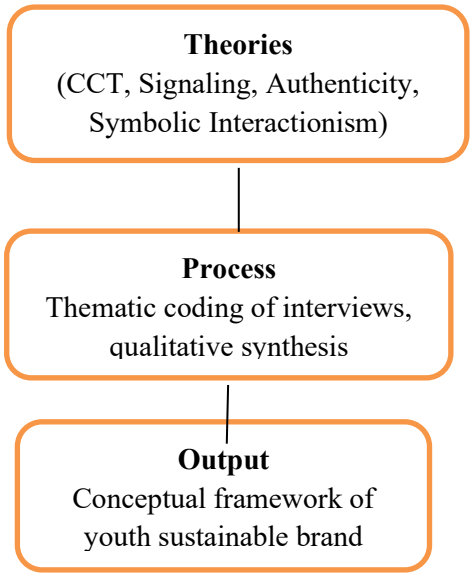


Figure 1: Conceptual Research Design

IV. CONCEPTUAL FRAMEWORK AND PROPOSITIONS

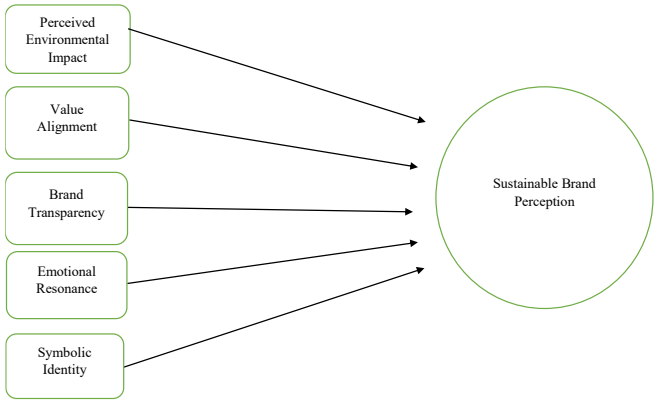


Figure 2: Conceptual Framework of Sustainable Brand Perception among Youth

This framework proposes five thematic domains:
1. Perceived Environmental Impact: Young consumers assess if a brand reduces harm (e.g., plastic-free packaging, ethical sourcing).
2. Value Alignment: Brands that mirror the personal or collective values of youth (e.g., gender equality, fair trade) are more trusted.
3. Brand Transparency: Clear, accessible information about sustainability practices fosters credibility.
4. Emotional Resonance: Stories that emotionally engage consumers (e.g., campaigns about climate justice) create lasting brand bonds.
5. Symbolic Identity: Brands become identity tools, symbolizing moral positioning or social status.

Proposition	Statement
P1	Higher perceived environmental impact is likely to enhance brand credibility.
P2	Value alignment is likely to positively influence emotional engagement.
P3	Brand transparency is likely to reduce greenwashing skepticism.
P4	Emotional resonance is expected to lead to brand advocacy and loyalty.
P5	Symbolic identity may drive peer endorsement and brand pride.

4.1 Proposition Development and Theoretical Justification

Consumer Culture Theory [9], Signaling Theory [8] Brand Authenticity Theory [10], and Symbolic Interactionism (Blumer, 1969) provide a solid theoretical basis for the suggested paradigm. These viewpoints highlight how young customers interpret sustainability in branding via social, psychological, and symbolic processes. Meanings in consumer culture are co-created via peer validation, identity expression, and cultural standards rather than being innate to items.

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Communication about sustainability, such as eco-labels or CSR disclosures, serves as a signal of legitimacy, according to signaling theory. However, signals are only effective if they are congruent with brand behavior and values, as the Brand Authenticity Theory emphasizes. If not, customers could think they're greenwashing. From a symbolic standpoint, adolescents support sustainability claims by relying on shared meanings among social networks and peer groups.

Therefore, it is envisaged that young consumers would evaluate businesses not only on ecological results but also on symbolic fit with their cultural values and identity. According to consumer culture theory, sustainability is more than simply a practical quality; it is a cultural and emotional construct. This perception is often influenced by family values, peer pressure, and group affiliation in collectivist countries like Bangladesh [29].

Perceptions of sustainability are therefore incorporated into larger emotional and cultural systems. If a clothing brand communicates ethical sourcing in a credible manner, a young person may see it as sustainable; however, this impression is reinforced if the brand aligns with the values of authenticity, justice, and identity expression in the youth's social circle.

The following claims are put forward in light of this reasoning:

Proposition 1: Young customers' perceptions of environmental effect have a beneficial impact on the legitimacy of sustainable companies.

Proposition 2: Emotional involvement with sustainable companies is favorably impacted by value congruence between company actions and young values.

Proposition 3: Brand openness improves perceived authenticity and lessens mistrust about greenwashing.

Proposition 4: Brand advocacy and loyalty to sustainable businesses are favorably impacted by emotional resonance.

Proposition 5: Youth pride in sustainable businesses and peer endorsement are favorably influenced by symbolic identity.

Table 2

Propositions	Theoretical Validations
P1: Perceived environmental impact positively influences the credibility of sustainable brands.	Signaling Theory (Connelly et al., 2011) suggests that eco-labels, certifications, and CSR reports act as credibility signals. CCT highlights how young consumers connect environmental actions with cultural values.
P2: Value alignment between brand practices and youth values positively influences emotional engagement.	Brand Authenticity Theory (Napoli et al., 2014) stresses consistency between brand values and consumer expectations. Hofstede's (1984) cultural dimensions emphasize collectivist value-sharing.
P3: Brand transparency reduces skepticism of greenwashing and strengthens authenticity.	Authenticity Theory (Beverland & Farrelly, 2010) highlights transparency as essential for trust. Symbolic Interactionism shows that peer validation of transparency reinforces credibility.
P4: Emotional resonance influences brand advocacy and loyalty.	Consumer Culture Theory frames brand love and advocacy as emotionally co-created. Thomas et al. (2024) find youth identity construction tied to emotional storytelling in sustainability.
P5: Symbolic identity drives peer endorsement and brand pride.	Symbolic Interactionism (Blumer, 1969) shows that meaning is socially validated. Peer groups amplify the symbolic identity of sustainable brands, shaping youth consumer pride.

V. CONTRIBUTIONS TO THEORY AND PRACTICE

5.1 Theoretical Contributions

This study suggests a qualitative method that incorporates symbolic, emotional, and cultural elements to comprehend how young customers see sustainability in branding. This research emphasizes the subjective, experience-driven character of teenage brand perceptions, while the majority of branding and sustainability literature has concentrated on quantitative surveys or consumer attitude scales [20].

Conventional branding theories, particularly those based on utilitarian value frameworks or rational choice, imply that consumers evaluate sustainability claims by cognitively evaluating eco-performance or corporate social responsibility disclosures [21] These viewpoints could be relevant for official marketing messages, but they don't account for the identity-driven, symbolic, and peer-validated processes that young consumers use to give sustainable brands significance.

The paradigm proves the Consumer Culture Theory [23] since, according to the researchers, the brand preferences of young people cannot be separated as one of their individual choices but as an element of social identities and cultural stories, and peer culture. It extends the notion of Brand Authenticity Theory [25],[28] by suggesting that authenticity can be achieved when sustainability initiatives by a brand do not contradict individual and collective values among the youth.

Furthermore, by presenting sustainable brands as symbolic identity markers that are approved by peer networks, this study enhances Symbolic Interactionism [5]. Young consumers negotiate and co-create these meanings socially rather than just evaluating sustainability claims on an individual basis. Lastly, the Signaling Theory [7] is expanded upon by highlighting the fact that sustainability signals are only successful when backed by open, reliable procedures that lessen suspicion of greenwashing.

In order to bridge symbolic, cultural, and emotional viewpoints into sustainability and branding theory, this study suggests a qualitative sustainability perception model that positions young consumers as meaning-makers (Table 2).

Table 3. Theoretical Contributions of the Proposed Study

Theoretical Lens	Key Focus	Contribution to Sustainable Branding Theory
Consumer Culture Theory (Arnould & Thompson, 2005)	Cultural identity & co-created meanings	Expands CCT by showing sustainability as a youth-driven cultural narrative shaped by peers and values.
Brand Authenticity	Consistency between values & brand behavior	Demonstrates how authenticity in sustainability depends on

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Theory (Napoli et al., 2014)		alignment with youth expectations, not only CSR disclosures.
Symbolic Interactionism (Blumer, 1969)	Social validation of meaning	Frames sustainable brands as identity symbols co-constructed in youth peer groups.
Signaling Theory (Connelly et al., 2011)	Communication signals (labels, CSR)	Extends signaling by emphasizing credibility only when transparency reduces greenwashing skepticism.
Qualitative Branding Approach	Subjective experiences & lived meanings	Humanizes sustainability branding by incorporating emotional resonance, cultural alignment, and symbolic identity.

Table 4. Practical Implications

Stakeholder	Key Implication	Strategic Action
Marketers	Build authenticity and credibility in sustainable brand communication	• Use transparent campaigns showing measurable environmental/social impact. • Avoid "greenwashing" by aligning actions with claims. • Develop emotionally resonant storytelling around sustainability achievements. • Build long-term youth engagement through interactive campaigns and digital communities.
Policymakers	Strengthen regulatory and institutional trust in sustainability	• Standardize eco-labeling to reduce confusion among young consumers. • Regulate misleading environmental claims to counter greenwashing. • Support youth-focused sustainability awareness campaigns. • Create incentives for businesses to adopt transparent, verifiable sustainability practices.
NGOs & Educators	Enhance youth literacy on sustainability and empower critical consumption	• Integrate sustainability evaluation skills into school/university curricula. • Partner with student organizations to promote peer-to-peer awareness campaigns. • Develop workshops that highlight authentic vs. symbolic sustainability practices. • Encourage youth-led sustainability initiatives to strengthen ownership and advocacy.
Businesses	Embed sustainability as a core brand identity rather than a peripheral feature	• Integrate sustainability into supply chains, sourcing, and production transparency. • Position sustainability as part of brand purpose, not as an add-on CSR activity. • Highlight how sustainable products connect with cultural and generational values (e.g., fairness, inclusivity, activism). • Collaborate with youth influencers and communities to co-create sustainability narratives.
Future Researchers	Extend sustainability branding research with qualitative depth	• Conduct cross-cultural studies on how young consumers in different societies interpret sustainability claims. • Explore the emotional and symbolic meanings young consumers attach to sustainable brands. • Use ethnographic and ethnographic methods to capture youth online communities in shaping sustainability perceptions.

5.1 Limitations and Future Research Directions

Despite its noteworthy achievements, this study has many drawbacks. A conceptual and qualitative investigation of young consumers' definitions and interpretations of sustainable branding is provided by the suggested framework. However, the claims remain theoretical and interpretative rather than generalizable due to the lack of empirical testing. Thus, additional empirical studies are necessary to confirm these results in real market conditions as well as in different socioeconomic and cross-cultural contexts [13].

The second weakness has to do with the focus of young viewers. Whereas this is particularly noteworthy today as the Millennials and Generation Z take up an increasingly disproportionate share of the commercial and cultural sphere, it does not imply the views held by other age groups, who may feel quite differently about the concept of sustainability. Sustainability is connected to identity, activism, or symbolic meaning more often than to cost, utility, or institutional trust in younger consumers, but it can also be more important to older customers [15]. In this way, future studies could compare the opinions of, amongst others, people of different ages and discuss how priorities and meaning alter as people grow older.

Also, the framework presupposes that those young consumers are culturally homogenous, whereas, in reality, the opinions on sustainability depend on numerous cultural traditions, social expectations, and the degree to which the institutions can be credibly [12]. Sustainable businesses can be socially endorsed through the influence of peers and institutional affiliations among collectivist communities, but individual ethical conviction can be more effective when doing so in individualist countries [4].

Therefore, a comparative cross-cultural study will provide important insights into how sustainability beliefs are culturally unique versus universal.

Another drawback is the possibility of symbolic sustainability, which is the term used to describe the practice of businesses presenting sustainability narratives without actual sustainability activities [17] While this study highlights the importance of authenticity, it does not yet empirically assess how young consumers detect and respond to symbolic versus authentic sustainability efforts. Therefore, future studies may look more closely at teenage skepticism and how it can both encourage and hinder genuine marketing practices.

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Lastly, although the framework emphasizes the significance of cultural narratives and symbolic meaning, future research might broaden the model by embracing technology impacts, including influencer culture, digital transparency platforms, and social media activism. Tracing how online communities mold young sustainability narratives and transform individual perspectives into collective cultural movements may be especially beneficial for ethnographic and ethnographic research [10].

To sum up, further studies are supposed to test these results, extend the cultural coverage, and incorporate a technical and intergenerational level, although the current work has contributed to a conceptual framework to comprehend sustainable branding as viewed through the lenses of young customers. These initiatives can not only raise theoretical rigor but also provide practical knowledge of how to establish authentic brand practices that can be made sustainable over the long term.

VI. CONCLUSION

With an emphasis on cultural, emotional, and symbolic aspects rather than just logical or financial considerations, this study presents a conceptual framework for understanding how young people see sustainability in branding. The research emphasizes how young consumers understand sustainability via collective values, symbolic meaning, and the authenticity of brand behavior by combining Consumer Culture Theory, Signaling Theory, Brand Authenticity, and Symbolic Interactionism. The following five claims are put forward to explain how cultural norms promote trust, trust strengthens emotional resilience, resilience influences preferences for non-traditional or informal systems, and these preferences in turn promote brand-related and adaptable financial tactics.

The research makes a theoretical contribution by expanding behavioral and consumer culture frameworks to include cultural identification and emotional resilience as key decision-making factors. It reframes informal and symbolic behaviors as valid, trust-based organizations that impact long-term involvement rather than as departures from formal systems. In practice, the results indicate that rather than enforcing universal models of literacy or access, inclusive branding and finance strategies should take into consideration the ambitions, cultural customs, and emotional triggers of young people. By incorporating cultural significance and authenticity into sustainable goods and campaigns, institutions, legislators, and marketers may increase adoption, cultivate trust, and cultivate loyalty.

To sum up, further studies are supposed to test these results, extend the cultural coverage, and incorporate a technical and intergenerational level, although the current work has contributed to a conceptual framework to comprehend sustainable branding as viewed through the lenses of young customers. These initiatives can not only raise theoretical rigor but also provide practical knowledge of how to establish authentic brand practices that can be made sustainable over the long term.

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Connecting Tourism and Economic Growth: Rethinking Bangladesh Through AI-Powered Sustainable Tourism

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Abstract: **Tourism in Bangladesh has significant potential to improve environmental sustainability, promote cultural preservation, and stimulate economic growth. This study examines how artificial intelligence (AI) can transform the sustainable tourism and hospitality industry in Bangladesh. Using a quantitative approach, the research analyzes tourism revenue from 1995 to 2021, with tourism revenue as the independent variable and GDP per capita as the dependent variable. The results indicate a positive correlation between tourist revenue and GDP per capita, suggesting a beneficial impact on economic growth. Additionally, the Johansen Cointegration method confirms a long-term relationship between these variables. Despite this potential, the industry faces several challenges, including inadequate infrastructure, limited promotion, safety concerns, and issues related to airlines. To address these challenges and promote economic sustainability, the government should implement targeted policies. This study offers recommendations that aim to strike a balance between economic growth, environmental protection, and social responsibility, with a focus on community benefits and cultural preservation.**

Keywords: **Artificial Intelligence, economic growth, gross domestic product, sustainable tourism, tourism revenue, tourists**

I.INTRODUCTION

The tourism industry in Bangladesh plays a vital role in boosting the country's economic growth. It has been a major source of foreign currency. It offers tourists a variety of sights, stunning landscapes, friendly local communities, and mild weather while also ensuring their safety and security [1]. The industry's economic importance is clear in its contribution of 3.02% to the nation's GDP and its role in accounting for 8.07% of total employment in Bangladesh [2]. The growth potential is further highlighted by Bangladesh's rich natural attractions, diverse cultural experiences, and many historical sites [3]. The tourism industry has seen significant growth, with more visitors from both domestic and international sources [4]. Therefore, including top tourist destinations and resources is essential for expanding tourism in Bangladesh. These attractions provide a unique chance to showcase the country's untapped potential to visitors worldwide [5]. Effective tourism management strategies can lead to positive environmental effects, help preserve cultural heritage, and promote cultural exchange [6]. The tourism sector is not only a key economic driver but also a facilitator of cultural exchange and global understanding [7],[8],[9],[10].

The study aims to demonstrate the following objectives, with practical implications for the real-world issues of sustainable tourism in Bangladesh:

- To assess the connection between tourism and economic growth in Bangladesh.
- To examine how sustainability practices impact long-term tourism growth.
- To explore how AI applications, such as smart tourism (e.g., AI-powered virtual tour guides), predictive models (e.g., forecasting tourist influx based on historical data), and data-driven marketing (e.g., personalized marketing strategies based on tourist preferences), can enhance sustainable tourism.
- To create a framework connecting AI-driven sustainable tourism and economic growth in Bangladesh.

This study is timely because sustainable development strategies, which aim to promote economic growth while minimizing environmental impacts, are gaining importance. Historically, tourism growth has closely followed economic prosperity, with GDP serving as a reliable indicator of a destination's financial health and its ability to attract tourists [11], [12].

Relationship between GDP and Tourism Growth

The relationship between economic growth and tourism has been extensively studied across different regions, consistently showing patterns of interaction between international tourism and economic performance. Research indicates that global uncertainties, especially economic and political instability, negatively affect tourism demand [13]. Notably, Antonakakis, Dragouni, Eeckels, and Filis [14] and Fawaz, Rahnama, and Stout [15] have identified a strong connection between tourism and economic growth that goes beyond differences in political systems, economic conditions, and the development of the tourism industry across countries. Their findings underscore the significant role of tourism in driving economic growth. The link between GDP and tourism growth is also affected by economic cycles, with varying results during periods of expansion and recession. For example, while tourism specialization might lessen some positive growth effects, higher tourism receipts generally support economic growth [16]. The degree to which tourism impacts local income levels often depends on a country's stage of development and infrastructure capacity [17].

Can and Gozgor [18] introduce a market diversification index showing how diverse tourism arrivals positively influence economic growth. Panagiotou and Katrakilidis

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[19] emphasize the complexity of the tourism-economic growth relationship, considering factors such as tourism specialization, globalization, and financial complexity. Antonakakis, Dragouni, Eeckels, and Filis [14] discovered that tourism-driven growth is particularly significant in developing, nondemocratic countries with low tourism specialization, highlighting the potential of tourism to drive economic growth in these regions. In contrast, bidirectional growth dynamics are more evident in democratic nations with high governance effectiveness. Additionally, Figini and Patuelli [20] and Badulescu, A., Badulescu, D., Simut, and Dzitac [21] analyze the long-term contributions of tourism to GDP, employment, and value added in EU countries, further highlighting the economic importance of tourism.

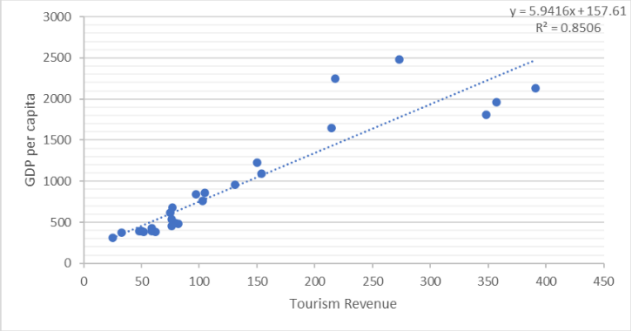


Fig 1 Relationship between GDP per capita and Tourism Growth

Source: Author's generation

Travel and tourism contributed BDT 809.6 billion, or 4.7% of the country's GDP, to the GDP of Bangladesh overall. By 2026, it is expected to have grown by 6.4% a year to BDT 1,596.0 billion, or 5% of the GDP [22]. Bangladesh must concentrate on developing new tourism industries to draw both local and foreign tourists in order to sustain this development rate, though, because traditional historical, cultural, and natural attractions are fiercely competitive in the global tourism market. Figure 1 shows a scatterplot that indicates a positive relationship between economic growth and tourism growth (revenue) in Bangladesh. The correlation r is 0.92.

Relationship between AI adoption and Tourism Growth

AI refers to the simulation of human intelligence processes by machines, especially computer systems, which can perform tasks that typically require human intelligence, such as problem-solving, decision-making, and learning [23], [24]. The adoption of AI in the tourism industry marks a significant shift, enabling more personalized, efficient, and environmentally friendly experiences. This transformation is well-documented in the literature. For example, Huang, Ozturk, Zhang, de la Mora Velasco, and Haney [25] and Ku and Chen [26] highlight the significant impact of AI on both economic outcomes and customer satisfaction in the tourism industry. Furthermore, as noted by Ansari et al. [27], AI reduces operational costs and helps develop new business models, making this a transformative period for the industry. AI has the potential to transform the industry from traditional to innovative tourism, meeting the demands of modern travelers for more customized and sustainable travel experiences [28].

Moreover, AI technologies, from chatbots to predictive analytics and personalized travel solutions, are essential in improving customer service by meeting individual needs and promoting sustainability through adaptable practices. Consequently, tourist satisfaction is notably enhanced [27]. This development highlights AI's widespread influence in both digital and real-world interactions within the tourism industry. Beyond virtual exchanges, AI also plays a key role in strengthening digital connectivity during face-to-face experiences, thereby enriching the hospitality environment. For example, [29] argues that AI is crucial for enhancing service standards, streamlining operations, and tailoring travel experiences. This integration of technology and tourism has transformed the industry, making AI a major driver of growth [30]. As AI capabilities grow, smart tourism—focused on personalized experiences and operational efficiency—has increasing potential [31]. However, despite its benefits, AI implementation also presents challenges. Stakeholders must carefully balance technological advances with maintaining human interaction in tourism [32]. As [28] notes, ongoing developments in AI and related technologies are likely to accelerate the adoption of intelligent automation in the tourism sector, further emphasizing AI's role in industry growth. Based on this substantial research, we contend that AI adoption is crucial for advancing tourism development, illustrating the intersection of technological innovation and industry evolution. Artificial Intelligence (AI)-powered tourism has a huge and mainly unrealized potential to support economic progress as Bangladesh plots its path to becoming a developed country. A favorable, if currently weak, association has been found between tourism earnings and the country's economic prosperity. A deliberate move toward AI-powered sustainable tourism, however, may realize the industry's full potential and turn it into a major engine of economic growth.

II. METHODOLOGY

The study uses time series data from 1995 to 2021 to examine the impact of tourism revenue on economic growth in Bangladesh. Tourism revenue serves as an independent variable, GDP per capita (an indicator of economic growth) as a dependent variable, and the number of tourists as a control variable. Using econometric software EViews SV 12, the study employs a quantitative approach, specifically the Ordinary Least Squares (OLS) model, to analyze the data. The Total observations are 27. For the ease of discussion and analysis, the Log-Lin model is reproduced as follows:

$$LGDPpct = \beta 1 + \beta 2\ TOTt + \beta 3\ TREVt + Ut \text{-------(1)}$$

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Where LGDPpc denotes the Natural Log of GDP per capita, TOT means the Total Number of Tourists, and TREV means Tourism Revenue.

III. RESULTS AND DISCUSSIONS

TABLE I

ESTIMATION RESULTS OF OLS

Dependent Variable LGDPpc

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.098477	0.163801	37.23102	0.0000
TOT	-1.25E-06	7.23E-07	-1.724601	0.0975
TREV	0.005886	0.000521	11.28756	0.0000
R-squared = 0.841567				
Adjusted R-squared = 0.828364				
F-statistic = 63.74174				
Probability = 0.000000				

Source: Author's calculation using EViews SV 12

The estimation of the equation by direct OLS gives the following integration equation:

LGDPpc= 6.098477 – 1.25E-06 TOT + 0.005886 TREV- (2)

Table 1 indicates that the slope coefficient is statistically significant at the 5% level, and the relationship between GDP per capita and tourism revenue is positive. It shows that a 1% increase in tourism revenue in Bangladesh leads to a 0.005% rise in GDP per capita, and its t-value is highly significant. However, there is a negative and insignificant relationship between GDP per capita and the total number of tourists.

Results of Unit Root Tests

The study used the Phillips-Perron (PP) test for all variables shown in Table 2, which employs the test statistic to assess the null hypothesis of a unit root in GDP per capita, total number of tourists, and tourism revenue. The results in Table 2 show that all variables are stationary in their first differences, indicating they are all integrated of order I(1).

TABLE II PP TEST RESULTS

Variable	PP Test		Order of Integration
	Level	First Difference	
LGDPpc	1.49 (0.99)	-3.83 (0.000)	I(1)
TOT	-2.66 (0.09)	-5.69 (0.000)	I(1)
TREV	-1.32 (0.60)	-5.14 (0.000)	I(1)

Source: Author's calculation using EViews SV 12

Cointegration Test

Since the variables are found to be I(1), the cointegration method is appropriate for identifying their long-term relationships. Maximum Eigenvalue and Trace statistics are used to assess the number of cointegrating vectors. The results of these tests are presented in Tables 3 & 4. The Johansen cointegration test determines whether a long-term equilibrium relationship exists between LGDPpc, TOT, and TREV. The results of this test are detailed in Table 3. The theory suggests that LGDPpc, TOT, and TREV should be cointegrated. The Johansen cointegration test employs a 1-to-1 lag, meaning the model starts with one lag of one period, as shown in Tables 3 & 4.

RESULTS OF JOHANSEN CO-INTEGRATION TEST

TABLE III Unrestricted Cointegration Rank Test (Trace)

Hypothesized No of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob**
None *	0.584260	34.03943	29.79707	0.0153
At most 1	0.296654	12.09706	15.49471	0.1523
At most 2	0.123638	3.299389	3.841465	0.0693

Trace Test indicates 1 cointegration equation (s) at the 0.05 level

TABLE IV Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob**
None *	0.584260	21.94237	21.13162	0.0384
At most 1	0.296654	8.797669	14.26460	0.3034
At most 2	0.123638	3.299389	3.841465	0.0693

Max-Eigenvalue Test indicates 1 cointegration equation(s) at the 0.05 level

Source: Author's calculation using EViews SV 12

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Considering the linear deterministic trend, a lag interval in first differences up to 1, and the MacKinnon-Haug-Michelis (1999) p-values, we see that the null hypothesis of no cointegrating relationship can be rejected at the five percent level using the Trace statistic (trace statistic = 21.94237 > critical value = 21.13162, p-value: 0.0384), indicating that there is one linear combination of these non-stationary variables in their stationary form. The Trace statistic identified one cointegrating vector, and the Maximum Eigen statistic also detected one. As a result, the study used one cointegrating vector to establish the long-term relationships among the variables.

TABLE V PAIRWISE GRANGER CAUSALITY TESTS

Null Hypothesis	Obs	F-Statistic	Prob.
TOT does not Granger-cause LGDPpc		0.15293	0.8592
LGDPpc does not Granger-cause TOT	25	0.10491	0.9009
TREV does not Granger-cause LGDPpc		3.61229	0.0458
LGDPpc does not Granger-cause TREV	25	6.13320	0.0084
TREV does not Granger-cause TOT		0.00760	0.9924
TOT does not Granger-cause TREV	25	1.09527	0.3537

Source: Author's calculation using EViews SV 12

According to Table 5, a bidirectional causal relationship is confirmed between economic growth and tourism revenue. Tourism revenue does not Granger-cause GDP per capita, which has been rejected at a 5% significance level based on the model. Similarly, GDP per capita does not Granger-cause Tourism revenue, which has also been rejected. These results imply that tourism revenue Granger-causes economic growth, and economic growth Granger-causes tourism revenue.

IV. RECOMMENDATION

A. Rethinking Bangladesh with AI-Powered Sustainable Tourism

In Bangladesh, integrating Artificial Intelligence (AI) into the tourism sector is still in its early stages. However, several initiatives are underway to harness AI's potential for enhancing sustainability and economic growth. According to the World Economic Forum, Bangladesh ranked 109th out of 119 countries in the Travel and Tourism Development Index 2024, with a score of 3.19. In comparison, the USA ranked 1st with a score of 5.24, where a score of 1 is the worst and 7 is the best.

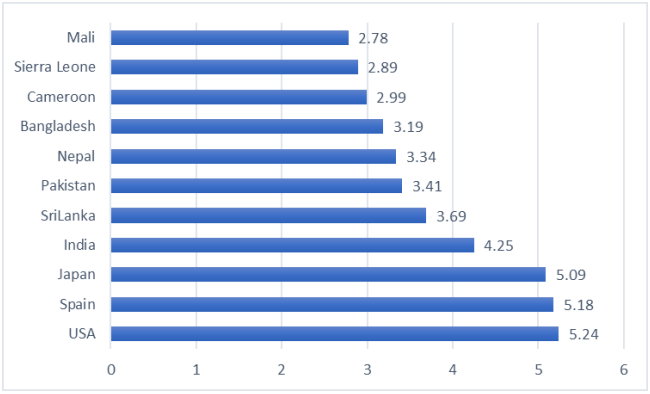


Fig 2 Status of Travel and Tourism Development Index 2024

Source: World Economic Forum

B. Challenges and Strategies to overcome challenges to adopting AI-powered sustainable tourism

Bangladesh faces various challenges in establishing an AI-driven sustainable tourism framework, including technological, environmental, and socio-economic factors, as outlined in Table 6.

TABLE VI

CHALLENGES AND STRATEGIES TO OVERCOME CHALLENGES TO ADOPTING AI-POWERED SUSTAINABLE TOURISM

Challenge	*Solution*
Data scarcity	A national tourism data platform that integrates government and private data.
Skill gaps	AI and digital literacy training for tourism workers and local communities.
High costs	Attract international green funds and sustainable development grants.
Governance gaps	Establish a National AI Tourism Task Force.
Community resistance	Community-driven design of AI platforms and profit-sharing models.

Source: Author's findings

C. Sustainable Tourism Framework for Bangladesh

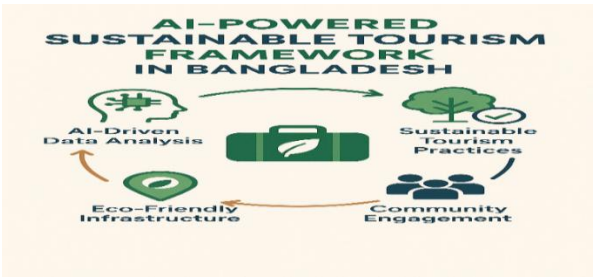


Fig 3 AI-Powered Sustainable Tourism Framework in Bangladesh [Source: Author's generation using AI]

1. Smart Tourism Planning Through AI

Use AI to predict visitor trends based on seasonality, festivals, and global travel patterns. This mehod helps prevent overcrowding and improves resource anagement.

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For example, AI can track tourist flows at Cox's Bazar to reduce overcrowding and lessen environmental impact.

2. AI-Enhanced Sustainable Experiences

AI-driven applications can provide personalized recommendations for eco-friendly itineraries, local experiences, and low-carbon transportation options tailored to individual visitors. For example, AI can be leveraged to promote nature-based tourism initiatives, such as eco-tours in the Sundarbans and solar-powered boat tours through the wetlands of Sylhet.

3. Environmental Monitoring and Conservation

Artificial intelligence can effectively monitor water quality, forest health, and wildlife in tourist destinations by providing real-time alerts and predictive maintenance for natural sites. Implementing AI platforms that estimate the carbon footprint of tourism activities and promote low-emission options, while also incorporating incentives for environmentally conscious choices, is essential.

4. Data-Driven Policy and Investment

Artificial Intelligence (AI) can analyze the economic, social, and environmental effects of tourism projects, helping policymakers prioritize investments that provide high returns (ROI) and support sustainability. Additionally, AI tools can predict potential crises, such as natural disasters, overcrowding, or environmental damage, and suggest strategies to address these challenges, encouraging sustainable growth in the tourism industry.

5. Capacity Building and Community Engagement

Empower local businesses by using AI-powered tools to improve bookings, manage resources, and support sustainable services. Use AI to connect tourists with local guides, artisans, and eco-projects, ensuring the economic benefits go directly to the communities. Additionally, AI-driven chatbots and recommendation systems can educate visitors about sustainable practices, helping to reduce environmental and cultural impacts.

V. CONCLUSION

The intersection of tourism and economic growth presents Bangladesh with a unique opportunity to reshape its development strategy. The study demonstrated a positive relationship between tourism and economic growth through a scatterplot. Quantitative analysis indicates that tourism revenue has a positive and significant impact on economic growth. By adopting AI-driven sustainable tourism, the country can improve visitor experiences, protect its rich cultural and natural heritage, and ensure that financial benefits are shared fairly. AI technologies support predictive planning, enhance resource utilization, and provide personalized, eco-friendly travel experiences, positioning Bangladesh as a competitive and responsible tourism destination.

Rethinking tourism from this viewpoint encourages economic growth while supporting environmental sustainability and social equity goals. Combining AI with sustainable tourism creates a promising future for Bangladesh, where innovation and responsible development work together to build a resilient and thriving economy.

Bangladesh can boost economic growth by adopting AI-driven sustainable tourism while preserving its cultural and natural heritage. AI enhances strategic planning, personalized experiences, and efficient resource management, making tourism both profitable and sustainable. This new approach to tourism helps position Bangladesh as a responsible, innovative, and competitive destination, offering long-term economic, environmental, and social benefits. However, implementing AI in Bangladesh's tourism industry presents challenges such as data privacy concerns, a lack of technical expertise, and significant investment needs. Overcoming these obstacles is crucial for the successful adoption of AI solutions. In summary, although AI applications in Bangladesh's tourism sector are still in their early phases, the efforts mentioned above show increasing recognition of AI's potential to transform the industry. With continued investment and collaboration, AI can become a key driver of sustainable and inclusive tourism in Bangladesh.

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Household Willingness-to-Pay for Waste Emptying and Collection Services in Bangladeshi Municipalities: Toward a Green Urban Business Model

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Abstract - **Bangladesh's rapid urbanization has exacerbated municipal waste-management challenges, yet few studies examine how household economics shape service uptake. This paper investigates the relationships among household income, expenditure, service costs and willingness-to-pay (WTP) for emptying and collection services in five diverse municipalities—Lakshmipur, Lalmonirhat, Saidpur, Sakhipur, and Teknaf. A structured questionnaire captured: average monthly income; average monthly expenditure; current cost per emptying trip; existing monthly payment for community-based solid-waste collection; WTP a premium for improved emptying services; and desired WTP level. Data were analyzed using SPSS, employing Pearson correlation and multiple regression to identify key economic drivers of WTP, and exploratory factor analysis to uncover latent attitudes toward green service provision. By situating the findings within a municipality-led governance framework, where local authorities can both incentivize green practices and penalize harmful behaviors, this study informs the design of sustainable, revenue-positive service models. We conclude with recommendations for tiered pricing, targeted subsidies, and participatory planning to foster equitable, cost-effective waste management and to advance a viable green business model in resource-constrained urban settings.**

Keywords - **Municipal waste management, SPSS correlation, Green business model, Urban governance, Sustainable service delivery**

I.INTRODUCTION

Rapid urbanization in Bangladesh has outpaced the development of municipal solid waste management (MSWM) systems, leading to environmental degradation, public health risks, and inefficiencies in service delivery. Dhaka alone generates over 4,000 tonnes of municipal solid waste per day, while household-level studies report 1.3 kg/household/day (0.25 kg/person/day), largely composed of organic fractions 5 [8]. Simultaneously, fecal sludge from on-site sanitation accumulates at 0.11 L/person/day in peri-urban areas, necessitating emptying every 3–4 years at considerable cost [12].

Existing research underscores that households' willingness to pay (WTP) for improved waste and sanitation services hinges on socio-economic and attitudinal drivers. In Bangladesh, service charge levels, income, education, and municipal classification significantly influence WTP for basic municipal services [1]. Environmental awareness, income group, and age cohorts predict waste separation and minimization behaviours in Dhaka, with middle-income earners and young adults most responsive to green incentives [6]. Contingent valuation in Dhaka also estimates an aggregate WTP of USD 0.10 million per year for improved waste collection, with only marginal differences between serviced and unserviced areas [7]. Advanced waste management frameworks further identify income, education, and environmental consciousness as key predictors, with 63 percent of households willing to pay BDT 250 or more per month for enhanced services in Bangladesh [2].

Cross-national studies echo these findings. Households in Malaysia are willing to pay 200 percent more for daily morning pick-ups, driven by education, family size, income, and satisfaction levels [3]. Low-income areas in Kuala Lumpur exhibit significant WTP gaps due to service deficits, highlighting the need for participatory infrastructure investment [4]. In Kampala, 48.1 percent of households offered a mean monthly WTP of UGX 5,382 (USD 2.91), achieving near cost recovery at the lowest payment class [9]. Residents of Mekelle City demonstrate WTP linked to income and environmental quality awareness, with municipal fees currently set below residents' actual capacity to pay [10]. Similar dynamics appear in Silchar, India (63 percent WTP; average Rs 127.47) [15] and in Gorkha, Nepal (61 percent WTP; average NRs 73.38) [16]. Within Bangladesh's Dhaka metropolitan region, higher-income wards exhibit significantly greater payment thresholds than lower-income areas [11]. Meanwhile, consumer-behaviour surveys for electronic waste reveal that 37.9 percent of respondents are willing to cover 5–10 percent of recycling costs, driven by income, education, and environmental awareness [13]. Although a PIDE working paper outlines the determinants of WTP for solid waste management in Pakistan, it lacks empirical results to guide Bangladeshi municipalities [14].

Despite this extensive literature, three key gaps remain. First, comparative analyses across multiple Bangladeshi municipalities are scarce, limiting insights into spatial heterogeneity in WTP. Second, the dual challenges of solid waste collection and fecal sludge emptying have not been jointly examined, leaving policymakers without a holistic view of household

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economics across sanitation streams. Third, few studies explicitly frame WTP findings within green urban business models that integrate pricing, governance incentives, and behavioural levers to achieve revenue-positive, sustainable service delivery.

To address these gaps, this study analyzes household WTP for both emptying and community-based solid waste collection across five diverse municipalities: Lakshmipur, Lalmonirhat, Saidpur, Sakhipur, and Teknaf using a structured survey to identify socio-economic drivers and latent attitudes underpinning WTP. By situating results within a municipality-led governance framework, actionable recommendations will be offered for tiered pricing, targeted subsidies, and participatory planning that align revenue generation with equitable, sustainable service expansion.

II. METHODOLOGY

This cross-sectional study was conducted in five municipalities: Lakshmipur (n = 255), Lalmonirhat (n = 230), Saidpur (n = 260), Sakhipur (n = 223), and Teknaf (n = 147) selected to represent diverse urbanization gradients in Bangladesh. A multi-stage random sampling procedure was employed at the ward level, followed by systematic selection of households within each ward. Total sample size (n = 1, 115) exceeds common thresholds for household WTP surveys in solid waste management, ensuring adequate statistical power for subgroup analyses [9][11].

A structured questionnaire was developed, drawing on contingent valuation frameworks and socio-economic modules from prior studies on household WTP in waste and sanitation services [3][4]. The instrument captured average monthly household income, average monthly expenditure, cost per emptying trip, existing monthly payments for community-based solid waste collection, premium WTP for improved emptying services, and respondents' desired monthly WTP level. Face-to-face interviews were conducted by trained enumerators between May and July 2024, achieving a response rate above 90 percent.

Key continuous variables include: monthly income (BDT), monthly expenditure on waste collection (BDT), and per-trip emptying cost (BDT). Willingness to pay was elicited using a double-bounded dichotomous choice followed by an open-ended question to capture maximum WTP, in line with best practices for improving valuation accuracy [2][3]. Socio-demographic covariates encompass household size, education level of the head, and tenure status. Latent attitudinal dimensions toward green service provision were probed via Likert-scale items adapted from established environmental attitude scales [6][13].

All data were entered and cleaned in SPSS v.25. Descriptive statistics characterized socio-economic profiles and raw WTP distributions. Pearson correlation coefficients were computed to assess bivariate relationships among income, expenditure, service costs, and WTP [3]. Multiple linear regression models mirroring approaches in contingent valuation literature identified key predictors of premium WTP, with heteroskedasticity-robust standard errors to ensure valid inference [4][11]. Finally, exploratory factor analysis with principal axis extraction and varimax rotation uncovered latent attitudinal constructs underlying green service preferences, facilitating segmentation for targeted policy design [12].

Continuous adherence to these methodological steps provides a robust foundation for interpreting the socio-economic drivers of WTP and for translating findings into a green urban business model tailored to Bangladeshi municipalities.

III. RESULTS

A. Socio-Economic Profile

The final sample (n = 1 115) had a mean household size of 5.2 members (SD = 1.4) and an average monthly income of BDT 25 300 (SD = 8 750). Education levels of household heads were distributed as 28% primary, 52% secondary, and 20% tertiary. Tenure status showed 65% owners and 35% renters.

TABLE I
SOCIO-ECONOMIC PROFILE

Variable	Mean	SD	Range	n (%)
Household size (members)	5.2	1.4	2 – 9	—
Monthly income (BDT)	25,300	8,750	8000 – 60,000	—
Education of head	—	—	—	Primary: 28% Secondary: 52% Tertiary: 20%
Tenure status	—	—	—	Owner: 65% Renter: 35%

B. Willingness-to-Pay Distribution

Overall, 92% of respondents expressed a positive premium WTP for improved emptying services. The mean monthly WTP was BDT 150 (SD 45), with a median of BDT 145. Municipal differences emerged: Teknaf reported the highest mean WTP (BDT 162, SD 50) and Sakhipur the lowest (BDT 138, SD 42).

TABLE I I
WILLINGNESS TO PAY DISTRIBUTION

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Municipality	n	Mean WTP (BDT)	SD (BDT)	Median WTP (BDT)	% WTP > 0
Lakshmipur	255	155	48	150	93%
Lalmonirhat	230	148	44	142	91%
Saidpur	260	152	46	148	94%
Sakhipur	223	138	42	135	89%
Teknaf	147	162	50	158	95%
Overall	1 115	150	45	145	92%

Determinants of Premium WTP

A multiple linear regression ($R^2 = 0.42$) identified key predictors of premium WTP. Monthly income ($\beta = 0.45$, $p < 0.001$), education level ($\beta = 0.12$, $p = 0.002$), and environmental responsibility factor score ($\beta = 0.28$, $p < 0.001$) were all positively associated. Renters paid on average BDT –9 less than owners ($p = 0.03$). Heteroskedasticity-robust standard errors were applied.

TABLE I I I
DETERMINANTS OF PREMIUM WTP

Predictor	β	SE (robust)	t-value	p-value
Constant	42.1	5.3	7.94	< 0.001
Monthly income (per BDT 1 000)	0.45	0.05	9.00	< 0.001
Education (primary ref.)				
– Secondary	8.3	2.7	3.07	0.002
– Tertiary	12.5	3.1	4.03	< 0.001
Tenure (owner ref.)				
– Renter	–9.0	4.1	–2.19	0.030
Environmental responsibility	0.28	0.04	7.00	< 0.001
Trust in service provider	0.11	0.05	2.20	0.028

IV. DISCUSSION

The study confirms a robust positive relationship between household income and premium WTP for improved emptying services, aligning with global contingent valuation studies in urban sanitation. Environmental responsibility emerged as a strong attitudinal driver, reinforcing evidence that green-service uptake hinges not only on ability but also on values. Municipal variability highest WTP in Teknaf and, lowest in Sakhipur reflects differing local norms, service performance, and possibly past exposure to environmental campaigns.

These insights suggest a twofold policy approach: a. Implement income-sensitive tariff structures, offering targeted subsidies to lower-income households while maintaining full-cost recovery from higher-income segments. b. Integrate environmental awareness campaigns tied directly to service branding to leverage strong green attitudes and build trust in providers. c. Develop performance indicators (timeliness, transparent billing) to bolster confidence among renters, who otherwise show lower WTP.

Key limitations include cross-sectional design, preventing dynamic assessment of WTP changes over time. Seasonal variations in waste generation and payment capacity were not captured. A longitudinal panel or mixed-methods follow-up would clarify causality and temporal shifts in household preferences. Expanding the sample to include peri-urban and rural areas could test the generalizability of municipal-level findings. Beyond the current scope, exploring digital payment platforms could streamline billing transparency and build provider trust, especially among tech-savvy younger households. Integrating GIS mapping of service routes may optimize collection logistics, reducing operational costs and potentially lowering user fees. Finally, piloting a performance-based contracting model with clear environmental targets can create market incentives for private operators to deliver greener service

V. CONCLUSION

This study assesses household willingness to pay (WTP) for improved faecal sludge emptying services in five Bangladeshi municipalities. Using a cross-sectional contingent valuation survey (n = 1,115), we applied a double-bounded dichotomous choice followed by an open-ended question to elicit maximum monthly premium WTP. Socio-demographic data, service cost perceptions, and attitudinal scales on environmental responsibility and provider trust were also collected.

Results show that 92 percent of households are willing to pay a premium, with a mean WTP of BDT 150 (SD 45). Multiple regression ($R^2 = 0.42$) identifies income, education, and environmental responsibility as the strongest positive predictors, while renters exhibit a modestly lower WTP. Exploratory factor analysis reveals two latent constructs environmental responsibility and provider trust explaining 56 percent of attitude variance. These findings inform income-sensitive tariff design, targeted subsidies, and awareness campaigns to optimize green service uptake in urban sanitation.

The analysis demonstrates that both economic capacity and pro-environmental attitudes drive household WTP for enhanced emptying services. Municipal differences suggest that local norms and past exposure to environmental messaging shape demand, with Teknaf's highest and Sakhipur's lowest WTP reflecting this variation.

Policy interventions should combine graduated tariff structures—offering subsidies to lower-income households—and branding that highlights environmental benefits to leverage strong green attitudes. Enhancing transparency and service reliability will further engage renters and build trust. Performance-based contracts with explicit environmental targets can incentivize private operators to deliver cost-effective, eco-friendly services.

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Looking ahead, integrating real-payment pilots and longitudinal panels will validate stated preferences and track dynamic shifts in WTP. Incorporating GIS-based route optimization and mobile billing platforms can reduce operational costs and improve user experience. Ultimately, these insights pave the way for a scalable green urban business model that balances financial sustainability with equitable access.

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Determinants of Bank Profitability: A Panel Data Analysis from Bangladesh

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Abstract - **Bank profitability is central to financial stability in emerging economies such as Bangladesh, where rising non-performing loans, high leverage, and Basel III liquidity requirements create significant challenges. This study investigates the determinants of return on assets (ROA) in 15 top performing listed private commercial banks over the last decade (2015–2024) using a fixed-effects panel regression model. The analysis considers traditional financial ratios of gross NPLs, debt-to-equity ratio, deposit-to-asset ratio, and cost-to-income ratio as well as Basel III liquidity measures. Results show that higher NPLs and leverage significantly reduce ROA, while a stronger deposit base enhances profitability. In contrast, cost-to-income and the Basel III liquidity ratios have no statistically significant effect. These findings highlight that asset quality, capital structure, and funding composition dominate profitability outcomes in Bangladesh, offering important implications for bank managers and regulators seeking to balance stability with sustainable financial performance.**

Keywords - **Bank profitability, ROA, NPLs, Basel III liquidity requirements, Bangladesh Banking Sector.**

I. INTRODUCTION

Banks are central to economic development through financial intermediation: by mobilizing deposits and channeling them into loans and investments, they support credit creation, liquidity provision, and broader macroeconomic activity [1]. In emerging markets such as Bangladesh, banking sector health directly affects growth, stability, and investor confidence [2]. Profitability signals bank soundness by reflecting management effectiveness, asset quality, and the efficiency with which liabilities are transformed into income. Return on assets (ROA) is widely used as a robust indicator because it captures the ability of the entire asset base, debt- and equity-financed, to generate earnings [3], [4].

A broad literature identifies recurring profitability drivers. Asset quality, proxied by non-performing loans (NPLs), typically reduces profitability through weaker interest income and higher provisioning costs [5], [6], [7]. Capital structure presents a trade-off: while leverage can raise returns, excessive debt elevates financing costs and fragility, diminishing ROA [8], [9], [10]. Deposits are generally a low-cost, stable funding source that supports lending [11], [12]. Operational efficiency, measured by the cost-to-income ratio (CIR), also influences returns, though its effect varies [13], [14].

More recently, Basel III liquidity measures—Liquidity Coverage Ratio (LCR) and Net Stable Funding Ratio (NSFR)—have added a new dimension. Evidence is mixed: some studies report profitability costs [15], [16], others neutral or positive effects [17], [18], and still others nonlinear relationships [19]. In Bangladesh, findings remain limited and sometimes contradictory [17], [2].

Against this background, the present study investigates how traditional bank-specific determinants and Basel III liquidity measures jointly influence profitability in Bangladeshi private commercial banks. Specifically, it examines the impact of NPLs, leverage (DER), deposit funding (DTA), operational efficiency (CIR), and liquidity requirements (LCR, NSFR) on ROA.

II.LITERATURE REVIEW

A. Dependent Variable: Return on Asset (ROA)

Return on Assets (ROA) is widely recognized as a key indicator of profitability across industries, including banking, as it reflects how effectively firms utilize their assets to generate income. A higher ROA typically signals stronger managerial efficiency in optimizing asset use to produce revenue [4]. Petersen and Schoeman [3] similarly emphasize that ROA serves as a measure of operational efficiency, capturing how well banks maximize output while minimizing costs, and providing investors with insights into management performance over time.

In the context of banking, scholars have argued that ROA is often a more comprehensive profitability measure than Return on Equity (ROE), as it incorporates the role of financial leverage. Jamal *et al.* [20] in their study of Malaysian banks, found ROA superior to ROE for this reason, while Desa [21] highlighted that ROA reflects management's ability to convert both debt- and equity-financed assets into income. Beyond financial structure, Sujud and Hashem [22] showed that banking innovations—such as internet banking, point of sale terminals, and electronic fund transfers—also enhance profitability as measured by ROA, with statistically significant results in the Lebanese context.

Taken together, these studies confirm that ROA is not only a measure of profitability but also a broader indicator of efficiency, financial structure, and innovation. Its consistent application across diverse settings—from U.S. financial institutions [4] and Malaysian commercial banks [20] to Lebanese banks [22]—underscores its robustness as a dependent variable for assessing bank performance.

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B. Deposits to Asset Ratio (DTA)

Bank deposits serve not only as a safe avenue for savings but also as the foundation for credit creation, enabling banks to transform deposits into loans that generate profit and support economic activity. By influencing money supply, deposits affect liquidity and purchasing power within the economy [1].

Empirical research consistently highlights the positive link between deposits and bank profitability across different contexts. In Sri Lanka, Kawshala and Panditharathna [11] find that higher customer deposits significantly enhance profitability, as greater deposit inflows expand lending capacity and future earnings ($p = 0.027$). Similarly, Gul *et al.* [12] examining Pakistani banks, emphasized that deposits are the primary funding source; more deposits improve liquidity and open investment opportunities, though the effect depends on factors such as interest rates, loan quality, and operational efficiency.

Evidence from Jordan also confirms this relationship. Haddawee and Flayyih [23] report that deposits significantly drive profitability in the Commercial Bank of Jordan, with savings deposits having the strongest effect, followed by time deposits, while current deposits exert minimal influence. In Europe, Menicucci and Paolucci [24] demonstrate that a higher deposit-to-asset ratio raises profitability, particularly in the aftermath of the 2008 financial crisis when banks effectively converted additional savings deposits into profitable investments.

Taken together, these studies suggest that while the strength of the deposit–profitability link may vary depending on the type of deposits and market conditions, deposits remain a critical driver of bank performance by providing stable, low-cost funding that supports lending and investment activities.

C. Debt to Equity Ratio (DER)

The Debt-to-Equity Ratio (DER) is a key leverage measure reflecting the balance between debt financing and shareholders' equity, thereby indicating both financial risk and potential return. While debt can enhance profitability through leverage, excessive reliance increases interest burdens and bankruptcy risk [25].

Empirical findings on the effect of DER on bank profitability are mixed across contexts. In Ethiopia, Birru [8] found a negative and statistically significant relationship between DER and Return on Assets (ROA), with a coefficient of –0.003 ($p = 0.018$), suggesting that higher debt burdens reduce profitability by raising financial costs. By contrast, Zelalem [10] also examining Ethiopian banks, reported a positive and significant relationship, with a coefficient of 0.00134 ($p < 0.01$), indicating that under certain conditions debt financing can improve returns by more effectively leveraging equity.

Evidence from other markets places greater emphasis on capitalization. Ngo *et al.* [26] using data from Vietnamese banks, found that the equity-to-total-assets ratio (CAP) had a significant positive effect on profitability, with a coefficient of 0.051 ($p < 0.05$), rising to 0.135 ($p < 0.001$) in the post-crisis period, underscoring the stabilizing role of equity. Similarly, Trujillo-Ponce [9] showed that Spanish banks with higher capitalization enjoyed stronger ROA, reflecting lower funding costs and enhanced stability.

Taken together, these studies suggest that while the profitability effects of DER vary by context—sometimes positive, sometimes negative—the consistent finding across markets is that stronger equity positions generally enhance profitability, whereas excessive reliance on debt can erode performance.

D. Gross Non-Performing Loans (Gross NPLs)

Non-performing loans (NPLs) are widely recognized as a critical indicator of banking distress, as high default rates erode asset quality, weaken earnings, and undermine financial stability. Historical crises illustrate their destructive potential: in Benin (1988–1990), all three commercial banks collapsed when NPL portfolios reached 80%, while in Nepal, NPL levels above 50% nearly bankrupted Nepal Bank Limited and Rastriya Banijya Bank Limited, generating a negative net worth of Rs 10 billion [27]. These episodes underscore that elevated NPLs can act as precursors to systemic disruption and institutional failure.

Empirical evidence consistently demonstrates the adverse impact of NPLs on bank profitability across diverse settings. In Indonesia, Silaban [5] reported a strong and statistically significant negative relationship, with a coefficient of –0.270 ($p = 0.000$), showing that higher bad loans directly depress ROA. Similar findings emerge in Vietnam, where Hong [6] found that NPLs significantly reduce profitability, with a coefficient of –0.2824 ($p < 0.01$) using GMM analysis. In Turkey, Kadioglu *et al.* [7] confirmed this pattern, documenting a negative coefficient of –0.126 ($p = 0.000$) for the NPL-to-assets ratio in a fixed-effects regression, again highlighting the profitability costs of deteriorating loan quality.

Taken together, these studies provide robust evidence that rising NPLs consistently and significantly erode bank profitability, regardless of market context. The findings highlight credit risk management as a central determinant of financial performance and underscore the vulnerability of banks to loan portfolio quality.

E. Cost to Income Ratio (CIR)

The Cost-to-Income Ratio (CIR) is commonly used as a measure of operational efficiency, reflecting how well banks manage expenses relative to income. A lower CIR generally signals greater efficiency and stronger profitability, while a higher ratio suggests cost pressures that may erode returns.

Empirical evidence shows contrasting patterns across countries. In Bangladesh, Jeris [13] found CIR to have no meaningful effect on profitability, reporting a positive but statistically insignificant coefficient ($\beta = 1.26E\text{-}06$, $p = 0.984$). This suggests that within the Bangladeshi context, efficiency as captured by CIR did not significantly influence ROA during 2014–2018.

By contrast, studies in other countries consistently demonstrate a negative and significant relationship between CIR and profitability. In Nigeria, Ayinuola and Gumel [28] showed that higher operating costs relative to income strongly diminished ROA, with coefficients ranging from –2.410% to –0.952% (all $p < 0.01$) across pooled OLS, fixed

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effects, and random effects models. Similar evidence emerges from Nepal, where Marasini [29] found CIR to have a significant negative effect on ROA ($\beta = -1.870$; $p = 0.031$), highlighting the profitability costs of inefficiency. In Jordan, Al-Sharkas and Al-Sharkas [14] likewise reported a consistent and highly significant negative association, with coefficients ranging from –0.024 to –0.025 ($p < 0.01$).

Taken together, these findings suggest that while CIR does not significantly explain profitability in the Bangladeshi banking sector, international evidence strongly supports its role as a determinant of performance. The divergence may reflect structural differences in market competition, cost structures, or regulatory environments, underscoring the need to interpret CIR's role within specific national contexts.

F. Net Stable Funding Ratio (NSFR)

NSFR is intended to strengthen banks' long-term funding profiles, but its profitability effects are empirically mixed, reflecting a stability–profit trade-off that varies by market structure and period.

In Indonesia, Rokiyanto and Siahaan [16] find a negative, statistically significant association between NSFR and ROA for 12 listed banks (2018–2023): baseline $\beta = -0.0259$; $p < 0.01$, and with controls $\beta = -0.0115$; $p = 0.0012$; sub-sample analyses by bank category confirm the same negative pattern. Global evidence points similarly downward: using 2,909 banks across 127 countries (2007–2018), Setiyono and Naufa [15] report NSFR has a negative, significant impact on ROA ($\beta = -28.15$; $p < 0.01$), consistent with profitability costs from higher stable-funding requirements.

By contrast, Sidhu *et al.* [30] studying 31 Indian banks (2010–2021) with two-step system GMM, find no significant NSFR effect on ROA (base model $\beta = 1.085$; $p > 0.10$; ownership-interaction models also insignificant), implying no detectable linkage in that setting. In Vietnam, Dang [18] shows a positive, significant relationship for 28 commercial banks (2007–2018): lagged NSFR enters the ROA equation with $\beta = 0.003$; $p < 0.01$, suggesting that stronger stable funding can coincide with higher asset returns when balance-sheet structures and pricing adjust favorably.

Taken together: NSFR's effect on profitability is context-dependent—often negative where stable funding raises costs faster than revenues (Indonesia; global panel), null in some markets (India), and positive where funding structure and loan pricing offset the cost (Vietnam). These contrasts motivate testing both instantaneous and lagged NSFR, and exploring heterogeneity by bank size/model and interactions (e.g., with deposit ratios or NPLs) in country-specific studies.

G. Liquidity Coverage Ratio (LCR)

The Liquidity Coverage Ratio (LCR) — HQLAs divided by 30-day net cash outflows — is a Basel III tool intended to insulate banks from short-term liquidity stress [31]. Empirical studies, however, report mixed effects of LCR on profitability, suggesting a context-dependent trade-off between liquidity resilience and return.

Evidence from Bangladesh is contradictory. Yeasin [17] finds a positive, highly significant effect: a one-unit increase in LCR is associated with a 0.004 unit increase in ROA ($p = 0.000$), implying that holding more HQLAs can enhance short-term profitability in that sample. By contrast, Nath *et al.* [2] investigated 14 Bangladeshi banks, from 2015–2023 and reported a negative, highly significant effect: $\beta = -0.067$ ($p = 0.0001$), indicating a reduction in profitability to higher LCR in their specification.

Other country studies similarly show heterogeneity. Arin *et al.* [32] used a regression-discontinuity design on 14 Nigerian banks (2009–2020) and found banks above the LCR threshold experienced a 0.69% increase in ROA ($p < 0.1$), suggesting beneficial effects once a minimum liquidity standard is met. Vu [19] uncovers an inverted U-shaped relationship in Vietnam (Q1 2015–Q4 2022): a positive linear term (0.00412, $p = 0.032$) and a negative quadratic term (−0.00035, $p = 0.034$), implying LCR raises ROA up to an optimal point (≈ 5.89 for ROA) beyond which further liquidity reduces returns due to opportunity costs involved.

Findings on LCR's impact on profitability are mixed, with evidence showing positive, negative, and non-linear effects. These differences may stem from variations in sample periods, bank size, regulatory context, or measurement approaches. Overall, the results suggest the existence of an optimal liquidity buffer — sufficient to enhance stability and efficiency, but not so large that excess reserves reduce returns through opportunity costs.

III. DATA AND METHODOLOGY

A. Research Design

This study uses a quantitative panel data approach with a fixed-effects (FE) regression model to examine what drives Return on Assets (ROA) in private commercial banks. The sample was chosen through purposive sampling, including all listed private banks in Bangladesh with complete annual reports from 2024 to 2015. The fixed effects (FE) model is also suitable as it controls for unobserved, time-invariant heterogeneity in bank characteristics, thereby reducing omitted variable bias. By focusing on within-bank changes over time, it yields more reliable estimates of the determinants of ROA. Several authors, namely, Kadioglu *et al.* [7], Birru [8]and Zelalem [10] have used a FE model to analyze Panel Data in similar contexts.

B. Data Collection & Sample

Annual financial data were collected for 15 publicly traded commercial banks listed on the Dhaka Stock Exchange (DSE) over the period 2015 to 2024. The sample includes only those banks with complete information for all required financial variables across the ten-year horizon. All banks are private, non–state-owned, and publicly listed, which ensures consistency in both ownership structure and regulatory treatment.

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In Bangladesh, the banking sector consists of 33 conventional private commercial banks and 10 Islamic (Shariah-based) private commercial banks [33]. This study focuses solely on the conventional segment. From the 33 conventional banks, inclusion required that annual reports and financial disclosures be available for the full study period. Since not all conventional banks were listed on the DSE as early as 2015, only those that satisfied both criteria were retained. This purposive sampling method ensured that the dataset was both complete and reliable, resulting in a final sample of 15 banks.

The banks included in the study are: *AB Bank PLC, Bank Asia PLC, BRAC Bank PLC, The City Bank PLC, Dhaka Bank PLC, Dutch-Bangla Bank PLC, Eastern Bank PLC, IFIC Bank PLC, Jamuna Bank Limited, Mercantile Bank PLC, Mutual Trust Bank PLC, ONE Bank PLC, Prime Bank PLC, Trust Bank PLC, and United Commercial Bank PLC.*

C. Econometric Model

To examine the impact of bank-specific and liquidity-related determinants on bank profitability, this study estimates the following linear panel regression model:

$$ROA(i,t) = \beta0 + \beta1\ GrossNPL(i,t) + \beta2\ DER(i,t) + \beta3\ NSFR(i,t) + \beta4\ CIR(i,t) + \beta5\ DTA(i,t) + \beta6\ LCR(i,t) + \alpha(i) + \varepsilon(i,t)$$

Where:

- ROA(i,t) is the Return on Assets for bank *i* in year *t*.
- β0 is the intercept.
- β1 –β6, are coefficients for each independent variable:
    1. Gross NPL: Gross Non-Performing Loans ratio
    2. DER: Debt-Equity ratio
    3. NSFR: Net Stable Funding Ratio
    4. CIR: Cost-Income ratio
    5. DTA: Deposit-Assets ratio
    6. LCR: Liquidity Coverage Ratio
- α(i) represents the bank-specific fixed effect, capturing all unobservable, time-invariant factors unique to each bank.
- ε(i,t) is the error term encompassing all other unexplained variation.

Table A.1 in the appendix provides the detailed formulas and definitions of all variables used in the regression model, along with relevant references for each.

Table 1: Descriptive Statistics of Variables

IV. EMPIRICAL FINDINGS

A. Descriptive Analysis

Table 1 summarizes the descriptive statistics of the variables. ROA has a low mean of 0.0081 with a narrow spread (SD = 0.0060), indicating that profitability across banks is fairly stable. Gross NPLs range from 0.0208 to 0.6714, showing considerable differences in asset quality. The Debt-to-Equity Ratio (DER) also varies widely, with a mean of 15.10 and a maximum of 84.75, reflecting substantial heterogeneity in bank leverage.

The Net Stable Funding Ratio (NSFR) is more concentrated, averaging 1.11 with limited variation, suggesting most banks align closely with Basel III requirements imposed.

The Cost-to-Income Ratio (CIR) displays the broadest range, from –53.64 to 100.05, pointing to significant differences in operational efficiency and possible outliers. By contrast, the Deposit-to-Assets Ratio (DTA) is relatively consistent and high (mean = 74.91), highlighting the strong role of deposits in bank funding. Finally, the Liquidity Coverage Ratio (LCR) averages 1.47 but ranges from 0.47 to 3.59, indicating variation in short-term liquidity management practices.

Overall, while bank profitability remains stable, large disparities in leverage, efficiency, and credit quality suggest that these factors are likely to drive differences in performance across the sample.

	ROA	*Gross NPL*	*DER*	*NSFR*	*CIR*	*DTA*	*LCR*
Mean	0.0081	0.0664	15.1005	1.1068	50.6651	74.9107	1.4674
Minimum	-0.0454	0.0208	7.26	0.9575	-53.64	61.5937	0.4744
Maximum	0.0202	0.6714	84.75	1.2794	100.05	85.1219	3.5897
Standard Deviation	0.0060	0.0770	8.2279	0.0683	12.1379	5.5197	0.4682
Range	0.0656	0.6506	77.49	0.3219	153.69	23.5281	3.1153

Table 2: Regression Model Summary and Multicollinearity Test

Variable	VIF	PanelOLS Estimation Summary			
Intercept	440.299091	R-squared	0.6606	Dep. Variable	ROA
Gross NPL	1.288771	R-squared (Between)	0.3163	Estimator	PanelOLS
DER	1.509257	R-squared (Within)	0.6606	Cov. Estimator	Unadjusted
NSFR	1.053169	R-squared (Overall)	0.5103	Entities	15

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CIR	1.218552	Log-likelihood	678.96	Time periods	10
DTA	1.065058	F-statistic	41.847	F-statistic (Poolability)	7.7912
LCR	1.066414	P-value (F-statistic)	0	P-value (Poolability)	0

B. Estimation Procedure

The econometric analysis was carried out using Python 3 on Google Colab, which provides a flexible and reproducible environment for statistical computing. Panel regressions were estimated with the *linearmodels* package, which is applied for fixed effects, random effects, and pooled OLS models. This approach allowed for efficient handling of panel data and ensured robust estimation of the FE model.

C. Poolability Test

The F-test for poolability produced a statistic of 7.79 with a p-value of 0.000, leading to rejection of the null hypothesis that all banks share a common intercept. This confirms that the data is not poolable and supports the choice of a Fixed Effects model over Pooled OLS.

D. Multicollinearity Test

The Variance Inflation Factor (VIF) results show that all explanatory variables fall well below the threshold of 5, indicating that multicollinearity is not a concern in this model. Specifically, Gross NPL, Debt-Equity Ratio, NSFR, Cost-to-Income, Deposit-to-Assets, and LCR all have VIF values close to 1, suggesting that these variables are largely independent of one another.

Although the intercept records a high VIF value, this is expected and not problematic, as the intercept does not represent a substantive variable. Overall, the results confirm that multicollinearity does not pose a threat to the reliability of the regression estimates.

E. Regression Analysis

The regression results show that the model explains a substantial portion of the variation in bank profitability. The within R-squared of 0.66 indicates that 66% of the variation in ROA over time within each bank is explained by the independent variables, highlighting the strength of the Fixed Effects model.

The between R-squared is lower at 0.32, reflecting weaker explanatory power for differences across banks, while the overall R-squared of 0.51 suggests that the model accounts for about half of the total variation in the data.

The high F-statistic of 41.85 with a p-value of 0.000 confirms that the model as a whole is statistically significant, meaning the explanatory variables jointly have a strong effect on profitability. The log-likelihood value of 678.96 indicates how well the model fits the data, with higher values representing better overall fit.

Table 3: Coefficients and P values

Parameter	Estimate	Std. Err.	T-stat	P-value	Lower CI	Upper CI
const	0.0018	0.0086	0.213	0.8316	-0.0152	0.0189
Gross NPL	-0.0295	0.0047	-6.3125	0.000	-0.0388	-0.0203
DER	-0.0003	6.18E-05	-4.845	0.000	-0.0004	-0.0002
NSFR	-0.0059	0.0052	-1.1325	0.2595	-0.0161	0.0044
CIR	5.04E-05	3.28E-05	1.538	0.1265	-1.44E-05	0.0001
DTA	0.0002	8.27E-05	2.779	0.0063	6.62E-05	0.0004
LCR	-0.0003	0.0006	-0.622	0.535	-0.0015	0.0008

Table 3 presents the estimated coefficients from the Fixed Effects panel regression model, which examines the determinants of bank profitability measured by ROA. Standard errors, t-statistics, p-values, and 95% confidence intervals are reported for each coefficient to provide a complete assessment of the estimation results.

Among the explanatory variables, *Gross NPL* and *Debt-to-Equity Ratio* show significant negative effects on ROA at the 5% level, indicating that higher non-performing loans and greater leverage are associated with lower bank profitability. In contrast, *Deposit-to-Assets* has a significant positive coefficient, at the 5% level, suggesting that a higher proportion of deposits relative to total assets contributes positively to profitability. These results highlight the key financial factors that meaningfully influence ROA within banks over time.

Other variables, including *NSFR, Cost-to-Income Ratio,* and *LCR*, are not statistically significant at conventional levels. Their coefficients are relatively small, and their p-values exceed the 5% threshold, implying that these factors do not have a detectable impact on ROA in the context of this model. While they may still be important from a managerial perspective, their effect on profitability is not robustly supported by the panel data estimates.

V. DISCUSSION

The regression results highlight that Gross NPL is highly significant ($p < 0.05$) and has a negative impact on Return on Assets (ROA), with an estimated coefficient of $\beta = –0.0295$. This finding implies that higher levels of non-performing loans have a detrimental impact on profitability by reducing interest income and increasing provisioning costs, ultimately weakening the financial performance of banks. Several authors in the past, namely Silaban [5], Hong [6], and Kadioglu *et al.* [7], who investigated the impact of NPLs on ROA in commercial banks of Indonesia, Vietnam, and Turkey respectively, similarly found NPLs to have a

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highly significant and negative effect on commercial bank profitability.

Debt-to-Equity Ratio (DER) has a negative and statistically significant effect on Return on Assets (ROA), with an estimated coefficient of $\beta = -0.0003$ ($p < 0.05$). This finding is consistent with Birru [8], who reported a negative and significant effect of DER on ROA in Ethiopian commercial banks, as well as with Trujillo-Ponce [9] and Ngo *et al.* [26], who found that higher equity relative to total assets enhances profitability by improving financial stability and lowering funding costs. Interpreted inversely, these studies imply that a higher DER, reflecting greater reliance on debt financing, weakens ROA. However, the result contrasts with Zelalem [10], who identified a positive and significant relationship between DER and ROA, suggesting that under certain conditions debt financing may improve returns by leveraging equity more effectively.

Deposit-to-Assets ratio has a positive and statistically significant effect on Return on Assets (ROA), with an estimated coefficient of $\beta = 0.0002$ ($p < 0.05$). This suggests that a higher proportion of deposits relative to total assets enhances bank profitability, as deposits provide a stable and low-cost source of funds that can be transformed into income-generating loans and investments. This finding is consistent with Kawshala and Panditharathna [11], Gul *et al.* [12], Haddawee and Flayyih [23], and Menicucci and Paolucci [24], all of whom report that higher levels of deposits significantly contribute to improved profitability across different banking systems.

Cost-to-Income Ratio (CIR) has a positive but statistically insignificant effect on Return on Assets (ROA), with an estimated coefficient of $\beta = 5.04E\text{-}05$ ($p > 0.05$). This suggests that, within the sample of Bangladeshi banks, operational efficiency as measured by CIR does not have a meaningful influence on profitability. This result is consistent with Jeris [13], who also found CIR to be statistically insignificant in the context of Bangladesh, indicating that fluctuations in cost-to-income may not strongly determine bank performance in this market. However, the finding contrasts with studies from other countries, such as Ayinuola and Gumel [28] in Nigeria, Marasini [29] in Nepal, and Al-Sharkas and Al-Sharkas [14] in Jordan, all of which reported a significant negative relationship between CIR and ROA. Their results suggest that higher operating costs relative to income significantly reduce profitability, underscoring the importance of efficiency in bank performance.

The regression results show that both the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR) have negative but statistically insignificant effects on Return on Assets (ROA), with estimated coefficients of $\beta = -0.0003$ ($p > 0.05$) and $\beta = -0.0059$ ($p > 0.05$), respectively. These results suggest that in the Bangladeshi banking context, compliance with Basel III liquidity requirements does not exert a meaningful influence on short-term profitability.

The findings diverge from several studies that identified significant effects of these ratios on bank performance. For the LCR, Yeasin [17] reported a positive and highly significant relationship with ROA in Bangladeshi banks, while Arin *et al.* [32] also found a positive effect in Nigerian banks. By contrast, Nath *et al.* [2] documented a significant negative effect in Bangladesh, and Vu [19] revealed an inverted U-shaped relationship in Vietnam, where profitability rises with LCR up to an optimal point before declining due to the opportunity costs of excess liquidity.

For the NSFR, Rokiyanto and Siahaan [16] reported a significant negative impact on ROA among Indonesian banks, while Setiyono and Naufa [15] found a similar global pattern of profitability costs linked to higher stable funding requirements. In contrast, Dang [18] reported a positive and significant relationship in Vietnam, whereas Sidhu *et al.* [30] found no significant effect in Indian banks.

VI. POLICY IMPLICATIONS

The findings of this study provide valuable insights to bank's management, policymakers and regulatory authorities such as Bangladesh Bank for strengthening bank profitability in Bangladesh.

First, the strong and negative relationship between Gross NPL and ROA highlights the urgent need for *stricter credit risk management and loan monitoring practices*. Regulators such as Bangladesh Bank should encourage banks to adopt advanced credit appraisal techniques, strengthen recovery mechanisms, and implement early-warning systems to reduce the accumulation of non-performing loans. Reducing NPLs will not only enhance profitability but also ensure greater stability in the sector.

Second, the negative effect of the Debt-to-Equity Ratio suggests that excessive reliance on debt financing undermines bank profitability. This calls for policies that promote *sound capital adequacy and stronger capitalization of banks*. Regulators should continue enforcing Basel III capital standards and encourage banks to raise more equity capital relative to debt, thereby lowering financial risk and enhancing resilience during periods of stress.

Third, the positive impact of the Deposit-to-Assets ratio indicates that deposit mobilization remains a critical driver of bank profitability. Policymakers should therefore prioritize *strategies that boost deposit growth*, particularly through savings and term deposit products. At the same time, banks should be incentivized to design innovative deposit schemes to attract retail customers and channel these funds into productive investments, thus contributing to both profitability and economic growth.

Fourth, the insignificant effect of the Cost-to-Income Ratio suggests that operational efficiency, while important, does not currently play a decisive role in determining profitability in Bangladesh. However, given the consistent international evidence of a negative CIR–profitability relationship, policymakers should encourage banks to *improve cost management and invest in digital transformation*. This will help reduce overhead costs and prepare banks to remain competitive in a more efficiency-driven global environment.

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Finally, the insignificant effects of LCR and NSFR indicate that Basel III liquidity requirements, while vital for stability, may not directly influence short-term profitability. This suggests that regulators should *strike a balance between liquidity resilience and profitability*, ensuring that liquidity rules are implemented in a manner that safeguards stability without imposing excessive profitability costs.

Periodic review of liquidity standards, alongside capacity building for banks to better deploy liquidity buffers into income-generating opportunities, can help harmonize regulatory compliance with sustainable performance.

VII. CONCLUSION

This study examined the bank-specific and regulatory determinants of profitability in Bangladeshi private commercial banks by analyzing annual panel data from 2015 to 2024. Using a fixed-effects regression framework, the research addressed how non-performing loans, capital structure, deposit funding, operational efficiency, and Basel III liquidity metrics influence return on assets (ROA). The findings reveal that profitability is most strongly shaped by asset quality, leverage, and deposit mobilization: higher levels of non-performing loans and greater reliance on debt financing significantly reduce ROA, while a larger deposit base enhances it. By contrast, the cost-to-income ratio and Basel III liquidity requirements (LCR and NSFR) showed no statistically significant impact on profitability within the study period.

These results carry important implications. For bank management, the findings underscore the necessity of strengthening credit risk management, reducing leverage, and innovating deposit mobilization strategies. For regulators such as Bangladesh Bank, the evidence suggests that strict liquidity requirements can be maintained without materially harming short-term profitability, allowing regulatory focus to shift toward credit quality and capitalization.

By jointly analyzing traditional financial ratios and modern regulatory liquidity measures, this study fills a gap in the empirical literature on Bangladesh and provides actionable insights for balancing profitability with financial stability. Future research could expand the scope by incorporating state-owned and Islamic banks, or by examining how macroeconomic variables and nonlinear relationships interact with profitability. Such extensions would further support policy design and strengthen the resilience of Bangladesh's banking sector.

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APPENDIX

Table A.1: Descriptive accounts of the variables used in the FE regression model

Variable	Formula	Reference
Return on Assets (ROA)	Net Income / Total Assets	[3]
Gross NPL Ratio	Gross Non-Performing Loans / Total Loans	[6]
Debt-Equity Ratio	Total Debt / Shareholders' Equity	[25]
Net Stable Funding Ratio (NSFR)	Available Stable Funding (ASF) / Required Stable Funding (RSF)	[15]
Cost-Income Ratio	Operating Expenses / Operating Income	[14]
Deposit-Assets Ratio	Total Deposits / Total Assets	[11]
Liquidity Coverage Ratio (LCR)	High-Quality Liquid Assets (HQLA) / Total Net Cash Outflows over 30 days	[19]

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Bangladesh: Leveraging Digital Tools for Targeted Investments

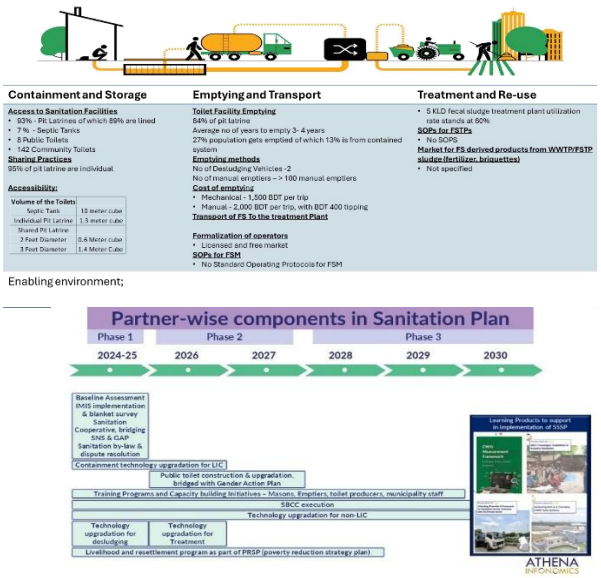
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Abstract: **Urban areas in Bangladesh are grappling with serious sanitation issues due to rapid population growth and insufficient infrastructure. To tackle this, the Department of Public Health Engineering, with support from development financial institutions, launched a strategic initiative to create Strategic Sanitation Service Plans (SSSPs). Lakshmipur was selected as a model town for this effort. With technical support from Athena Infonomics, the planning process involved reviewing existing systems, identifying service gaps, and designing targeted interventions. Digital tools like the EquiServe Tool were instrumental in modeling scenarios and planning investments, helping identify cost-effective and practical solutions. These tools ensured efficient resource use and improved public health outcomes[1]. The Lakshmipur case highlights the value of a structured, data-driven approach to urban sanitation. The lessons learned can guide other government bodies and financial institutions in scaling similar efforts, ensuring sustainable and impactful sanitation planning across Bangladesh's urban centers.**

Keywords - **Inclusive Sanitation Planning; Innovative Digital Tools; Investment Planning**

I. INTRODUCTION



Urban areas in Bangladesh face significant sanitation challenges due to rapid population growth and inadequate infrastructure. Effective sanitation service planning is crucial to keep waste away from residents and maintain public health and hygiene. To address these issues, the Department of Public Health Engineering, with support from development financial institutions such as the Islamic Development Bank and the Gates Foundation, has implemented a comprehensive initiative focused on developing Strategic Sanitation Service Plans (SSSPs). Lakshmipur, one of the model towns in this initiative, required a strategic approach to enhance its sanitation services. This document outlines key steps and process guidelines for local and national government authorities to implement inclusive and safe solutions, mitigating health risks along the sanitation value chain—from safe access and containment to transportation, disposal, treatment, and reuse. It also provides guidance for development financial institutions on how to better target their financial support.

II. METHODOLOGY

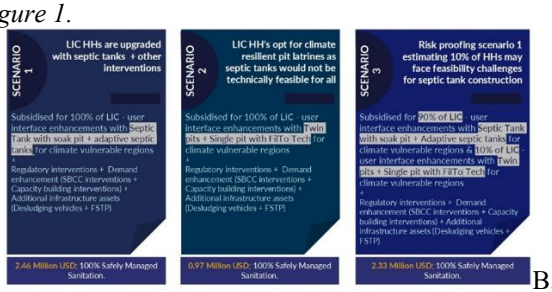
During the development of the strategic sanitation service plan, Athena Infonomics provided technical assistance (TA) support to DPHE and Lakshmipur Pourashava. The planning process began with a review of the Pourashava master plan, which revealed several gaps. These included limited situational analysis, overlooked non-sewered sanitation aspects such as emptying and transport, and a failure to consider the financial burden on households. Additionally, there was a weak analysis of mandate gaps and overlaps, leading to uncoordinated efforts and neglected areas of the sanitation chain. The capacity of public data systems to aid and operationalize service improvements was rarely assessed, and the financial health of service authorities was often ignored, resulting in sub-optimal investments. Furthermore, staffing capacities were not adequately evaluated, and targets were adopted without realistic roadmaps. Plans tended to equate infrastructure with services, focusing on technical specifications rather than customer acceptability and willingness to pay[3].

To address these gaps, Athena Infonomics, in collaboration with the Pourashava, developed a strategic sanitation service plan for Lakshmipur. The process began with forming a dedicated team responsible for developing and executing the plan. This team included stakeholders directly involved in sustaining the city's sanitation efforts and monitoring sanitation-related performance indicators. A Planning Implementation Committee, endorsed by the mayor, was established for the SSSP. This committee comprised elected representatives and municipality staff members, including the sanitary inspector, executive engineer, accounts officer, conservancy supervisor, social development officer, and local DPHE office staff members.

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III. INSIGHTS & FINDINGS

A. Baseline Assessment: As a first step, Athena conducted a baseline assessment in 2023-24 to evaluate the current situation of WASH service delivery within the city. Interviews were conducted with Pourashava staff, healthcare and educational institutions, sanitation service providers including private operators, treatment plant operators, and community members, in addition to surveys with households. The household sample size was statistically representative with a confidence interval of 95% and a margin of error of 3%. A non-response rate of 15% was also factored in. The sample represented residents from all income groups and was distributed across all wards. The baseline included a city profile of Lakshmipur, a climate vulnerability assessment, and an evaluation of sanitation infrastructure and facilities based on the needs of each ward[2]. Findings from the baseline study is presented in *figure 1.*



B. Intervention Design: The SSSP identified gaps in regulatory mechanisms, technological interventions, institutional strengthening, and financial mechanisms. Athena collaborated with development sector partners working in Lakshmipur to develop interventions to mitigate these gaps and costed the different components being implemented *(refer figure 2)*. Additionally, Athena developed process documents to provide ongoing assistance and guidance to the municipality's team, ensuring skills transfer.

C. Scenario Modeling: Athena developed three scenarios *(refer figure 3)* and utilized the EquiServe Tool to identify the most feasible scenario that minimizes investment risks for the municipality. This tool assessed funding requirements, tracked progress within agreed timelines towards achieving safely managed sanitation, and suggested effective strategies to enhance revenue and reduce expenses. Based on the tool's data, while Scenario 1 is the currently adopted investment scenario, Scenario 2 was proposed, which achieves 100% safely managed sanitation with a 60% reduction in investment value. Alternatively, Scenario 1 could be replaced with Scenario 3, which is more realistic. Scenario 3 accounts for the fact that not all households in lower-income settlements can implement septic tanks due to space constraints and would instead rely on alternative onsite sanitation systems, such as climate-adaptive single and twin pit systems. This approach would also result in a lower investment amount compared to Scenario 1.

IV. CONCLUSION

The strategic sanitation service planning exercise in Lakshmipur underscores the importance of following a structured process while developing a sanitation plan[4]. This process should be co-developed with local stakeholders to ensure that the plan is tailored to the specific needs and challenges of the community. Engaging stakeholders such as elected representatives, municipality staff, and local DPHE office members fosters ownership and accountability, which are crucial for the successful implementation and sustainability of the plan.

Digital tools like the EquiServe play a vital role in decision-making and making informed choices. In the context of scenario modeling, data and evidence from the ground, analyzed using the EquiServe tool, demonstrated that there can be alternative options to the initially chosen interventions. These alternatives can drive the most impact out of the investments made, ensuring that resources are used efficiently and effectively. For instance, Scenario 2, which achieves 100% safely managed sanitation with a 60% reduction in investment value, and Scenario 3, which considers space constraints in lower-income settlements, provide more feasible and impactful solutions compared to the initially adopted Scenario 1.

Insights from this planning exercise can be scaled up and adopted by other government agencies and development financial institutions. By following a similar structured process and leveraging digital tools for data analysis and scenario modeling, these entities can develop effective and sustainable sanitation plans. This approach ensures that investments are targeted and optimized, leading to improved sanitation services and better public health outcomes in urban areas.

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Algorithmic Marketing: What Social Media Platforms Shape Purchase Decisions

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Abstract- **Algorithms are all around us in today's world, even in the Marketing arena. This paper investigates how algorithmic marketing on social media platforms such as Facebook, Instagram, and the like shape consumer buying decisions. Taking evidence from multidisciplinary insights, the paper calls attention to how AI and machine learning technologies have redesigned content delivery by enabling dynamic customization that drives consumer behaviour. Our analysis has revealed that algorithmic marketing systems do not only predict the customers' next course of action, but it also reinforces behavioral patterns in them to amplify user engagement, thus guiding consumer decisions subtly in a way that will benefit the company. By harnessing the power of predictive analysis, marketers are able to launch campaigns that are highly targeted and will enhance their strategic outcomes. However, the growing reliance on opaque algorithms raises critical concerns around consumer autonomy, ethical data use, digital transparency, and the probability that it may compromise consumer protection laws. The review concludes by identifying key areas for future research, including the long-term psychological effects of algorithmic targeting and the need for regulatory frameworks to ensure responsible use of AI in marketing.**

Keywords: **AI in marketing, algorithmic marketing, personalized suggestions, social media, Instagram, TikTok, social media influence, social media marketing.**

I. INTRODUCTION

In the digital age, marketing has undergone a radical transformation by moving from traditional media campaigns to data-driven, algorithm-enabled strategies that dominate platforms such as Facebook, Instagram, TikTok, and YouTube. At the heart of this shift lies algorithmic marketing, a system where artificial intelligence (AI) and machine learning tools dynamically tailor content based on user behavior, preferences, and engagement history [1, 5]. This growing reliance on algorithms has not only enhanced the efficiency and precision of marketing campaigns but has also deeply influenced how consumers perceive, evaluate, and decide on purchases [2, 8].

Contemporary research highlights how social media platforms deploy recommendation systems to personalize content feeds, often using cookies and behavioral data to guide consumer attention and stimulate buying intentions [1, 10]. Moreover, the rise of influencer marketing and user-generated content further enhances the reach and effectiveness of these algorithms by fostering trust and peer influence, elements that traditional advertising often lacks [12, 13, 14]. As studies show, a significant portion of younger consumers admit to following influencers' recommendations during their purchase journey, demonstrating the persuasive power of algorithmic stimuli [3]. However, while algorithmic marketing offers unprecedented benefits such as reduced search costs, hyper-targeted promotions, and improved brand visibility [6, 7], it also raises critical concerns. The opacity of algorithmic processes, the potential for bias, risks to consumer privacy, and threats to individual autonomy are increasingly being scrutinized by scholars and regulators alike [5, 9, 11].

This dual-edged nature of algorithmic marketing necessitates a deeper understanding of its mechanisms, its influence on consumer psychology, and the ethical considerations it brings forth. This paper investigates how algorithmic marketing on social media platforms shapes consumer purchase decisions. By synthesizing insights from empirical studies and existing literature, it aims to unpack the role of algorithms in customizing content, influencing behavioral patterns, and driving engagement. The study also explores the potential risks and calls for responsible practices and regulatory frameworks that protect consumer interests while enabling innovation in digital marketing.

II. METHODOLOGY

We primarily relied on secondary data sources to conduct the initial research into this topic by performing a keyword search on Google Scholar and then 20 drawing papers from various journals including the *Technium Social Sciences Journal*, the *International Journal of Engineering Science and Application*, *International Journal of Advance Research in Computer Science and Management Studies*, etc., published in Sage Journals, EBSCO, Emerald, and Research Gate.

III. LITERATURE REVIEW

References [1, 2] state that social networking sites use sophisticated recommendation algorithms to select and show content based on users' demographic and behavioral data, collected through website cookies, and hence encourage consumers to make buying decisions through these targeted stimuli. Moreover, customers use social media sites such as Instagram and TikTok to not only conduct search up on an item of interest before purchasing, but they also engage in spreading word of mouth (WOM or eWOM) through post-purchase interactions with the brands' page and by chatting with their peers about said item.

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The latter ultimately forms a network of information for future customers that directly shapes their purchasing decisions, since customers are more likely to believe fellow consumers and influencers (or opinion leaders) rather than the brand itself [12 - 14]. With similar findings, one research we came across showed that 63% of its younger audience reported following social media influencers in their purchase decisions [3].

The algorithms are programmed to push out user-generated content, sponsored posts, and influencer endorsements that serve as crucial antecedents that shape consumers' problem recognition, information search, and evaluation of alternatives, as described in the Antecedents - Decision - Outcomes (ADO) model [1].

Further research also suggests that algorithmic recommendations reduce search costs and improves the perceived relevance of the brand in the minds of the audience. However, relying on algorithms and AI to draw in more customers often comes at the price of a data leakage risk and algorithmic bias (the systematic and repeatable errors in a computer system that create unfair outcomes, such as privileging one arbitrary group of users over others.) [5, 9, 11].

Apart from choosing the right influencer to promote their brand, and the reliance on social media algorithms to take the wheel for the rest of the promotional journey, brands also need to focus on user engagement metrics - likes, shares, and comments - to magnify their social presence and subsequently heighten their products' visibility to stand out against their competitors and turn clicks to action.

Brands rely heavily on the context of their posts (the day, date, and time it was posted) to achieve these results [6]. Likewise, factors such as the message structure itself, the ease with which it can be understood, empathy, moral reasoning associated with the post, and past helpfulness shape consumer behaviour on social media [7].

One study used predictive analysis and trained machine learning models on big data sets from popular social media platforms like Facebook, Pinterest, Instagram, and YouTube and concluded that with the data it was provided, the model was able to achieve a 98% accuracy rate in predicting consumer behaviour patterns, including their engagement levels and the likelihood of them making a purchase in the end [8]. Furthermore, algorithmic marketing enables cluster analysis which groups customers based on how they engage with posts and their demographics so that brands can approach each group with differentiated marketing strategies [7].

Even though it has numerous benefits for brands, researchers across board have one common concern for algorithmic marketing: *privacy*. Most users are unaware of the way their data may be collected and used (*through website "cookies"*) by the sites they visit, and how algorithms may gradually influence their purchase decisions with it [10]. Moreover, users may become overly reliant on algorithmic marketing, thus affecting their self-efficacy and autonomy levels when making a purchase [5].

Reference [10] also talks about the FOMO (*fear of missing out*) trap laid down by social media sites and algorithmic marketing that forces users to constantly stay online for hours, just so that they don't miss out on the latest trends or news-bit. Social media sites further push this notion by sending users constant notifications about new posts, likes, shares, and messages - all of which often go unnoticed by customers until they're too addicted to their phones, or have already become too accustomed to having products recommended to them by the algorithm.

In the same study, respondents reported that with prolonged exposure to algorithmic marketing, their purchase decisions have started to be shaped by the algorithm, even in cases where they may not need the product they just added to their cart [10].

To conclude, algorithmic marketing is definitely a powerful tool for marketers to promote and sell (and also upsell) their products to their customers by mobilizing data-driven customization and integrated business features. However, marketers should also maintain the fine line between exposure that is necessary and overexposure.

Additionally, they should be transparent about the data they're collecting and how it may be used. Lastly, algorithms should be designed to promote and strengthen customer autonomy instead of making users fully reliant on it.

IV. FINDINGS & DISCUSSION

Recent literature mentions that algorithmic marketing uses AI and big data to change how businesses connect with consumers. Reference [11] describes it as the merging of technological progress and data science in marketing, where algorithms play a key role in extracting value from data. In the real-world, companies use an ongoing data collection process and machine learning models to automate, tailor, and optimize their marketing efforts. Systems like these can improve customer experience, satisfaction, loyalty, and efficiency by customizing options based on user data [5]. One study we looked into used unsupervised machine learning on social media inputs to identify consumer segments, thus enabling targeted strategies and offerings [7].

E-commerce sites use recommendation engines that analyse user activity to suggest products, thereby enhancing CX and increasing overall company sales. One study [8] found that predictive analytics using large datasets from social media can forecast consumer behaviour with up to 98% accuracy, and can hence be used as a support mechanism for target marketing. Furthermore, AI-driven platforms such as TikTok and Instagram use personalised content in real-time, thus significantly boosting user interaction and retention [16].

On a broader scale, automated algorithms and data analysis allows marketers to achieve a deeper level of personalization, segment their markets more effectively, and achieve better predictive capabilities than conventional methods.

AI-powered algorithmic tools contribute substantially to enhancing both the efficiency and effectiveness of contemporary marketing practices. Reference [15] states that such technological advancements can significantly

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optimize marketing operations, while also facilitating strategic planning and campaign executions. On the other hand, employed machine learning techniques can help to analyze a vast dataset of Instagram posts, identifying key textual and visual elements that correlate with heightened user engagement - therefore offering empirically grounded guidance for content optimization [6].

A study conducted further highlights the precision enabled by algorithmic targeting on social media platforms, where the analysis of user behavior and demographic data allows marketers to deliver tailored messages to the most relevant audiences - thus enhancing campaign impact [1].

Furthermore, empirical data supports these claims as the same research found that approximately 70% of consumers are influenced by social media when making purchasing decisions, with over half actively using such platforms for product research.

Moreover, influencer marketing has become a pivotal component of algorithmic outreach, with social media personalities acting as trusted opinion leaders whose endorsements greatly impact consumer behavior. In the beauty and cosmetics industry, influencer-driven opinion leadership on Instagram notably increases both purchase intentions and actual buying behavior, thus making it a potent channel for brand communication [13].

Social networks also allow firms to capitalize on user-generated content and peer influence at scale, enabling widespread dissemination through digital word-of-mouth recommendations. This synergy between artificial intelligence and social media platforms translates into concrete business benefits. Personalized recommendation systems improve click-through rates and boost sales performance while also enhancing customer satisfaction and fostering brand loyalty [17].

From the literature we reviewed, we also came across some that examined how consumers perceive algorithmic decision-making compared to human judgement. Reference [18] visualised a shift towards “algorithmic consumers”, where AI agents independently manage purchases by predicting references and negotiating transactions. While this does show us the disruptive potential of AI in consumer behavior, psychological studies point to mixed reactions from users.

One such study [19] showed that people usually respond differently depending on whether the suggestions are delivered by humans or by AI-driven algorithms. Positive results (like approval) generally got lower satisfaction ratings when it came from an algorithm, as opposed to when it came from a human. In simpler words, people tend to react more positively when good news is delivered to them by a person rather than an AI machine. However, bad news delivered by both a human and AI yielded similar responses.

At the same time, algorithms shouldn’t be given too much or too little power, as doing so would reduce their overall effectiveness. This “sweet spot” depends on multiple factors including a person’s confidence when using technology and their cultural background [5]. In an online retail environment, many consumers prefer personalised recommendations, mostly because they save time and effort on the consumer's part [20]. However, some consumers still worry about losing their control to AI systems they don’t fully understand.

V. CRITICISMS & LIMITATIONS

In addition to its advantages, the scholarly literature emphasizes several critical, ethical, and practical challenges associated with algorithmic marketing. A primary concern revolves around consumer autonomy and data privacy. Researchers identify a fundamental tension between delivering personalized content and engaging in intrusive data surveillance, raising pressing questions about the adequacy of informed consent in AI-mediated environments [16]. In line with this, qualitative findings reveal that participants frequently expressed apprehension over AI-based marketing infringing upon their sense of autonomy, thereby reinforcing the need to uphold individual agency in algorithm-driven interactions [20].

Reference [10] conceptualize social media algorithms as powerful content “gatekeepers” that influence user exposure and behavior, sometimes fostering phenomena such as fear of missing out (FOMO), which in turn can significantly shape consumer decision-making. Over time, this type of algorithmic curation may contribute to the suppression of diverse viewpoints, reinforcing echo chambers or limiting consumer choices through selective content amplification.

Another prominent issue pertains to trust and perceptions of fairness. Scholars have noted that consumer trust in algorithmic recommendations may diminish, particularly in high-stakes contexts where transparency is perceived as lacking. Authors also caution that even well-intentioned algorithmic interventions can lead to adverse effects on customer satisfaction when users perceive the system as impersonal or biased [19].

Reference [15] emphasizes the imperative of ethical AI system design, arguing that fairness, accountability, and honesty are essential to maintaining consumer confidence and safeguarding brand reputation. Nonetheless, real-world implementations of AI tools are susceptible to algorithmic bias or inaccuracies, which can result in misdirected advertisements or the exclusion of certain user groups - often provoking public criticism or reputational risk.

Concerns about authenticity further complicate algorithmic influence, mainly in the domain of influencer-marketing. Approximately 58% of consumers express skepticism regarding the transparency of influencer endorsements, illustrating the need for rigorous standards to ensure credibility and prevent deceptive practices [1]. More broadly, [11] critique the systematic power asymmetries exacerbated by algorithmic profiling. They argue that as organizations increasingly rely on granular consumer data, the resulting algorithmic influence introduces new strategic vulnerabilities and ethical dilemmas.

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At its most extreme, unchecked algorithmic systems risk creating rigid, manipulative marketing frameworks that compromise consumer agency and may erode long-term trust in both brands and digital platforms.

Studies also point out a few technical and organizational criticisms of relying on algorithmic marketing. For instance, advanced algorithms need complex data analysis and skilled professionals, and many companies lack the expertise or resources to manage them properly. Privacy laws and data security concerns add another layer of difficulty and data-driven strategies must work with both ethical and legal boundaries [11].

Customers may get overwhelmed when faced with too many personalized suggestions leading to decision fatigue or even encouraging impulse buying behaviour [20]. Likewise, algorithmic feeds can also create "filter bubbles" and users may only be exposed to familiar content while missing out on newer perspectives and options.

VI. CONCLUSION

After reading through all the literature we used to write this paper, we agree that AI-powered marketing offers major benefits in efficiency, personalization, and customer engagement. These tools help businesses reach niche markets, fine-tune their advertising tactics, and use data from social media to turn clicks to sales. However, all the literature we reviewed also stressed the importance of ethics, transparency, and consumer autonomy. Needless to say, all the studies highlighted one key point: even though algorithmic marketing and decision-making has tremendous potential, companies should maintain transparency and give their customers a sense of control to build trust that will last. Using algorithmic marketing in the future should remain focused on the human-aspect of marketing, ensuring AI benefits consumers and companies, instead of sabotaging their right to autonomy and privacy.

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Green Business Practices for Competitive Advantage in the International Market: A Study on Green RMG factories in Bangladesh

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Abstract—***Companies across industries endeavor to gain competitive advantages in many ways. However, gaining a competitive advantage through green resources and capabilities, especially for RMG companies located in major sourcing destinations worldwide, is the new competitive frontier and a means to stay relevant in the intensely competitive fast-fashion industry. However, research into the factors that comprise green business models and how green business practices can enable the development of strategic capabilities, thereby helping to gain a competitive advantage for RMG companies in Bangladesh, the second-largest RMG exporter in the world, remains an underexplored issue. The primary objective of this study is to investigate the relationship between the green business practices of RMG factories and their competitive advantage in the international market. It aims to reveal how the green movement, climate change, and sustainability concerns shape the competitive dynamics of the fast-fashion industry. It is a qualitative study that primarily utilizes secondary data from reliable sources. Data about LEED-certified green factories is collected from the USGC, and export details of the companies are collected from Textile Focus and BGMEA. A well-structured thematic analysis is conducted to extract insight from the qualitative secondary data. The findings show that sustainability, fair trade, human rights, worker rights, animal rights, recycling, reuse, and reduction provisions primarily drive the sourcing policies of major fast-fashion companies worldwide. In major sourcing destinations like Bangladesh, companies that follow these provisions, model green business practices, and secure LEED accreditations have an edge over their rivals in bagging good deals. Companies at the forefront of going green in holistic business operations and on the verge of becoming environmentally, ecologically, socially, and equitably responsible players are getting a competitive advantage in local and global markets. The findings suggest the importance of acquiring green resources and capabilities for the RMG companies to stay competitive in the continuously changing fast-fashion industry. Due to widespread discourse on climate change, green consumerism, green technological advancement, and rapid information dissemination, it has become imperative for the RMG companies to adapt to these changes to stay competitive.***
Keywords—***Green business practices, competitive advantage, sustainability, RMG industry, LEED-accreditation, and strategic capability.***

I. INTRODUCTION

The ready-made garments industry is the lifeblood of Bangladesh's economy. More than 4,000 factories employ approximately 4 million people, primarily women, and more than 150 countries import apparel from Bangladesh [1]. According to the Export Promotion Bureau, almost 84% of the foreign currency ($47 billion in 2023) is generated from this sector alone [2]. In terms of women's empowerment and nation branding abroad, no other industry comes close to the RMG sector. The sustainability of this sector is critically important for Bangladesh's economy as competition is intensifying globally. Different dynamics and their savvy execution can give Bangladeshi RMG factories core competencies, alongside their existing low-wage advantage, to dominate their position in the international market. The green revolution is the buzzword across the RMG sector. It resonates well with the global movement for climate preparedness, eco-friendly market offerings, and the sustainable development agenda followed as a benchmark worldwide. This study aims to reveal the relationship between green business practices and the competitive advantage they may engender for the RMG factories in Bangladesh. This study also aims to unfold whether greenwashing can solidify the "Made in Bangladesh" tagline, a robust rebranding maneuver.

As a climate-vulnerable country like Bangladesh [3], it is difficult for policymakers to face this challenge alone. Climate change is becoming a juggernaut and must be tackled from many different facets simultaneously. Business communities have roles to play as business activities are tangibly responsible for many of today's predicaments on planet Earth [4]. Keeping this in mind, green business practices by the business communities can go a long way to minimize the environmental impact of their operations: reduce waste, conserve resources, and use renewable energy. Aligning with these green endeavors, leading RMG factories in Bangladesh are steadily going through a green revolution. Alongside demonstrating their commitment to the planet Earth, business interests such as receiving more orders from global buyers and getting an edge over competitors from Vietnam, Cambodia, India, Myanmar, China, etc., dominate the drive behind green business practices of RMG factories located here in Bangladesh [5]. In this study, we focus on the sustainability endeavors of the factories in Bangladesh and show how green actions pave the way for long-term profitability, offering a promising future for the RMG industry.

In the era of cutthroat competition, sophisticated customers, the green movement, and hyper-critical media outlets worldwide, sustainable and green business practices are pivotal for companies to keep themselves competitive [6]. Considering the environment, the needs of both present

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and future generations, and the economy at large, green business practices can pave the way for modern corporations to get an edge over competitors and win the hearts of today's well-informed, chameleon customers in many ways. Heading towards sustainable business operations will be the decisive moment for companies in the RMG industry in Bangladesh to ensure sustainable profitability. Sustainability through green business practices is already the contemporary vibe in the industry, as statistics show that Bangladesh hosts almost half of the green factories across the globe [7]. The way green initiatives give an edge over competition in the international market is one of the significant interests of our study. We will also investigate how well-equipped Bangladeshi factories are compared to their global counterparts. The findings of our study can be a critical learning point for other companies not in the green mission yet to follow suit, so that they can make themselves edgy and relevant in the global marketplace.

From a socio-economic perspective, RMG is one of the most important sectors. However, not much research is conducted to address the contemporary sustainability issues of this industry. Therefore, our study adds new dimensions to the existing literature on green business practices. Another uniqueness of this study is that it has articulated a specific strategic direction for ready-made garment companies currently engaged in green business practices and set examples for those that have yet to take any green initiatives. This study aims to answer these two research questions:

- Do the factories that follow green business practices get a competitive advantage in the international market?
- Is there any relationship between green business practices and competitive advantage?

II. RESEARCH OBJECTIVES

The following research objectives are at the core of this study, and they aim to address the above research questions.

- To identify the relationship between the green business practices of RMG factories and competitive advantage in the marketplace.
- To discern the mediating factors that impact green business practices and competitive advantage over rivals in the international market.
- To pinpoint the resources and capabilities required for the green revolution across the RMG industry.
- To evaluate the rebranding actions that portray green business practices and justify the merit of these actions based on existing literature.
- To identify how green actions protect the environment, preserve the climate as it is, and ensure sustainable profitability for business.

III. LITERATURE REVIEW

A. *Green Business Practices:*

Green business practices incorporate eco-friendly and sustainable principles into all business functions, from supply chains and manufacturing to operations, marketing, human resource management, and finance, aiming to mitigate environmental impacts and promote circularity through recycling and reuse. Green business practices seek to strike a balance among people, planet, and profit by reducing adverse effects on the local and global environment, considering the long-term well-being of society, and ensuring sustainable profitability by eco-friendly market offerings that utilize green production processes in the entire value chain network [8]. The core principles of green business models are sustainability, environmental responsibility, resource efficiency, and a circular economy. Green business practices often include renewable energy usage, waste reduction and recycling, sustainable sourcing, water conservation, green building, sustainable packaging, employee engagement, carbon footprint reduction, sustainable transportation and logistics, and green procurement.

Literature is fraught with the positive impact of green business practices across industries. Green business practices are a proven and time-tested endeavor that ensures a long-term revenue stream and a sustainable competitive advantage over market competitors. Despite allegations of greenwashing, which can mislead customers [9], green business practices are revolutionizing industries worldwide. The fast fashion industry and its central sourcing hub, Bangladesh, are at the forefront of implementing a sustainable value chain network. Particularly, the ever-increasing presence of LEED-certified green factories in Bangladesh reflects the prevailing business sense to meet the demands of eco-conscious, sophisticated customers and fulfill local and global regulators' environmental terms and conditions. Competitive advantage in the international market also largely depends on how responsibly companies act for the common future of all stakeholders. The measures of green business practices, namely supply chain, marketing, operations, finance, and people management, are elaborated from the competitive advantage perspective in the following section.

1. *Green Supply Chain Management:*

Green Supply Chain Management (GSCM) in the RMG sector facilitates all steps of traditional supply chain activities, encompassing concerns about environmental hazards. This practice addresses products' environmentally friendly closing loop, from sourcing, designing,

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manufacturing, packaging, storing, collaborating with stakeholders, transporting, and disposal to the end of the product's life cycle [10]. To elucidate, firms can ensure green supply chain management in application with some actions such as: green logistics (less fuel consumption and emission by using renewable energy sources and reduced toxic dispersion [11], green warehousing, reverse logistic, waste management [12], green transportation, choosing correct route for product delivery to waste less fuel and emission that enhance the probability of gaining competitive advantage [13] and [14]. Moreover, one of the focal points of sustainability practice is remaining vigilant with green practicing stakeholders in planning policies and strategies regarding technology adaptation and diffusion, reduced corruption, less lead timing, etc. [15] and [16]. Therefore, the emerging green supply chain management [17] is a panacea against many hazardous business practices, such as environmental pollution, customer deprivation, unfair procurement, compliance breach, and so on [18].

Bangladesh's logistics management practices across industries heavily rely on fossil fuel, thus emitting an alarming proportion of carbon dioxide, greenhouse gases, and other perilous gases that can endanger the environment and climate [19]. However, the global trend towards competitive advantage appreciates businesses that leverage lower emissions and lower pollution for sustainable long-run growth. Therefore, cross-border trade organizations incorporate green supply chain management practices for international image-building and improved organizational outcomes [20]. While GSCM is prevalent in developed nations, a promising developing nation like Bangladesh has drawn negligible interest in the implementation of this practice [21]. Bangladesh, being the second-largest exporter of RMG products in the global market [22], can secure a competitive advantage by implementing green practices from material sourcing to recycling [23]. The GSCM functionalities can ensure profitability and capture market share by reducing environmental risks and promoting sustainability [24]. This practice uplifts organizations' financial performance and enables them to achieve a competitive advantage [25]. In this regard, Porter's classical theory of "cost differentiation" and "product differentiation" strategies of gaining competitive advantage are replaced by the orientation of green and sustainable supply chain management [26].

However, greening a supply chain must be made with existing resources, thus often confronting some barriers, especially in a developing country like Bangladesh [10, p.3]. According to Rupa and Saif [27], implementing GSCM practices varies based on cost incurred, profit gain, time allocation, waste disposal, resource consumption, and greenhouse gas emission. Inadequate IT infrastructure, high waste disposal costs, uncertainty and fierce competition, inertia, and insufficient support from top management are the significant barriers to implementing GSCM practices in Bangladesh. Therefore, Khan et al. [28] have proposed extended investment, efficient utilization of renewable energy, and green operational support as the solution to implementing green supply chain to gain a competitive advantage. In addition, Hu *et al.* [29] have mentioned the outstanding role of FDI in implementing GSCM. Such initiatives can bring better opportunities for RMG firms to capture the lion's share of the global export market by gaining a competitive advantage [30].

2. *Green Marketing Management:*

With the growing demand for amalgamation between business practice and environmental concern, the concept of green marketing keeps a foot in the door in designing sustainable marketing policies [31] and [32]. A more holistic definition of organic or green marketing emphasizes innovating, promoting, packaging, recycling, and reusing products in an environmentally friendly manner. In addition, some studies pointed out that green marketing is how an organization improves its planning regarding pricing and promotion of products to satisfy customer demand, along with mitigating the adverse impact on the environment [33] and [34].

Previous studies have found that green branding management and profiling opportunities enable firms to explore competitive gain in the global market [35] and [36]. Some common tactics are green packaging [37] and ecolabeling [38]. Green packaging is concerned with the volume and weight of packaging and reducing packaging waste [39]. Ecolabeling, also known as green or environmental labeling, provides a clear signal to customers regarding the environmental image of product manufacturing and branding. According to Chemat *et al.* [40], eco-labeling attracts customer attention by distinguishing the environmentally clean product from conventional ones. Moreover, this practice depicts an organization's corporate social responsibilities to stakeholders.

Another prominent stream of green marketing is placing products in the exact market position to green consumers who purchase ecologically clean products, appreciate reuse, and avoid wastage of natural resources. In this regard, LealMillan *et al.* [41] added that worldwide environmental awareness has positively influenced consumers' buying behavior of green products. Therefore, better segmentation of green consumers based on their psychographic characteristics can facilitate the creation of efficient green marketing strategies and help them gain a competitive advantage.

Proposed by Esmaeili *et al.* [42], green marketing has four facets: lean green (an approach concerned about social welfare without any promotion), defensive green (when an organization adopts green marketing to cope up in competitive environment), shared green (when an organization thinks green marketing is an opportunity for long term sustainable growth and gaining competitive advantage) and extreme green that fully addresses

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environmental issues in a product's life cycle. The "going green" concept can become appealing to a firm for revenue growth and cost savings. The increasing revenue comes from distinguished products, brand image, reaching green customers, and efficient production [43]. Going green distinguishes a business from others and gains a competitive advantage. Though green marketing may incur additional costs, it brings tangible commercial benefits and enhances profitability. In his study, Porter [44] addressed the need for a generic competitive strategy focusing on efficient production through minimized marketing costs, creating unique and quality products, improving brand image, and focusing on market segments to gain a competitive advantage. This sustainable marketing strategy signifies better business performance by implementing social responsibilities and enhancing competitive advantage [45] and [46].

3. *Green Operations Management:*

Green operations include activities that reduce firms' environmental footprint, including less energy consumption, eco-friendly sourcing of raw materials, and reducing waste and toxic dispersion. In recent times, the surge of worldwide demand for RMG products has directly damaged the reputation of the textile industry for being accused of ecological catastrophes such as emitting carbon, water pollution, unsustainable natural resources, energy consumption, and waste generation [5. p.2]. Thus, the RMG industry is now under pressure from several global entities, such as the United Nations, cross-border governments, customers, and employees [47]. In this regard, adopting green manufacturing practices (GMPs) in the RMG industry can lessen the unfavorable production's impact on the environment and simultaneously boost the profitability of textile industries by gaining a competitive advantage [48].

One of the prerequisites of green operations and manufacturing is arranging organic sourcing [49] and finding the right supplier committed to the green concept [50]. Another significant aspect of green operation is ensuring efficiency in manufacturing techniques. Green production aims for more output with fewer resources and energy consumption. Green manufacturing strives to minimize soil degradation, air and water pollution, and wastage [51] and [52]. In this regard, earlier studies have found that using eco-friendly renewable energy sources can lower the carbon footprint and cause less environmental harm [53] and [54]. According to Abreu *et al.* [55], lean-green models aligned with eco-efficient green operations can improve green managerial practices, supply pollution control technologies, minimize waste, and improve financial performance. Al-Hakimi *et al.* [56] added that green manufacturing reduces regulatory compliance costs, ensures workplace and ecological safety, and lessens potential liabilities. Thus, green operations improve corporate image and help to gain a competitive advantage in the international market [57].

In addition, Pal and Gander [58] have found that incorporating a sustainable business model can benefit RMG industries to compete in the global fashion industry by creating better value. Manufacturing demand-driven products with green energy, less extra production, efficient waste management, and technologically specialized equipment can give firms an edge over others [59] and [60]. Instead of cancelling any RMG item, installing a tailoring system can slow down wastage further. A closed loop is attractive for sustainable sourcing to disposal [61] and [62]. In their study, Chuang & Huang [63] found that environmental corporate social responsibility positively impacts green IT human capital, structural capital, and relational capital.

Additionally, Green IT structural and relational capital positively influence environmental performance and business competitiveness. Moreover, Cheng *et al*. [64] added that the coupling synchronization of economic (output and efficiency) and social subsystem (social infrastructure, scientific innovation, lifestyle) can boost the regional green competitiveness. New or modified production equipment that facilitates cleaner production by minimizing environmental load is called eco-innovation and green process innovation positively and significantly impacts a firm's long-term benefits [65], [66], and [67].

Following the green operations and building necessary infrastructure, RMG firms are looking for "4Rs"- reduction (of waste and resource consumption), reuse, recycling, and recovery [68]. "Eco-design" practices bring profit to firms by promoting easier recycling and savings on packaging [69]. Additionally, by efficiently utilizing waste, any RMG firm can incur cost savings [70]. Consequently, the firm can reduce its product pricing and gain a competitive advantage in the world export market [71].

4. *Green Human Resource Management:*

Green human resource management implies efficiently managing all HR practices targeting environmental sustainability. This approach integrates green selection and recruitment, green training and development, green compensation and benefits, green performance management, and green employee relations. Implementing green business directly relates to an organization's human resource management capability. According to Chaudhry *et al.* [72], stakeholders' engagement, supportive top management, empowered workforce, effective communication, relationship building, collaboration, and proactiveness can uplift an organization's competitive advantage. In this regard, Zhao *et. al.* [73] have found that green transformational leadership, HRM, and innovation significantly impact a manufacturing firm's sustainable business performance.

Green recruitment and selection attract green human capital to a business firm. According to Hatch and Dyer [74], the embodied knowledge and set of skills turn an employee into human capital. Green human capital

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comprises the workforce's knowledge, skills, and abilities, encompassing green attitude, commitment, sustainable innovation, and green entrepreneurship. Additionally, other studies found that green human capital and eco-innovation increase green competitive advantage [75] and [76], although they might not always have a significantly positive impact [77] and [78]. Educating and training employees with the light of green energy-saving technology, along with green IT capabilities, creates green IT human capital [79]. Incorporating Green IT human capital enhances productivity with eco-friendly production methods.

Green human capital contributes to competitive advantage thanks to its inimitability based on its intangible and socially complex nature. From the resource-based view of firms, green human capital is superior to others; thus, they can improve and enhance productivity by learning eco-friendly techniques. Another aspect of green human resources is green entrepreneurial orientation. Chuang and Huang [80] found that green entrepreneurial orientation and market orientation have a significant positive role in green supply chain management practices that affect firms' sustainability index. Therefore, green HRM practices such as recruiting green human capital or training the existing employees with green concepts, promoting green office cultures such as a paperless system, less commuting emissions, energy conservation, and waste reduction can significantly influence cost savings, improve corporate image, and thus assist in gaining a competitive advantage in the global market.

5. *Green Financial Management:*

Green Finance in the RMG sectors refers to investment and financing in projects concerned with sustainability and ecological balance. This practice refers to investing in eco-friendly projects such as implementing renewable energies, green technology, recycling, waste disposal equipment, etc., in RMG firms. Moreover, financing in more energy-efficient structures [81] and [82], financial support provided by the government [83], tax rebate facilities, subsidies, and feed-in tariffs for power generation [84] are other modes of green finance.

According to Falcone [85], investing in green projects is still challenging because of high intensity, complexity, and uncertainty. In this regard, green finance can be a propeller in accelerating the sustainable transition process. Despite risks, green financing can emphasize the pollution tax imposed on RMG firms' output or workforce size. RMG firms can be taxed for pollution emissions above the target based on the pollution target and subsidized for better performance [86]. Regulators can redistribute to firms that will lessen the negative impact.

Furthermore, regulators can subsidize RMG firms to enhance R&D to adopt cleaner technologies, ultimately producing greener products. This policy will open the door to the global market, where green labels are valued. Eventually, this may welcome drastic foreign investments from importers of RMG products. Therefore, strategic investment in green financial projects is important. Nohong *et al.* [87] stated that there is a strong association between strategic finance and green competitive advantage. Financing strategically in green projects enables the RMG sector to align with worldwide competitors and may help it gain a competitive edge.

B. *Strategic Capabilities*

Strategic Capabilities refer to the individual skills of the employees and unique resources emerging from the interplays and interactions of different actors within the company. Strategic capabilities could emerge within team members, between workers and managers in the form of workplace camaraderie, and between personnel and tangible assets in the form of optimizing outputs. These interactions could be omnipresent across various industries and contingent upon the caliber of the individual forms to develop [88]. Strategic capabilities are often considered crucial sources of sustainable competitive advantage worldwide compared to other tangible or intangible resources companies possess. Barriers to duplication, strong working relationships among supply chain network partners built over years of experience, complex design, engineering excellence, and robust quality assurance systems often shape companies' capabilities across the industry. Green capability-building endeavors can drive RMG firms to redefine their ability and compete in the global market. The forward-looking RMG firms in Bangladesh are emerging as dominant forces in green capability building to gain strategic agility and outperform their regional and global rivals in the fast-fashion industry. A strong ecosystem of individual skills of people working in the RMG companies in Bangladesh, their interactions among themselves, keenness to follow green business models, and acquire necessary skills through learning experiences are positioning RMG firms to revolutionize the sustainability movement through green initiatives and implementations.

Similar cost structures, tax waivers, government incentives, and access to specific resources do not generate competitive advantages [89]. The strategic capabilities that lead to competitive advantages are company-specific and embedded in procedural arrangements, unique system excellence, and an incomparable amalgamation of human skills and company resources. Competitive advantage also relates to dynamic capabilities built on robust research and development and business acumen to implement green marketing strategy [90] and [91]. By exploiting these capabilities and implementing green business models, the largest and most successful RMG firms have achieved LEED certification, awarded to factories designed and built to reduce energy and water usage, improve air quality, and uplift living standards significantly higher than required by domestic laws. Competing beyond geographic territories and ensuring competitive advantage over other global

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players, top-tier LEED recognition enhances the credibility of Bangladesh RMG firms. Furthermore, the impact of buyers' strict sourcing policies has led forward-looking RMG firms to adopt cleaner production measures through an integrated strategy that maximizes profits. It helps these firms make more efficient use of inputs (such as energy, water, or chemicals) while increasing production and minimizing waste and pollution at source.

Green business practices assist RMG companies in developing strategic capabilities. All the functional aspects of green business practices—green supply chain management (sustainable sourcing, in-bound and out-bound logistics), green marketing management (eco-friendly products, eco-packaging, eco-labelling, eco-positioning and green brand imagery), green operations management (recycle and reuse, reducing carbon footprint, using renewable energy and conserving and optimizing resources), green HRM (green recruitment and selection, training and development, compensations and benefits) and green financial management (green investment, return on invest and measuring green financial performance)—are the orchestrators behind versatile strategic capabilities that firms seek to acquire. These acquired capabilities, either through process buildup or resource creation, lead to competitive advantages for firms in the international market.

C. *Competitive Advantage*

The green business model for sustainable development determines companies' green competitiveness [92]. The paradigm of competitiveness is changing and gradually leaning towards companies that focus on corporate green performance, which incorporates green innovation [93] and [94], improved products or processes [65 p.7] in a way that fulfils the customers' quality concern and environmental performance simultaneously [95]. Long-term sustainable performance, continuous pressure from investors, consumer rights groups, and strict regulation from local and international bodies, is replacing short-term thoughts of profiteering. The race towards sustainability and corporate green performance is accelerating among firms to get an upper hand over market rivals by green offerings, installing green processes [96], and practicing green management [97] to mitigate the environmental impacts of business operations. Fleeting competitive advantage due to widespread imitation is gaining new momentum thanks to sustainability features in business activities.

The concept of competitive advantage has undergone significant changes. Moreover, it is inevitable because competitive advantage is not something companies can enjoy without the necessary changes to keep themselves relevant in the dynamic marketplace. Contemporizing business practices is needed to keep pace with competition and lead from the front. Firms should strive to develop unique characteristics that distinguish them from competitors in the eyes of the consumer [98]. In their studies, Hamel and Prahalad [99] and Dickson [100] discussed the need for firms to create new advantages that will give them an edge over competitors. Though the term sustainable competitive advantage emerged in the work of Porter [101], no elaboration of the concept researchers developed until Barney [102] formally defined sustainable competitive advantage: "*A firm is said to have a sustained competitive advantage when it is implementing a value-creating strategy not simultaneously being implemented by any current or potential competitors and when these other firms are unable to duplicate the benefits of this strategy*" (p. 102). In a nutshell, sustainable competitive advantage refers to a unique situation of value creation endeavor, not simultaneously pursued or readily imitated by current or potential competitors. If implemented and sustained prudently, going green in every aspect of business operations could be the right move towards sustainable profitability.

Firms can achieve a competitive advantage by configuring a strategic system developed through a green business model. The strategic system resource is a socially complex network of tradable and non-tradable factors. The complexity of this relationship makes it difficult for competitors to imitate. The green caliber that firms build regarding physical, human, and organizational capital resources allows firms to exploit opportunities or neutralize threats, creating a competitive advantage. Robust competition, regulatory changes, and technological advancement are catalysts to develop strategic green resources, which help firms achieve and sustain competitive advantage [103]. The resource-based view of the firms asserts that although a given firm may possess many resources, only those resources that are valuable, rare, inimitable, and non-substitutable provide a sustainable competitive advantage [104]. Adopting a green approach, fast fashion companies can gradually thrive by accumulating new resources and capabilities. The RMG firms that successfully leverage valuable, rare, non-substitutable, and difficult-to-imitate resources will likely gain an advantage over their market competitors, thus ensuring superior profitability [105].

Climate change, environmental protection, the circular economy, and sustainable development are creating a new consumer class that is significantly watchful of responsible consumption and galvanizing consumerism worldwide. The size of this consumer pool is getting bigger and necessitates green offerings to meet sophisticated stated and unstated consumer needs. Competitive advantages are leaning toward those RMG firms that can tap into the new resource-creation abilities of the fast fashion industry. Sustainability features in products and production process, responsibility to people and planet, and 3R initiatives are the crucial ground to build resources and capabilities.

III. METHODOLOGY

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It's a qualitative study, primarily based on reliable secondary data. A thematic analysis is conducted to develop common themes [106] and to articulate the commonalities of sourcing policies followed by global garment buyers. The validity of this approach is established by earlier studies in business and management research [107] and [108].

A. Data Sources

Secondary data is analyzed for the study. The LEED-certified company's accreditation details are collected from the USGC [109] official website. Major exporting companies and their details are collected from the Textile Focus website, a specialized textile-oriented news portal. Information on the overall scenario of the RMG industry is gathered from the website BGMEA [110], the leading trade body consisting of RMG owners. The sourcing policies of the global buyers are collected from their respective publicly available websites to inform their relevant stakeholders about transparent business practices. Only official sources are considered for maximum credibility and reliability throughout the data collection process. Extraneous information and unnecessary details are discarded to ensure relevance to the study.

B. Qualitative Analysis:

1) Thematic Analysis: It refers to identifying recurring themes and patterns in textual or narrative data [111]. Presumably, the qualitative research involves systematically reading and interpreting data to extract meaning and understand different perspectives [112]. A thematic analysis is conducted to identify a common theme in the sourcing policy of global buyers from publicly available information. The following approaches are followed to discern the desired theme:

- Familiarization: Become thoroughly familiar with the data and information on the sourcing policy of global suppliers, especially those who have operations in Bangladesh, often through multiple readings.
- Categorization and Tabulation: The sourcing policies of global garment buyers are categorized and tabulated into relevant sections of the data to generate potential themes.
- Theme Development: Themes that substantiate the versatile aspects of green business pertinent to the global fashion industry are carefully developed.
- Reviewing Themes: Identified themes are carefully crafted and well-defined to establish relevancy with research questions on green business practices in the RMG industry and the dynamics of competitive advantage in the international market.
- Defining and Naming Themes: Clearly defining what each theme represents and giving them concise, understandable names such as sustainability, human wellbeing, animal welfare, responsible sourcing, human rights, people's policy, supply chain policy, and protecting the planet—all these address different aspects and outcomes of green business practices.
- Writing Up: Presenting the findings, demystifying the identified themes, supporting evidence, interpreting research results to address research questions, and achieving the study objectives.

TABLE 1: STEPS FOLLOWED FOR THEMATIC ANALYSIS

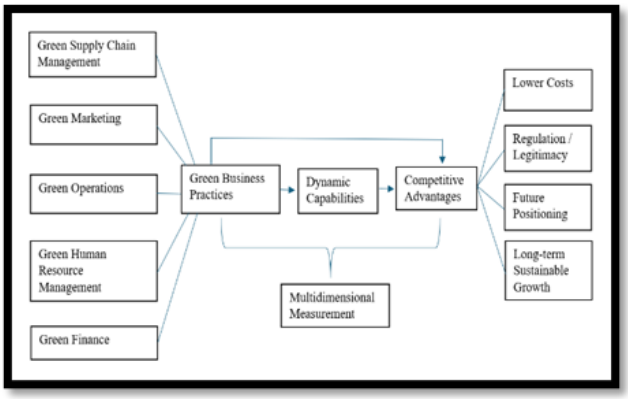
STEPS	THEMATIC ANALYSIS	DESCRIPTION
1.	Familiarization	Orienting with relevant data
	Categorization and Tabulation	Tabulating information into specific sections
	Theme Development	Developing a common theme
	Reviewing Themes	Connecting with research questions
5.	Defining and Naming Themes	Denoting precise names
	Writing Up	Transcribing findings

2. Rationale Behind Applying the Thematic Approach: Thematic analysis is particularly suitable for its simplicity, fewer prescriptions and procedures. It helps to compare and contrast and to generate unanticipated insights [113]. In this study, thematic analysis has been deployed to summarize a large volume of data on sourcing policies of fast-fashion companies, follow a well-structured approach in managing data, and report findings in an orderly manner [114].

IV. RESEARCH FRAMEWORK

The following research framework shows that exogenous variable green business practices have multidimensional measurements: green supply chain management, green marketing, green operations, green human resource management, and green finance. Presumably, these green business practices impact the companies' competitive advantages through building dynamic capabilities, which are measured by pollution prevention, product stewardship, and sustainable development that entails clean technology and the base of the pyramid

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. Fig. 1. The proposed research framework

On the other hand, endogenous variable competitive advantages are measured by lower costs, reputation or legitimacy, future positioning, and long-term sustainable growth. The framework also demonstrates that dynamic capabilities mediate between green business practices and competitive advantages. It refers to the fact that green business practices lead to competitive advantages once companies are good at building dynamic capabilities.

This proposed research framework is regenerated to comply with the study at hand based on the natural-resource-based view (NRBV) of the firm proposed by Hart [115]. The idea of NRBV itself was the upgradation of the resource-based view (RBV), which ignores the impact of environmental elements necessary for sustaining competitive advantage. The facets of RBV, such as resources [116], capabilities [117] and [118], and competitive advantage [119], are thoroughly studied by researchers over the years. However, NRBV fills the void of the biophysical (natural) environment, which was previously missing in the firm's competitive success discourse. Later, NRVB was contemporized with the perspectives of clean technology and BoP (bottom of the pyramid) incorporated into strategic capabilities for a more comprehensive understanding of the environmental strategies and sustaining the success of the firms in the continuously evolving marketplace.

V. ANALYSIS AND DISCUSSION

One of the biggest global hubs for garment manufacturing and affordable sourcing, and the second-largest garment exporter in the world, Bangladesh's ready-made garment (RMG) industry is the driving force of the South Asian emerging economy. In 2023, Bangladesh's RMG exports reached $47.5 billion, the second-largest figure after China's $165 billion [120]. Major markets for Bangladesh's RMG products are the USA, EU, Japan, Canada, and Australia [121]. Since the 1970s, the RMG sector has been Bangladesh's most significant foreign currency contributor, and it will graduate to a developing economy status in 2026. The green revolution in the RMG sector in Bangladesh is bringing global recognition as it houses the highest number of green garment factories in the world. The RMG industry has a strong female workforce, with women making up 60-70 % of the industry's workforce [122]. More than 100 international clothing brands are directly sourced from Bangladesh annually, and export destinations reach more than 150 countries worldwide [123]. Based on data from the National Board of Revenue [124] and the vernacular daily The Prothom Alo [125], the following table shows the top buyers for the fiscal year 2023-24. This list has been prepared by analyzing and synthesizing nearly 2.1 million export shipments from last year.

TABLE 2: THE TOP FOREIGN COMPANIES PURCHASING BANGLADESHI GARMENTS: 2023-24

Company Name	Country of Origin
H & M	Sweden
Inditex	Spain
Primark	Ireland
Bestseller	Denmark
Marks & Spencer	United Kingdom
C&A	Netherlands
Uniqlo	Japan
Kmart	United States of America
LPP	Poland
Next	United Kingdom
Pepco	Poland
Walmart	United States of America

The sourcing policies of these companies are very rigorous. Alongside strict quality control measures, companies in the USA and EU often ask for their sourcing destinations to comply with sustainability standards, human rights, animal rights, ethical business practices, and fair trade across the supply chain. Any violation is tantamount to business termination. Continuously increasing pressure from consumer rights groups, human rights groups, animal rights groups, global media houses, regulators, and governments makes it difficult to eschew responsibility for malpractices in the supply chain of fast fashion garment items. The following table demonstrates the common theme of sourcing policies of top RMG purchasing companies in Bangladesh. This list is not exhaustive but covers the major issues in sustainable sourcing.

TABLE 3: SOURCING POLICY OF TOP RMG PRODUCTS PURCHASING COMPANIES IN BANGLADESH

No.	Company Name	Common theme of the sourcing policy
1.	H & M [126]	• Sustainability: • Save water • Reduce fossil fuel use • Reduce environmental risk • Animal welfare • Human rights: • OECD Due Diligence Guidelines for Responsible Business Conduct

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		• UN Guiding Principle on Business and Human Rights • Supplier relationships
	Inditex [127]	• Culture of sustainability: • Sustainable recruitment • Participation of purchasing team: • Training for purchasing teams on the sustainability of the supply chain • Collaboration with the industry: • Promote best practices in the industry that foster the payment of living wages
3.	Primark [128]	• Sustainability and ethics • Strengthening Clothing Durability • Halving Carbon Footprint • Clothes That Can Be Recycled • Cotton Project: cotton that's organic, recycled, or sourced through profitable farming • Protecting life on the planet: • Promoting biodiversity • Eliminating non-cloth waste • Responsible manufacturing • Eliminate, innovate, circulate • Improving people's lives • Tackle gender-based violence • Improve financial resilience • Empowering women
	Bestseller [129]	• Sustainability: • Climate impact • Circular future • Supply chain policy: • Social and environmental sustainability across the supply chain • Forest protection • People's policy: • Promoting diversity, inclusivity and strong values • Packaging policy: • Moving away from plastic and paper-based packaging
5.	Marks & Spencer [130]	• Sustainability: • Net-zero business across the entire value chain • People's policy: • Organizational culture that promotes diversity, inclusivity, personal development and respect • Responsible sourcing and human rights: • Upholding Global Sourcing Principles • Allowing individuals to lead a dignified and independent life, free from abuse and violation
6.	C & A [131]	• Sustainability: • Environmental management • Sustainable chemical management
		• Climate change and water stewardship • Human welfare: • Labor and human rights • Equity, inclusion and freedom from discrimination • Health and safety • Freedom of association • Animal welfare
	Uniqlo [132]	• Sustainability: • Reuse, Recycle • Ethically produced materials • Low carbon footprint • Minimizing environmental impacts • Abolishing fur, feather and merino wool suppliers who source from farmers practicing mulesing • Animal welfare • No human rights violations
8.	LPP [133]	• Sustainability • Decarbonization • Promoting circularity • Recycling and reducing the carbon footprint • Eliminating single-use plastics • More optimized production • Energy-efficient infrastructure • Human welfare: • Appropriate remuneration • No child labor • Freedom of association • Voluntary work • Health and safety standards
	Next [134]	• Sustainability approaches: • Measuring climate impacts • Energy efficiency • Distribution efficiency • Waste and recycling • Product lifecycle management • Packaging • Responsible sourcing • Human rights and modern slavery • Community engagement • Trading ethically throughout the supply chain
10.	Pepco [135]	• Sustainability: • Reduce carbon footprint • Use less material • Minimize waste • Use responsibly sourced materials in products • Develop people • Care for colleagues and partners • Practice strong governance

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The sourcing policies of global buyers indicate the priority of sustainability. The major themes from the above table are ethical business practices and the utmost concern for people and the planet. As customers are becoming sophisticated and compliance with fair trade and ethical business standards is becoming a dominant norm, global fashion brands have few choices but to keep themselves relevant by using sustainability. Though costly, a sustainable endeavor is the only way to contemporize or inevitably differentiate product offerings. Any sustainability effort often calls for green business practices inside the organization to reap the benefits of evolving new opportunities in international markets. The recent green revolution in the RMG industry in Bangladesh is a timely move to grab these untapped opportunities. A few pioneering companies have started to go green, and others have followed suit. Increasing numbers of LEED-certified factories in Bangladesh indicate this sector's green revolution. The following chart summarizes the categories of different levels of certification.

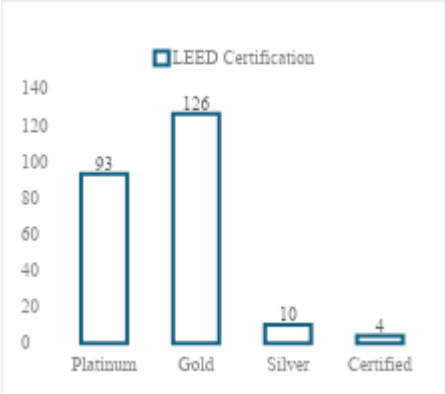


Fig. 2. Categories of LEED certification

Platinum certification is the highest level of LEED and requires projects to earn more than 80 points out of 110. Gold is the second-highest level with significant achievement and requires projects to earn between 60 and 79 points. Silver is the third highest recognition of sustainable practices and requires projects to earn between 50 and 59 points. Currently, 55 out of 100 LEED Green Factories worldwide are in Bangladesh. Among them, nine of the top 10 and 18 of the top 20 are located in Bangladesh, indicating a significant leap toward solidifying Bangladesh's reputation as a sustainable RMG manufacturing hub [136]. It also indicates the green capacity-building ability of the RMG companies in Bangladesh and their agility to stay competitive. As of January 2025, a total of 233 RMG factories received LEED (Leadership in Energy and Environmental Design) certification from the US Green Building Council (USGBC), a nonprofit organization that promotes sustainability in building design, construction, and operation [137]. The following Table 4 tabulates a few leading RMG manufacturers located in Bangladesh.

Bangladesh's Progress in green manufacturing gives the companies located in Bangladesh an edge over other players in the international market. It is the global apparel industry leader, with a growing number of LEED-certified factories. The leading trade body, Bangladesh Garment Manufacturers and Exporters Association (BGMEA), plays a key role in promoting sustainable practices in the RMG industry. Especially, aftermath of the Rana Plaza tragedy, one of the world's most devastating industrial accidents that killed approximately 1200 people in 2013 [138], the move towards green manufacturing helps to improve and regain Bangladesh's image and strengthen its position as a responsible global player.

TABLE 4: LEADING RMG FACTORIES WITH LEED CERTIFICATION IN BANGLADESH

Ha-Meem Group	Masco Industries Limited	Spinning Ltd (Unit-2)
Beximco Apparels Ltd	Asian Apparels Limited	Saadatia Sweaters Ltd
Square Fashions Ltd	Envoy Textile	Executive Greentex Ltd
DBL Group	Plummy Fashion Limited	Ananta Jeanswear Limited
Posh Garments	Amanat Shah Group	Big Boss Corporation Limited
Ananta Group	Sepal Garments Ltd	Aptech Caswier Limited
Basic Shirts Limited	Cotton Field BD Ltd	Euro knit spinn ltd
TM Jeans Limited	Consist Apparels Limited	Eurotex Group
Babylon Casualwear Ltd	Continental Garments Ind. P. Ltd.	Banga Fashion Ltd

VI. CONCLUSION

This study addressed the impact green business practices have on the competitive advantage of Bangladeshi RMG companies in the international market, focusing on the rigorous sourcing policy of global garment buyers and their predilection towards sustainability. The objective was to highlight how sustainable green business practices could catalyze competitive advantage and robust financial outcomes, as the business dynamics in the global fast-fashion industry are continuously changing.

Key findings indicate that Bangladeshi RMG companies that got certification from global sustainability measurement bodies, such as LEED, have an edge over other players in the industry. The compliance these companies follow befits the expectations of the top-notch global buyers and their sourcing policy. From environmental sustainability and climate impact to human rights, animal welfare, ethical business practices, and fair-trade practices, LEED-certified RMG companies are demonstrating better performance and leading the sector by being recognized as a top sourcing destination for global buyers. As Bangladeshi companies have the most LEED certifications, they have the upper hand over their counterparts in China, Vietnam, India, Indonesia,

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Cambodia, Turkey, and other RMG exporting countries. Another notable finding of this study is the alignment of all the company's functional activities, as the scope of green business practices necessitates a comprehensive sustainability impact on the company's operational configuration. Especially in functional areas, firms should implement the green agenda effectively to achieve a holistic sustainability impact across their supply chain, marketing, operations, finance, and human resource management.

The implications of these findings are profound. They emphasize the importance of policymakers encouraging RMG companies to adopt green practices for sustainable profitability and a competitive edge. The RMG sector is the backbone of Bangladesh's economy and earns the lion's share of foreign currency. Therefore, the stake is high to keep this industry performing at its best and remain well-equipped to confront competitive pressure in the international market, as companies in other countries are stepping up fast.

This study acknowledges the limitations of numerical analysis of the financial state of the companies under study for a clear understanding of their performance in the international market. At the same time, empirical evidence could demonstrate how green business practices help build the companies' strategic capabilities and ensure competitive advantages and the causal relationship between them.

Future research should focus on gathering robust financial data to examine the top LEED-certified Bangladeshi companies' monetary performance and compare their edge over local and global rivals in the RMG sector. Additionally, robust primary data collected from the companies could make the causal relationship between green business practices and competitive advantage more convincing and compelling. Furthermore, future studies could empirically prove the relevance of the green business measurement shown in the research framework.

In conclusion, green business practices are the breeding ground of sustainability that global buyers keenly look for when sourcing their garment orders. Alongside the fast-fashion industry, the business world is evolving around sustainability, justice, and equity. Therefore, companies that configure their business practices based on a green agenda, fairness, and the rights of all stakeholders and have acquired strategic capabilities are getting a competitive advantage and are likely to do well in the future.

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Impact of Digital Detox on Mental Well-being and Productivity – Insight from University Students

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Abstract - **This study explored how taking a break from digital devices, known as a "digital detox," impacts the mental health and productivity of university students. In today's world, students use smartphones, laptops, and the internet for study, communication, and entertainment. However, excessive use of digital devices can lead to stress, sleep problems, and decreased attention span. To understand this issue, the study used a qualitative approach and spoke to students at a public university in Bangladesh through semi-structured interviews. Studies have shown that many students feel better mentally, sleep better, and can manage their time more effectively after a digital detox and it's a helpful way for students to balance their technology use and improve their well-being. The results of this study can provide guidance to teachers, parents, and policymakers to help students use digital media in healthy ways.**
Keywords- **Digital Detox, Mental Well-being, Productivity, University Students, Technology Addiction.**

I. INTRODUCTION

In today's technology-centric world, overreliance on digital devices has led to technology addiction, especially among university students who rely on technology for studying, communication, and entertainment. Excessive use leads to mental health problems such as insomnia, anxiety, depression, and decreased productivity. Radtke et al. [1] describe that digital detox can help reduce smartphone use and improve depression symptoms in some people. They reviewed 21 studies (12 were randomized controlled trials) that tested taking breaks from smartphones or apps and their results were mixed—some studies showed benefits, while others showed no effect or even negative effects. Although this study shows that digital detox may improve smartphone use and reduce depression, there is still a lack of high-quality research that clearly identifies when and for whom digital detox is most effective. Digital well-being theory and research [2] conceptualizes digital well-being as a multifaceted construct involving emotional, domain-specific satisfaction and overall life contentment within our digitally-saturated environments, emphasizing that outcomes vary widely depending on individual user characteristics and usage patterns. Mirbabaie et al. [3] explore the concept of digital detox as a response to the growing problem of technostress caused by excessive IT use, especially among knowledge workers. That article highlights the need for clear definitions, strategic implementation, and further research to understand how digital detox can improve well-being,productivity,and organizational balance. Sharma and Sharma [4] discuss how digital detox can improve focus, reduce stress, and boost productivity and well-being and discussed the effects of constant digital use and explained the benefits of taking breaks from technology. Digital detox helps organizations understand how cybersecurity fatigue affects employee mental health and productivity, and it gives practical tips to improve well-being and performance. The authors used a quantitative research method, surveyed 351 employees from IT, finance, healthcare, and education sectors, and analyzed the data using Spearman correlation, regression, and Structural Equation Modeling (SEM) [5]. Seong Soo and Bo-Kyung [6] explore the impact of establishing a digital detox culture in the workplace, analyzing how it affects employees' mental well-being and productivity. Following PRISMA guidelines, 15 peer-reviewed studies published between 2018 and 2025 were examined. The findings reveal that in modern workplaces, information overload, technostress, and blurred boundaries between work and personal life negatively affect employees' mental health and performance. Various digital detox strategies have shown positive effects in addressing these issues; however, their effectiveness depends on the context of implementation and individual factors [6].

Temporary detachment from digital devices, which has emerged as a strategy for restoring self-control, improving sleep, increasing concentration, and increasing productivity. Global studies highlight its benefits, research in the Bangladeshi context remains limited. This study aims to explore university students' awareness, practices, and experiences of digital detox, as well as its impact on their mental health and productivity. This research will provide insights for policymaking, educational strategies, and mental health interventions, which will contribute to the development of a balanced digital culture

II. METHODOLOGY

A. Research Design

The first and most important step in conducting a study is to select an appropriate research design. The author chose a qualitative research method to analyze digital detox. Qualitative methodology has been adopted because qualitative methodology helps in in-depth analysis of real experiences, perspectives, and feelings.

B. Population and Sampling

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This study targeted undergraduate and postgraduate students at public universities for research population. Participants were chosen based on their direct relevance, as they actively use digital platforms and face stress-related challenges where digital detox can help. The sample included students with a variety of detox experiences, from reducing screen time to completing offline breaks, ensuring a variety of insights.

C. Data Collection Methods

The data collection phase of the study was very meticulous and planned. The aim of this study was to explore the personal experiences, feelings and perceptions of university students regarding digital detox so a qualitative method selects for conduct the data. The researcher mainly used semi-structured interviews for data collection. Interview method allows the researcher to follow the structure of certain questions, that also ensuring the freedom of the participant to speak. If questions were asked in a completely structured manner, there would not have been an opportunity to express many valuable feelings and experiences. Besides if a completely unstructured interview was conducted, it might have deviated from the main aim of the study. A semi-structured method was the most suitable, where new questions were created based on the participant's answers, and the discussion progressed based on that context. The interviews were conducted face-to-face, but in some cases, interviews were also conducted via online due to time and space constraints. The researcher tried to create an environment where the participant felt safe and comfortable. Typically, each interview lasted form 15 minutes to 30 minutes, but in some cases it was longer.

D. Instruments for Data Collection

The selection of instruments or materials used for data collection was very important, because the instruments used in a qualitative study can affect the quality and reliability of the research. This study mainly used two main instruments — interview guide and audio recorder.

1. Interview Guide

The main instrument used by the researcher to collect data was the interview. It was an open and flexible structure. In interview session the main questions were predetermined and new questions were also added according to the answers of each participant. The guide consisted of three main sections:

Section 1: The participant's initial experiences (e.g., 'Have you heard of the term digital detox?' or 'How did you realize that you needed a digital detox?')

Section 2: The impact of digital detox on their mental and physical well-being (e.g. 'Do you think taking a break from digital devices improves your teaching effectiveness? Why or why not?' or 'Have you noticed any improvement in focus and concentration after a digital detox?')

Section 3: Future plans and experiences related to digital detox (e.g., '.Do you believe that reduced screen time leads to better research productivity?' Or 'Have you implemented any personal or institutional strategies to minimize digital distractions while working?')

2. Audio Recorder

Another important instrument was the audio recorder. The researcher recorded the entire discussion during each interview, which was helpful in later analysis. The recording ensured that the participants' exact words were noted and that no important statements were missed. The researcher ensured that the participants gave verbal consent before the recording and that their confidentiality was protected. The recording of the interviews was later converted into text and used later during the analysis.

E. Data Analysis Techniques

Data analysis was one of the most important steps in this study, where the collected data was made meaningful according to the main purpose of the study by observing and interpreting it in depth. Since this study is qualitative in nature, qualitative methods were also followed in the analysis. The researcher mainly used thematic analysis method, which is ideal for identifying specific patterns or "themes" from the participants' experiences and analyzing them in depth. The researcher first read the transcriptions of all the interviews to form an initial idea. At this stage, a holistic view of the data was developed, where the researcher not only tried to capture the main points of the data, but also felt the feelings, dreams, dilemmas and indications of change of the participants. Each interview was read repeatedly so that no subtle information was missed. This stage was the "immersion" stage, where the researcher completely immersed himself in the data.

III. RESULTS & FINDINGS

Participant Demographics

This study analyzed the opinions and experiences of a total of 18 participating students. The participant ratio was 9:9 (male and female). All were studying in their 3rd, 4th, and postgraduate years at a government university in Bangladesh. The average age of these participants was between 21 and 26 years. Some of them lived in dormitories; some lived in rented houses in the city with family or friends.

In this chapter, we analyzed not only their names, ages, or gender identities, but also their technology-dependent life backgrounds, daily habits, mental and emotional attachment to technology, social media activity, and their experiences before and after taking a digital detox. First, it is important to know about the participants' technology usage habits. Each of the participants was part of a modern technology-dependent life. They used smartphones regularly, social media, streaming apps,games, online classes, research assignments—everything was part of their digital lives. Most of the students spent anywhere from 7 to 12 hours a day in front of a mobile or computer screen. Technology was a necessity for them, and sometimes it was a kind of addiction.

However, these 18 students have one thing in common—they have all consciously participated in a digital detox at

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one time or another. Some took a break from social media, some deleted certain apps, some turned off their smartphones for a few days, and some completely observed "digital silence"—where they stopped all forms of technological communication for a few days. There were some subtle differences in the digital detox experiences between male and female participants. Many male participants said they started the habit to increase productivity—such as staying focused before exams, spending more time on research projects, or gaining mental clarity. On the other hand, many female students said they went on a detox to reduce stress and anxiety.

One female participant said: "If I didn't wake up every morning and check Instagram, I felt like I was missing out. But then I realized—this 'fear of missing out' was making me more anxious."

A male participant said: "I tried to focus on my research for a week, cutting out Netflix and games—I was surprisingly able to write a lot more."

Third-year students were generally more sensitive to the use of technology. Many of them had already developed a kind of "friendship" with technology since their first year. They were more active on social media, and found it challenging to take a digital detox. These students often said that they sometimes "lost themselves" in the virtual world.

This awareness was relatively higher among fourth-year and postgraduate students. They understood the importance of productivity, mental health, and saw detox as a necessary habit. *A postgraduate student said: "I deleted WhatsApp, Facebook during my exams. There was a strange peace that came over me at that time."* The reasons for going on a digital detox varied—some felt emotionally drained, some felt lonely, some started the habit to increase productivity or improve relationships. Others said they simply "wanted to see what would happen" if they didn't use their phones for even a day. *One participant said: "I would always scroll through Instagram after a certain time, comparing myself to others. One day I realized it was hurting me. So I stopped using Instagram for a week."* From this personal experience, it is clear that the digital detox for the participants was not just a technological break—but a journey of emotional and self-discovery.

Impact of Digital Detox on Students Productivity

The impact of technology on the daily lives of university students has become ubiquitous, smartphones, social media, email, video streaming platforms, and various digital apps have become an integral part of students. In this context, the concept of "digital detox" is deeply affecting students' mental and physical well-being as well as their productivity. This section mainly analyzes how digital detox is playing a helpful role in increasing students' academic and personal productivity. Based on the statements and experiences of 18 students (9 women, 9 men) who participated in the study, the following points have been highlighted.

A key question of this study was—does digital detox actually increase the productivity of university students? Analyzing the daily lives and pace of study of students, it is seen that they have become dependent on various types of digital technology. This dependence has ensured easy availability of information and quick communication on the one hand, but on the other hand, it has also created an invisible area of pressure and confusion. Digital detox is an attempt to temporarily remove that confusion and technology-dependence and return students to a normal, mind-centered life.

It is necessary to mention at the outset that productivity is not limited to academic performance or improvement in grades. Rather, it is a broad concept that includes internal mental characteristics such as attention to study, research quality, time management, creative thinking, problem-solving skills, and self-confidence. The students' narratives clearly show that digital detox positively affects their mental state, which directly or indirectly leads to positive changes in their productivity.

One student participant said, "I used to think that I would miss a lot if I didn't have my mobile phone. But when I turned off my phone for a week, I realized that I was able to focus on my studies much more than before." This 'regaining focus' theme was echoed in the narratives of several participants. During the digital detox, students were able to reorganize their thoughts, and the time they previously spent on social media or video content was spent reading books, taking class notes, or doing research. This is not just an improvement in time management, but also a reflection of a kind of psychological stability.

Many of the study participants were also involved in creative pursuits alongside their studies— some drew pictures, some were skilled at video editing. They reported that their creativity had returned after cutting back on social media.

This change in attitude largely helped students increase their inward focus. They were able to redirect their time and energy. "One day, I deleted the Facebook app. Then I realized that I had at least two hours free every day. At that time, I started doing some extra reading for the course. That reading helped a lot before the exam," said one student. This quote suggests that a significant result of digital detox is the recovery of time, and the time spent on meaningful activities.

However, not all experiences were so simple and directly positive. Some students initially felt a kind of 'empty feeling' or 'anxiety'. *They said, "When I didn't check WhatsApp, I felt like someone was looking for me, I was missing some important messages." This anxiety gradually subsided after a few days, but it immediately had a negative impact on their productivity.* This situation basically indicates a psychological addiction to technology, which is not easy to get out of.

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The analysis showed that those who had a digital detox for a long time were relatively more productive. Their interest in studies increased, attendance and participation in classes increased, and even their sleep habits changed. *One student said, "Before, I used to watch videos on YouTube before going to bed at night, now I read books at that time. I sleep better, my mind is fresh in the morning."* This relationship between improved sleep and increased concentration is very important, as it directly impacts the quality of learning.

Impact of Digital Detox on Students Mental Well-being

Reduced stress and anxiety
The digital detox experience helped students reduce stress and anxiety. One respondent said:
"I felt much calmer than before because I was away from social media."
This experience is consistent with other studies that have shown that digital detox helps reduce anxiety.

Improved sleep quality
Digital detox improved students' sleep quality. One respondent said:
"I slept better because I didn't use my phone at night."
This experience is consistent with other studies that have shown that digital detox improves sleep quality.

Increased attention and focus
Digital detox improved students' attention and focus. One respondent said:
"I was able to focus more on my studies during the digital detox."
This experience is consistent with other studies that have shown that digital detox improves attention and focus.

Self-awareness and emotional state
Digital detox improved students' self-awareness and emotional state. One respondent said:
"During the digital detox, I was able to think about my feelings and thoughts."
This experience is consistent with other studies, which have shown that digital detox improves self-awareness and mental state.

Students Experiences with Digital Detox
At present, the excessive use of digital technology is having a negative impact on stu-dents' mental well-being and it brings behavioral changes. Research has shown that digital detox helps students improve their anxiety, depression, stress, and sleep quality.

Students' experiences show that they have experienced mental peace, self-awareness, and improved social relationships through digital detox. They also say that digital de-tox has helped them increase their attention and focus.
In Bangladesh students are overusing digital technology, which creates a negative impact on their mental well-being. Therefore, it is possible to improve students' mental well-being through digital detox.

IV. DISCUSSION

Interpretations of Results
The interviews and personal experiences of the students participating in this study clearly reflect that digital detox serves as an important social and psychological process. In this chapter, we present an in-depth interpretation of the experiences, perceptions, and responses that emerged from the study results. Each of the 18 students who participated in the study consciously disconnected themselves from technology at least once or more—this isolation sometimes lasted for a day, sometimes for a week and sometimes for a month. The experience of this isolation was transformative in many ways, in some cases it gave rise to psychological relief, and in some cases it also caused temporary instability and anxiety.
The mental state that the students went through during this detox experience is not just a reaction to the absence of technology, but a deep analysis of the dependence that has developed in their psyche. Most students admitted that they spend an average of 7 to 12 hours a day in front of the screen of their mobile phone, laptop, or tablet. On the one hand, this technology has helped them in their academic lives, on the other hand, it has robbed them of their attention, wasted their time and subconsciously caused them to experience a kind of mental fatigue and stress. By stepping away from technology, they have realized what a life without technology can be like and how peaceful, focused and productive that life can be.
It is particularly noteworthy that there was a difference in the purpose of entering the detox between male and female participants. Male students went on the detox mainly to increase productivity, they wanted to improve academic focus, research skills and personal time management. On the other hand, female students' detox was a kind of self-defense effort—they wanted to get rid of stress, depression, and the pain of social comparison. In the words of one female participant, "If I didn't wake up in the morning and look at Instagram, I felt like I was missing something. But later I realized that this 'fear of missing out' was what was making me more anxious." This is a real reflection of the modern 'FOMO' or 'Fear of Missing Out'.
Not only did they experience a reduction in anxiety and stress, but they also experienced significant changes in their productivity and concentration. Many said they had read textbooks, taken on extracurricular activities, or pursued research during their detox. Others returned to creative pursuits such as drawing, creative writing, and video editing. This meant that the temporary disconnection from technology helped them regain their sense of self and skills. These experiences show that digital detox is not just about 'turning off' technology; it is a conscious and strategic effort to reconnect with you.

Comparison with Previous Studies

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If the results of the current study are compared with previous studies, it can be seen that many international and domestic studies have reported the positive effects of digital detox. For example, in a 2017 paper by Jean Twenge, an analysis was made of technology dependence and depression among teenagers in the United States. It was found that those who spend more than five hours a day on social media were at a higher risk of suicidal thoughts or depression. A study by Jenny Rodriguez (2018) found that when college students quit social media for a week, their stress levels decreased and their attention span increased. Similarly, recent studies in Bangladesh that have focused on students' use of technology have reflected various mental problems arising from technology dependence—such as anxiety, loneliness, sleep problems, etc. These are directly reflected in this study. In a study conducted by Tsai & Lin in 2019, out of 200 students who reduced their technology dependence to three hours a day for seven days, 74% said that they were able to concentrate better and their study quality improved.

These results directly align with the experiences of university students in Bangladesh. For example, one participant said: "After deleting the Facebook app, I saved two hours of time every day. I used that time to study." These comments are consistent with previous research findings, which show that students not only regain time through digital detox, but also increase their productivity through mental stability and self-control.

Implications for University Students

The most important part of this study is that it carries a realistic and relevant message for university students. Today's students are not just using technology, but have become part of a technology-dependent lifestyle. Online classes, assignment submission, sending research papers, and even maintaining social relationships are now done through technology. In this context, digital detox can become a conscious habit for students, which is helpful for their mental health, academic success and personal development.

Universities can provide institutional support to students to develop this habit if they want. For example, a one-week "digital detox challenge" can be organized every semester. Including one or more sessions on "digital wellness" in the curriculum can raise awareness on this topic. By forming volunteer groups among students, they can encourage each other, give advice and teach positive uses of technology. In this way, the university can create a "digital wellness-friendly" environment.

V. RECOMMENDATIONS

This study has generated important insights into digital detox and its effects, which have touched on various aspects of university students' mental, academic, and social lives. Although this study was conducted within a limited context—the experiences of university students—its findings and analysis provide a broad area for future research. As digital technology and human behavior change rapidly, the field of research also needs to be constantly updated. Therefore, in this chapter, we will analyze what future research is needed in light of this study, and how new research can provide deeper and broader insights into digital detox.

- The current study was conducted on the basis of a short-term experience. Future studies could analyze the effects of digital detox in the long term (e.g., six months, a year, or more). For example, if a student abstains from digital technology for a certain period of time every day, then after a year, the study could analyze how much their mental state, physical health, and academic life have improved.

- This study was mainly conducted among university students. Future research could be conducted in different social and cultural contexts: How do the experiences of digital detox differ between rural and urban students?

- Digital detox is not just a matter for university students; it is also relevant for schoolchildren, young workers, middle-aged people, or the elderly. Age-based comparative analysis will be important in future studies. For example, which age group is most dependent on technology and who is best able to accept digital detox?

- It is important to monitor what kind of changes occur when digital detox workshops, courses, or camps are added to students in universities, schools, and colleges. For example: If a university specifically introduces a 'weekly screen-free day' for students, what is the impact on the quality of education and mental well-being?

- Although the current research is on students, it is important to conduct research on professionals in the future. Because their lives are also deeply affected by technology. For example: What is the role of detox in maintaining mental well-being among people working in stressful professions like teachers, doctors, bankers?

VI. CONCLUSION

At present world, the impact of digital technology has left a deep impression on university students. Technology dependence is no longer just a means of academics or communication, but has become an integral part of life. Mobile phones, laptops, social media, video streaming apps and various online platforms have become so intertwined with students' lives that it seems difficult or uncomfortable for many to abstain from them or 'disconnect' from them. In light of that reality, this study analyzes students' personal experiences, psychological

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reactions and its impact on physical and mental health and productivity.

This study clearly reflects that digital detox has emerged as an important and positive practice in the lives of university students. Although excessive use of technology has a negative impact on their mental health, sleep, attention and productivity, students have largely gained mental peace, self-control and time management skills as a result of taking a timed technology break or detox.

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Tech YouTubers as Digital Influencers: An Analysis of Influencer Attributes and Content Features

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Abstract - **The rise of YouTube as a dominant platform in the digital age has popularized influencer marketing, especially for promoting electronic gadgets such as smartphones, laptops, smartwatches, and headphones among young digital natives in Dhaka, a rapidly growing urban center. This trend has led to the emergence of a distinct category of influencers known as 'Tech YouTubers.' Applying the Source Credibility Theory (SCT) and the Elaboration Likelihood Model (ELM) of persuasion, this study examines how Tech YouTubers' credible attributes (trustworthiness, attractiveness, expertise) and content features (visual attractiveness, originality, and engagement metrics) affect consumers' purchase intentions for electronic gadgets in Dhaka. Results reveal that all content features have significant positive effects on purchase intentions, with engagement metrics (e.g., views, comments, shares, likes) being the strongest predictor, particularly among younger consumers. However, influencer attributes did not show a significant direct effect on purchase intention. The survey findings indicate that within Dhaka's digital consumer landscape, content-driven persuasion is emerging as a more significant factor than personality-driven endorsement in influencing purchase intentions for tech-related gadgets. This study contributes theoretically by applying SCT and ELM in a South Asian digital marketing context and offers practical insights for influencers and brands to boost purchase intentions through visually appealing, original, and engaging content. Limitations include the non-random, geographically limited sample, suggesting future research with larger, more diverse populations.**

Keywords: **Influencer Marketing, Tech YouTubers, Purchase Intention, Gadgets, Dhaka**

I. INTRODUCTION

Over the past decade, social media has fundamentally transformed marketing strategies and consumer buying behavior due to the rapid expansion of digitalization and internet penetration. Considering this, a new group of opinion leaders has emerged, collectively referred to as Social Media Influencers (SMI). They help influence what to buy, and hence, change or reinforce buying behavior [1]. Emerging social media platforms, such as YouTube, Facebook, Instagram, TikTok, and Twitter, have become pivotal channels for product discovery, evaluation, and purchase decisions, and influencers play a significant role as trusted intermediaries between brands and consumers [2]. As a video-sharing platform, YouTube is immensely popular, especially among Generation Z, who were born between 1997 and 2012 [3]. YouTube has 34.50 million active users in Bangladesh as of 2022, and about 28 percent of them lies in the age category of Gen Z [4]. These young people mostly watch entertaining contents like movies, songs, and vlogs on YouTube. It has recently become a trend for these youth watching unboxing and reviewing product videos on YouTube and it includes product review videos of luxury and fashion items, such as Smartphone, computers, electronic accessories, kid's toys, cosmetics, and mystery boxes [5]. So, YouTubers as a SMIs play pivotal role to influence consumers' purchasing decisions. Among different content creators of YouTube, tech YouTubers, creators specializing in gadgets, software, and emerging technologies, have gained attention because of increasing popularity of electronic gadgets products and tech influencers' ability to simplify complex technical information and provide relatable reviews of electronic gadgets.

Extant study on influencer marketing has suggested a range of influencer and content features and specified message and source features as important communication stimuli that audiences process to form their attitudes and intention [6] & [7]. Both the characteristics of the influencer and the content features are crucial in shaping audiences' purchase decisions in the influencer marketing context [8] & [9]. However, these attributes have been rarely examined, and therefore, their effects in influencer communication remain unclear. Moreover, there is a lack of empirical research about the effects of YouTube influencers and their content features on consumer purchase behavior, particularly in the relation of electronic gadgets despite the growing popularity of tech YouTube influencers and the increasing number of tech-savvy young people in Dhaka, Bangladesh.

To address this gap, the purpose of this study is to investigates the impact of tech YouTube influencers and content features on audiences' purchase intention in electronic gadget products in Dhaka. In so doing, source credibility theory (SCT) and elaboration likelihood model (ELM) of persuasion are comprehensively integrated as the theoretical framework of this study. SCT argues that a communicator's perceived trustworthiness, expertise, and attractiveness critically determine the persuasiveness and acceptance of a message by its audience [10]. On the other hand, the Elaboration Likelihood Model (ELM) describes two routes of persuasion, central and peripheral, through which individuals process messages based on their motivation and cognitive ability [7]. Central factors are those considered in audiences' evaluation of the true value of contents, including visual attractiveness, originality, and engagement metrics (views, likes, comments, replies). Peripheral factors are heuristic cues that audiences use to

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make simple inference of message merits for decision, and in this study, author includes influencers' perceived trustworthiness, attractiveness, and expertise. These peripheral cues are also related with the key factors included in the Source Credibility Theory (SCT). The findings of the study contribute to both theoretical understanding of influencer marketing and offer practical guidance for SMIs, marketers and policymakers in leveraging influencer and content features in influencer marketing as marketing stimuli in persuasive communication. This paper aims to answer two research questions:

RQ1: To what extent do tech YouTubers' attributes (trustworthiness, attractiveness, expertise) influence consumers' purchase intentions for electronic gadgets?

RQ2: What impact do content features (visual attractiveness, originality, engagement metrics) have on consumers' purchase intentions for electronic gadgets?

II. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1 Tech YouTuber as Digital Influencer

An influencer is someone who has large followers on his social media accounts and possesses the professional capabilities to influence the followers to shop and buy products/services that they promote on their social media accounts [11]. The influencers hold a unique combination of power, information, professional status, or relationship with their followers which they leverage to shape consumer behavior [12]. Currently, influencers are widely used as a marketing tool, commonly referred to as influencer marketing. This strategy has gained popularity because it is considered more effective and efficient than many traditional marketing methods [13]. Followers often trust influencers, believing that the products and services they endorse are of guaranteed quality. Influencers who have a strong online presence are referred to as digital influencers, as they have the ability to shape their followers' purchasing patterns and behaviors [14].

As a video-sharing platform, YouTube has become especially popular among Generation Z. Users enjoy a wide variety of content, but a growing trend shows that people increasingly watch product reviews before making a purchase decision. The younger generation, in particular, is becoming more tech-savvy and frequently explores different types of products, especially electronic gadgets [15]. In this context, tech influencers play a crucial role by providing unboxing and review videos for their followers, thereby shaping consumer purchase behavior.

Tech YouTubers, a subset of digital influencers, offer diverse unboxing and review content on electronic gadgets, attracting dedicated audiences who follow their channels [16]. Through their perceived expertise, trustworthiness, and engaging content, these influencers have the capability to significantly affect their followers' buying decisions.

2.2 Influencer Attributes

There are different types of attributes of influencers, followers and content suggested as the central constructs being studied. The "Source Credibility Theory" was proposed by Hovland, Janis and Kelly in 1963 [17]. The theory suggests that favorable attributes of communicators impacts the receiver attitudes, perception and the level of message acceptance. Trustworthiness, attractiveness, and expertise are key influencer attributes associated with consumer purchase intention. The concept of "trustworthiness" implies the level of acceptance and assurance that followers place in the message the speaker conveys. Moreover, an endorser with high trustworthiness and strong opinion is more effective in influencing consumer attitudes and behavior than an untrustworthy endorser [18]. Source attractiveness may be examined through both physical and social attractiveness dimensions [19]. Here, social attractiveness refers to the familiarity, likeability, and similarity between the endorsers and their respective audiences, whereas physical attractiveness primarily associates with the physical structure, facial characteristics, and overall personality of the endorsers [20]. When a celebrity endorser appears to be attractive, it enhances the consumer's attitude toward the endorsed message, making the overall communication more compelling and believable. Hovland et al. (1953) describe expertise as the degree to which the endorser is perceived as a credible source of information, and consumers may rely on the information presented by them to make their purchasing decisions. It refers to a person's level of experience, knowledge, qualification, or competence regarding the product they endorse [10]. When a consumer believes that a celebrity endorser possesses a high level of expertise, the message in the commercial is more likely to be persuasive. These lead to the following hypothesis:

H1: Perceived trustworthiness of the influencer positively influences consumers' purchase intention toward electronic gadgets.

H2: *Perceived attractiveness of the influencer positively influences consumers' purchase intention toward electronic gadgets.*

H3: *Perceived expertise of the influencer positively influences consumers' purchase intention toward electronic gadgets.*

2.3 Content Features

The ELM, developed by Richard E. Petty and John T. Cacioppo, is a general theory of persuasion that posits persuasion primarily as a cognitive event where success of persuasion depends on the way the audiences receive the persuasive message [7]. Under this theory, there are two possible routes or methods of influence to the audiences: centrally routed messages and peripherally routed messages. The central route is also known as the elaborated route where the message is processed by high level of cognitive effort with rational arguments and draw conclusion with the supporting evidence [21]. On the other hand, peripherally route is also called as shortcut route to persuade the audience where message is processed

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by the audience's emotion and superficial means [21]. The content features such as visual attractiveness, originality, and engagement metrics, are associated with consumer purchase intention. Visual attractiveness is an important attribute in developing consumer attributes and perception, specifically in digital contexts where content aesthetics and visual play a pivotal role in drawing customer's attention [22]. In social media content, visual aesthetics appealing—such as high-resolution images, cohesive layouts, and professional editing—directly enhance user engagement and effect on shaping attitude and behavior [23]. Further research confirms that visually attractive posts on social media platforms like Instagram or YouTube enhance perceived product value and positively effect on the customer behavior and purchase intention [24]. Originality, defined as the creation of novel, unique, and creative content, is a key driver of influencer effectiveness in digital marketing [25]. It helps to distinguish social media influencer's content from repetitive or mainstream posts. Originality of posts capture more attention and perceived as more authentic and credible by followers [26]. In the context of influencer marketing, originality indicates creativity and individuality, contributing significantly to the influencer's perceived opinion leadership and influence in shaping consumer's behavior and intention to purchase [25]. Consumers' perceptions of social media content are shaped by others' interactions. Engagement metrics—including views, likes, comments, shares, and replies—quantify these interactions. Influencer posts with high number of views, likes, comments and replies (NVLCR) act as strong social-proof cues that shape consumer perceptions of product quality and credibility. Online social proof is indicated by "the amount of 'Likes', comments, [and] shares" that a post generates [27]. Different empirical studies confirm that high engagement metrics boost perceived trustworthiness and informativeness of posts. High number of likes, comments, and shares were seen as more credible and useful, which in turn raised viewers' purchase interest [28] and positively influence consumers' buying decisions by providing validation of the product [29]. These lead to the following hypothesis:

H4: *Visual attractiveness of the influencer's post or content positively influences consumers' purchase intention toward electronic gadgets.*

H5: *The perceived originality of an influencer's content positively influences consumers' purchase intention toward electronic gadgets.*

H6: The perceived engagement metrics (views, likes, comments, and replies) of the influencer's posts positively influence consumers' purchase intention toward electronic gadgets.

2.4 Purchase Intention

According to the Theory of Reasoned Action (TRA), purchase intention is defined as the consumer's planned or subjective likelihood of a person to perform the preplanned actions, reflecting their willingness or probability to buy [30]. Similarly, consumer behavior literature defines purchase intention as the consumer's conscious plan or propensity to make a purchase in the future. Purchase intention can be used to predict real purchase behavior; therefore, it has attracted a lot of interest by researchers [31]. There are several empirical studies conducted which examine purchase intention in various online platforms such as websites [23], social network sites [31], and blogs [32]. However, there are very few research which focus specifically on YouTube's influence on purchase intention. Mir and Rehman (2013) is among the few such studies, showing that user-generated YouTube videos can positively influence consumers' purchase intentions [33]. Given this gap, the present study investigates factors related to YouTube influencer videos that affect consumers' purchase intentions toward electronic gadgets

III. RESEARCH METHODOLOGY

3.1 Research Design, Research Instrument, Scale, and Measurement

This study adopts a quantitative research design to collect the numeric data for systematic and statistical analysis. As a quantitative study, a structured survey questionnaire was developed to collect relevant data. The survey (Appendix 1) for the study comprised a total of seventeen questions, divided into three major sections, with a combination of screening questions, demographic information, and scale-based construct measurements, integrating all the necessary information from respondents. The survey incorporated nominal, interval, and ratio methods to assess customer purchase intention. The nominal scale was employed for categorical data, including gender, age, and binary yes/no inquiries. Additionally, an interval and ratio scale was used to assess customers' perceived purchase intention which is influenced by the influencer attributes and content features. The survey employed 5 points Likert measurement scales to assess constructs and items.

3.2 Sampling Frame, Sample Size, Data Collection Method, Data analysis Techniques

In this study, the sampling frame comprised the researcher's personal social media network. The data collection was conducted using convenience sampling and snowball sampling, a nonprobability sampling technique. A survey was carried out, with a total of 220 participants. The data was collected using latest version of Google Forms and published online through social media platforms such as Facebook, WhatsApp, and Messenger, both in groups and individual inboxes. In this study, Partial Least Squares Structural Equation Modeling (PLS-SEM) technique was employed using SmartPLS v.4.1.1.2 software for analyzing and testing the proposed research model and hypotheses [34]. This study employed PLS-SEM because prior studies on influencer marketing frequently utilized this method for data analysis [25] & [35]. In addition, apart from the scale-based items, the

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respondents' demographic characteristics were analyzed using frequency distributions and percentages.

3.3 Measurement of Validity and Reliability

Ensuring validity and reliability is essential for keeping the research on track and accurately capturing the constructs and observable items under investigation. In research, reliability refers to the consistency -whether the research methods can reproduce the same result multiple times [36]. On the other hand, the validity in research refers to the accuracy and truthfulness - whether research measures what it intended to measure [37]. In this research project, internal consistency was measured using Cronbach's alpha and composite reliability where a value more than or equal to 0.70 indicates a satisfactory level of internal consistency among the items within a construct [38] & [39]. Observable items with factor loadings below 0.633 were excluded, as they did not reflect adequate alignment with the underlying construct [39]. In this study, two types of construct validity were further evaluated through correlation analysis to assess the degree to which the scale accurately represents the theoretical concepts being measured. Convergent validity was assessed using the Average Variance Extracted (AVE), which is considered satisfactory when the AVE value exceeds 0.500 [39]. Discriminant validity was evaluated using both the Fornell-Larcker criterion and the Heterotrait-Monotrait (HTMT) ratio. According to the Fornell-Larcker criterion, discriminant validity is established when the square root of the AVE of each construct is greater than its correlations with any other construct. Additionally, the HTMT ratio should be less than 0.900 to confirm discriminant validity [39]. Furthermore, multi-collinearity assessment was conducted to determine potential interdependencies among the independent variables and to ensure the reliability of subsequent analyses. In this study, researcher examined multi-collinearity using Variance Inflation Factor (VIF) where this VIF value for all variables ranged between 1 and 5; indicating moderate correlations among the independent variables [40] & [39]. The relatively low VIF values confirm that there is no problem of collinearity.

IV. DATA ANALYSIS AND DISCUSSION

4.1 Result:

4.1.1 Demographic Profile of Respondents

Table 1. Statistics of Respondents' Demographic Characteristics (Sample size, N=220)

Participants		Frequency	Percentage (%)
Gender	Male	153	69.5
	Female	67	30.5
Age	Below 18	10	4.5
	18–24	110	50
	25–30	77	35
	31–40	16	7.5
	40+	7	3.2
Educational qualification	HSC or below	16	7.3
	Undergraduate (Ongoing)	108	49.1
	Undergraduate (Completed)	66	30
	Postgraduate or above	30	13.6
Occupation	Student	156	70.9
	Employed (Full-time)	26	11.8
	Employed (Part-time)	11	5
	Self-employed	14	6.4
	Unemployed	8	3.6
	Retied	2	0.9
	Homemaker	3	1.4
	Others	0	0

Source: Self-compiled by the author using Microsoft Excel

4.1.2 Measurement Model Assessment

The current study establishes a measurement model to assess the internal consistency of construct items and to evaluate the accuracy of the data for subsequent analysis. As part of the Confirmatory Factor Analysis(CFA), factor loadings were assessed in this study, and items with loadings between 0.673 and 0.879 were retained, while those below 0.673 were excluded [41], [42] & [43]. Furthermore, in the context of influencer marketing, factor loadings slightly below the preferred cut-off of 0.700 are considered acceptable [44]. Here, four such items of constructs were retained because removing them would have lowered α, rho-a, and AVE, which could undermine the construct reliability and validity [39], [45] & [46]. The items (IPT2, IPT4, IPPA1, CPVA5, CPO5, CPEM5, and PPI2) were excluded, and the remaining items are presented in Table 2 for further analysis. Table 2 also presents the descriptive statistics the means, average response of the observable items, ranged from 2.782 to 3.577, suggesting moderately favorable responses on the measured constructs. On the contrary, standard deviations, response variability or dispersion, ranged from 1.027 to 1.401, indicating a reasonable level of variability in participant responses. The recommended minimum value for α and rho-a, is 0.700 or higher [47] & [39]. Table 3 shows that the values of α and rho-a exceeded the recommended threshold of 0.70, indicating strong internal consistency. Additionally, the factor loadings ranged from 0.673 to 0.879, further supporting the reliability of the constructs as all loadings exceeded the acceptable cutoff value (>0.633). Thus, construct reliability was established for each construct in the study. In addition, the AVE is used

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to assess convergent validity and should be greater than 0.500, meaning that the latent construct explains more than 50% of the indicator variance [48]. In this study, Table 3 shows that the AVE values for all of the constructs exceed the recommended threshold of 0.50, thereby indicating that convergent validity was achieved for all constructs.

Table 2. Descriptive Statistics, Factor Loading, Reliability and Convergent Validity

Constructs	Indicators	Factor Loading	Descriptive Statistics		Reliability		Convergent Validity
			M	SD	α	rho-a	AVE
Influencer Perceived Trustworthiness (IPT)	IPT1	0.879	3.050	1.363	0.813	0.833	0.726
	IPT3	0.835	2.923	1.228			
	IPT5	0.841	3.177	1.243			
Influencer Perceived Physical Attractiveness (IPPA)	IPPA2	0.722	3.409	1.098	0.734	0.733	0.556
	IPPA3	0.738	3.109	1.178			
	IPPA4	0.757	3.345	1.152			
	IPPA5	0.764	3.318	1.239			
Influencer Perceived Expertise (IPE)	IPE1	0.814	3.227	1.360	0.817	0.829	0.577
	IPE2	0.708	3.459	1.133			
	IPE3	0.747	3.191	1.168			
	IPE4	0.731	3.495	1.162			
	IPE5	0.793	3.500	1.295			
Content Perceived Visual Attractiveness (CPVA)	CPVA1	0.800	3.132	1.337	0.729	0.738	0.551
	CPVA2	0.761	3.577	1.128			
	CPVA3	0.726	3.168	1.169			
	CPVA4	0.677	3.486	1.138			
Content Perceived Originality (CPO)	CPO1	0.769	3.191	1.293	0.730	0.735	0.553
	CPO2	0.716	3.350	1.027			
	CPO3	0.796	3.182	1.196			
	CPO4	0.689	3.241	1.206			
Content Perceived Engagement Metrics (CPEM)	CPEM1	0.839	2.923	1.401	0.819	0.839	0.650
	CPEM2	0.683	3.327	1.199			
	CPEM3	0.857	3.123	1.250			
	CPEM4	0.833	3.314	1.271			
Perceived Purchase Intention (PPI)	PPI1	0.811	2.782	1.239	0.789	0.805	0.613
	PPI3	0.844	3.059	1.164			
	PPI4	0.673	3.295	1.128			
	PPI5	0.793	3.205	1.209			

Note: Mean=M, Standard Deviation=SD, Cronbach's Alpha=α, Composite Reliability (CR) =rho-a, Average Variance Extracted=AVE

Source: Self-compiled by the author using SmartPLS-4

In this study, discriminant validity, as presents in Tables 3 and 4, was assessed using both the Fornell-Larcker criterion and the Heterotrait-Monotrait (HTMT) ratio. Table 3 presents that as all bold diagonal values exceed the correlations in their respective rows and columns except for certain constructs, particularly between IPE, CPVA, and CPO, where inter-construct correlations slightly exceeded the square roots of AVEs; therefore, the criterion for discriminant validity is largely satisfied [48]. While these constructs are theoretically distinct [49] & [25] and demonstrated adequate reliability and conceptual consistency, this statistical overlap is acknowledged as a limitation. Table 4 presents HTMT ratio where all values were below the required threshold of 0.900 except for five values (0.920, 0.930, 0.975, 0.984, and 1.022), which slightly exceeded the threshold but still indicated strong discriminant validity of the constructs [45] & [50]. These five HTMT values were included here since Hair et al. (2023) indicated that a threshold of 0.90 or even values closer to 1 can be acceptable. Thus, satisfactory levels of discriminant validity were established all the constructs.

Table 3. Fornell and Larcker Criterion-Matrix

Constructs	IPT	IPPA	IPE	CPVA	CPO	CPEM	PPI
IPT	*0.852*						
IPPA	0.602	*0.746*					
IPE	0.704	0.723	*0.759*				
CPVA	0.597	0.683	0.771	*0.742*			
CPO	0.638	0.649	0.757	0.757	*0.744*		
CPEM	0.567	0.573	0.643	0.705	0.674	*0.806*	
PPI	0.552	0.554	0.601	0.658	0.655	0.693	*0.783*

Note: Bold and Italic on the diagonal are the square root of AVE; Non-bold values are the inter-construct correlations

Source: Self-compiled by the author using SmartPLS-4

Table 4. Heterotrait-Monotrait Ratio-List

HTMT Ratio	
IPT <-> CPEM	0.676
IPT <-> CPO	0.810
IPT <-> CPVA	0.758

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IPT <-> IPE	0.847
IPT <-> IPPA	0.775
IPPA <-> CPEM	0.728
IPPA <-> CPO	0.880
IPPA <-> CPVA	0.920
IPPA <-> IPE	0.930
IPE <-> CPEM	0.769
IPE <-> CPO	0.975
IPE <-> CPVA	0.984
CPVA <-> CPEM	0.898
CPVA <-> CPO	1.022
CPO <-> CPEM	0.858
PPI <-> CPEM	0.840
PPI <-> CPO	0.846
PPI <-> CPVA	0.849
PPI <-> IPE	0.731
PPI <-> IPPA	0.721
PPI <-> IPT	0.674
Source: Self-compiled by the author using SmartPLS-4	

4.1.3 Structural Model Assessment

After successfully assessing the measurement model, the next step is to assess the structural model by examining potential multi-collinearity issues and testing the proposed hypotheses. In this study, the structural model assessment includes variance inflation factor (VIF), R^2, path coefficient values (β), and Q^2 predict statistics, which are obtained from PLS-SEM and presented in Table 5, 6, and 7. VIF was used to measure the amount of multi-collinearity where all the values in the inner model were below 5 (Table 5), indicating no multi-collinearity between the constructs [39], [51] & [52].

Table 5. Variance Inflation Factor (VIF) values

VIF	
IPT -> PPI	2.168
IPPA -> PPI	2.367
IPE -> PPI	3.811
CPVA -> PPI	3.452
CPO -> PPI	3.106
CPEM -> PPI	2.260
Source: Self-compiled by the author using SmartPLS-4	

Consequently, we investigated the coefficient of determination (R^2) which provides the in-sample exploratory power of the model where it explains the variance in the endogenous construct (dependent variable) caused by the exogenous construct (independent variable). In this study, R^2 value of the model was 0.568 as visible Table 6 and Figure 2, indicating that approximately 56.8% of the variance in consumers' purchase intention (dependent variable) was explained by influencer attributes and content features (independent variables), which reflects a moderately substantial explanatory power (R^2 = 0.50 as moderate, 0.75 as substantial, and 0.25 as weak) [39]. Therefore, the model represents a moderate to strong goodness of fit in explaining consumers' purchase intention. In addition, we ran PLS predict to assess the model's predictive relevance where Q^2 value reflects the out-sample predictive power of the model. Table 6 depicts that the Q^2 value of the endogenous construct in this study was 0.529, indicating medium to high predictive relevance of the model [39].

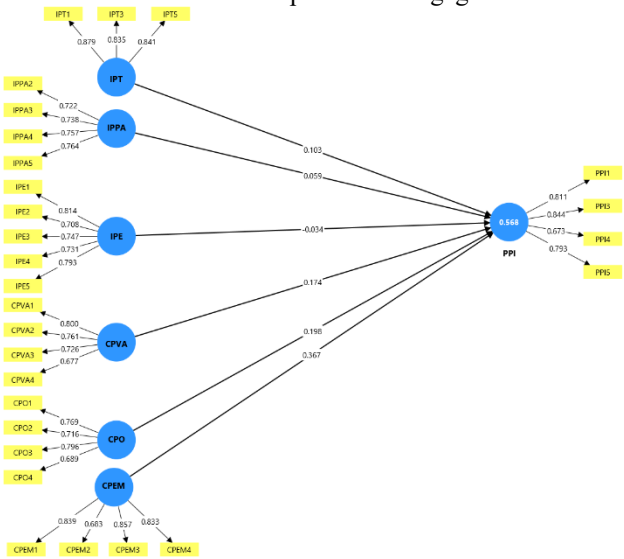
Table 6. R-square & Q-square Value

	R^2	Q^2
Perceived Purchase Intention (PPI)	0.568	0.529
Note: R^2= Coefficient of Determination Q^2= Coefficient of Prediction *Source: Self-compiled by the author using SmartPLS-4*		

For hypothesis testing, it is necessary to check the significance and relevance of path coefficients using bootstrapping at 5000 subsamples in SmartPLS-4 software. The path coefficient value is utilized to assess the strength and direction of the relationships between the constructs examined in this study, as visual Table 7 and Figure 2. The first hypothesis (H1) evaluates whether the perceived trustworthiness of the influencer positively influences consumers' purchase intention toward electronic gadgets. The results revealed that the influencer's perceived trustworthiness had an insignificant effect on consumers' purchase intention toward electronic gadgets (β= 0.103, t= 1.393, p= 0.082); hence, H1 was rejected. In addition, the second hypothesis (H2) examines whether the perceived attractiveness of the influencer significantly affects consumers' purchase intention toward electronic gadgets. The findings indicated that the influencer's perceived attractiveness had no statistically significant influence on consumers' purchase intention toward electronic gadgets (β= 0.059, t= 0.751, p= 0.226); therefore, H2 was not established. Furthermore, the third hypothesis (H3) investigates the relationship between the influencer's perceived expertise and consumers' purchase intention toward electronic gadgets. The statistical analysis

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revealed that the influencer's perceived expertise had an insignificant effect on consumers' purchase intention toward electronic gadgets (β=-0.034, t= 0.352, p= 0.362). Thus, H3 was not supported. Collectively, these three hypotheses—focusing on influencer attributes, namely perceived trustworthiness, physical attractiveness, and expertise—were not supported in the present study, indicating that these specific influencer characteristics did not significantly influence consumers' purchase intention toward electronic gadgets in the context of this research. Subsequently, the fourth hypothesis (H4) assessed whether the perceived visual attractiveness of the content had a substantial influence on consumers' purchase intention toward electronic gadgets. The results indicated that perceived visual attractiveness significantly influenced consumers' purchase intention (β= 0.174, t= 1.688, p= 0.046); therefore, H4 was supported. Conversely, the fifth hypothesis (H5) examined whether the perceived originality of the content had a statistically significant influence on consumers' purchase intention toward electronic gadgets (β= 0.198, t= 2.626, p= 0.004). The findings confirmed that perceived originality had a significant impact on consumers' purchase intention. Thus, H5 was supported. Furthermore, the sixth hypothesis (H6) tested the effect of perceived engagement metrics of the content (number of subscribers, views, comments, likes, and replies) on consumers' purchase intention toward electronic gadgets (β=0.367, t= 4.861, p= 0 .000). The results revealed that perceived engagement metrics



had a substantial effect on consumers' purchase intention. Hence, H6 was also supported.

Overall, these three hypotheses, which focused on content features such as visual attractiveness, originality, and engagement metrics, were all supported in this study. This suggests that these content-related factors have a significant influence on consumers' purchase intention toward electronic gadgets.

Table 7. Path coefficient statistics

Hypotheses	β	SD	T values	P values	Result
H1: IPT -> PPI	0.103	0.074	1.393	0.082	Not Supported
H2: IPPA -> PPI	0.059	0.079	0.751	0.226	Not Supported
H3: IPE -> PPI	-0.034	0.097	0.352	0.362	Not Supported
H4: CPVA -> PPI	0.174	0.103	1.688	0.046	Supported
H4: CPO -> PPI	0.198	0.076	2.626	0.004	Supported
H5: CPEM -> PPI	0.367	0.075	4.861	0.000	Supported
Note: Path coefficient value= β, Standard Deviation=SD *Source: Self-compiled by the author using SmartPLS-4*					

Table 7 also presents the t-values, p-values, and the results of the hypotheses. H4 (Visual Attractiveness), H5 (Originality), and H6 (Engagement Metrics) were accepted based on the t-values and p-values. The statistical analysis for H4 (t = 2.626, p = 0.004) revealed that the visual attractiveness of the content significantly influences consumers' purchase intention. This result is consistent with prior empirical studies, which also found that the visual attractiveness of content substantially influences consumers' purchase intention [53]. Furthermore, the statistical result for H5 (t = 2.626, p = 0.004) also revealed that the originality of the content greatly affects consumers' purchase intention. Prior empirical evidence similarly suggested that content originality from other content creators significantly influences consumers' purchase intention [35]. In addition, the result of the final hypothesis for H6 (t = 4.861, p = 0.000) demonstrated that engagement metrics significantly affect consumers' purchase intention. Previous research has also revealed that consumers' purchase intention is largely influenced by factors such as the number of subscribers of a particular content creator, as well as the number of views, comments, shares, and replies; indicating the level of engagement between the influencer and consumers, particularly among Bangladeshi social media users [54]. Besides, the findings from the hypothesis testing based on the t-values and p-values indicated that H1, H2, and H3 did not significantly influence consumers' purchase intention, as consumers placed more emphasis on content features rather than influencer attributes [35].

Source: Self-compiled by the author using SmartPLS-4 software

4.2 Discussion on Findings

This study aimed to investigate the extent to which tech YouTubers' attributes and content features affect customers' purchase intentions toward electronic gadgets in Dhaka, Bangladesh. Specifically, it examined the influence of YouTubers' trustworthiness, attractiveness,

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and expertise, along with their content's visual attractiveness, originality, and engagement metrics (NVLCR). The findings from the inferential analysis of the study, can be better understood in light of the descriptive profile of the sample.

Combining descriptive statistical data, the study identified that young males aged between 18–24 years residing in Dhaka city are the predominant users of YouTube and primary consumers of electronic gadgets. The survey results reveal that the largest proportion of these users were students, with the majority being undergraduate recently graduated students. This profile reflects a customer base that is highly active and young, tech-aware, and information-seeking, but also likely to make decisions based on observable and easily interpretable social signals, such as engagement metrics (views, likes, comments, shares), and visually appealing or original and novel content.

The results of the study clearly reflect a difference in the impact on purchase intention between content features and influencer attributes. All the content features, including visual attractiveness, originality, and engagement metrics, have direct and strong effects on customers' purchase intention, with engagement metrics emerging as the most prominent factor. These findings are consistent with previous studies [25], [55] & [56], which show that content features are critical elements influencing consumers' purchase decisions. However, the study also reveals that influencer attributes do not have a direct and strong effect on purchase intention, which contrasts with previous research emphasizing the role of influencers' characteristics in shaping customer buying behavior [57], [56] & [20].

The visual attractiveness of tech influencer content was found to have the positive association with buying intention. The results support prior studies [58], [23], [24] & [59] which consistently demonstrate that visually appealing content captures attention of consumers, which in turn directly influences consumers' intention to purchase, even in the absence of intervening attitudinal variables. The content originality of tech influencers on YouTube also proved significant in relation to buying intention towards electronic gadgets. This result is consistent with the findings of [60], [61], [26], & [25], which show that content originality directly influences purchase intention by offering unique and exclusive insights, thereby immediately enhancing customers confidence and motivation to purchase. The study results reveal that engagement metrics have a favorable association with buying intention toward electronic gadgets. Among all the content features, engagement metrics emerge as the most prominent factor directly influencing customer buying behavior. Ref. [28] studied the impact of engagement metrics on customer purchasing behavior and found that a high level of engagement — indicated by a large number of views, comments, shares, and replies — makes the content appear more credible, which in turn increases purchase interest [62]. Customers consider these engagement metrics as a form of social proof and are more likely to purchase the product [27] & [33].

The study shows that influencer attributes, including trustworthiness, physical attractiveness, and expertise, do not have a positive and direct association with purchase intention toward electronic gadgets. Several empirical studies have also investigated whether influencer attributes directly influence purchase intention. While some research has found a positive association between these attributes and purchase intention, these associations are not direct; rather, other mediating variables such as trust, play a role in shaping purchase decisions [63], [18], [64], [20] & [65].

V. CONCLUSION

The notion that content-centric persuasion, characterized by engagement metrics, visual attractiveness, and originality, has emerged as a more influential determinant of tech-related purchase intentions in the Bangladeshi context than influencer personality attributes. In fast-paced digital environments like YouTube, especially for young users who consume content frequently but may have limited time or cognitive ability to deeply evaluate source credibility (e.g. trustworthiness, physical attractiveness, expertise), peripheral cues like engagement statistics, aesthetic quality, and content novelty serve as shortcuts for assessing value and making purchase decisions. Furthermore, the predominance of students as consumers, who are more experimental, price-sensitive, and influenced by peer behaviors, trends, and word-of-mouth, becomes apparent when content has a high level of engagement (likes, comments, shares, and views). Given their extensive exposure to multiple influencers and emphasis on content quality, it is reasonable to infer that they value content utility, originality, and validation through engagement more than the persona of the influencer delivering the message.

This study offers valuable theoretical insights by integrating Source Credibility Theory (SCT) and the Elaboration Likelihood Model (ELM) of persuasion and examining both influencer attributes and content features to address a critical gap in existing literature that has largely focused on Western audiences. This study not only enriches the theories of consumer behavior and marketing but also provides new insights and approaches for understanding the role of influencers in digital marketing. This study also provides important practical implications for tech influencers to improve their post content by considering the followers' interest in their content. Influencers should focus on creating high-quality visuals, introducing fresh and creative concepts and encouraging interaction through polls, quizzes, giveaway and strong calls-to-action (CTAs) such as "Shop Now" (encouraging a purchase), "Like if you agree" (asking for likes), "Tag a friend" (encouraging shares and engagement), and "Comment your thoughts below" (asking for comments) can boost engagement metrics, leading to more likes, comments, shares, and ultimately, higher purchase intention.

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Although the study provides meaningful theoretical and practical implications, it has several limitations leading to further research avenues. First, the sample consists of individuals from the researcher's social media contacts who reside in Dhaka city, which may introduce regional and sampling biases. Future research could use a larger and more diverse sample to assess the generalizability and robustness of the results. Second, as the study is cross-sectional in nature, study outcomes were limited to a defined point in time. Therefore, future study might adopt a longitudinal study design with different time intervals in data collection. Third, the current study only investigated the direct relationships among variables, while future studies could examine the indirect effects of independent variables on dependent variables or assess consumer demographics (e.g., gender, education) as potential moderators. Fourth, all the variables in this study were selected from prior established research paper [25], [57] & [55]. Future research could expand the perspective and consider the effects of other relevant factors, such as homophiles, familiarity, influencer–product congruence, the average price level of influencers' endorsement and followers' ethnicity.

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Mapping the Intersection of Sustainability and Fintech: A Bibliometric Analysis

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Abstract- **The convergence of financial technology (fintech) and sustainability has emerged as a transformative force in the global effort to achieve inclusive, green, and efficient economic systems. Therefore, the objective of this paper is to understand and explore current trends in research, prolific authors, contributing countries, and prevailing themes. Data used in the study are collected from the Scopus database, and the analysis was done using VOSviewer and RStudio. The results of the study demonstrate that although fintech research began after 2015, there has been a surge in publications since 2023, which is expected to double by the end of this year. A significant rise in concern can also be seen among fintech authorities and related stakeholders regarding sustainability. This paper also demonstrates key themes and proposes future directions, including fintech's role in the circular economy and the integration of advanced technologies such as blockchain and AI in sustainable finance.**
Keywords- ***Fintech, Sustainability, Green Finance, Bibliometric Study, Financial Technology***

I.INTRODUCTION

Sustainability throughout the world has been a pressing concern since global warming's effect can be apprehended through rising sea levels, deforestation, and shifting weather patterns that threaten both ecosystems and human livelihoods [1]. Addressing this challenge requires coordinated efforts across nations, industries, and individuals to implement effective climate solutions [2], [3]. Developing economies, especially in South Asia, are facing high challenges because of high reliance on natural resources, high carbon emissions, deforestation, environmental pressures, and rapid industrialization [4]. Therefore, sustainable development has been a top concern for most countries since it requires figuring out and solving prevailing critical gaps of infrastructure, technology, and policy [5].

FinTech or Financial technology has the potential to provide ground for promoting sustainability through its innovative solutions [6]. In addition, Fintech facilitates green finance, financial inclusion, and efficient resource management that support sustainable practices across different industries [7]. Spanning from digital transformation of financial activities to modern technologies such as AI and blockchain, Fintech has offered various avenues to align technological growth with global environmental goals [6], [8].

Therefore, a priority shift can be noticed towards an inclusive financing culture/system that is presumed to be generated by the relationship of two very well-known terminologies, Fintech and Sustainability, making it a valuable area for study [9], [10]. To name a few of its capabilities, we can include proper controlling and tracking of environmental/digital footprint [11], empowering the overall financial inclusion [12], and pushing towards an efficient use of resources [9], [13]. As a result, sustainability has the high potential to be included and considered as a major factor in economic systems and its processes through various prospects by the rapid growth. As sustainability covers a wide range of concepts, some currently used digital instruments of Finance can ensure the ESG (Environmental, Social and Governance) accuracy by backing green investment (Environmental), rationalizing financing methods and sources for this circular economy (Social), and ensuring fairness in reporting (Governance) [14]. In addition, sustainability and Fintech collaboration can also potentially assure financial inclusion in developing economies [15].

This interrelationship between Sustainability and Fintech has already been assessed from various viewpoints by number of authors and researchers in past studies. Notable ones among them can be corporate sustainability that has been refined by better green finance activities [11], sustainable innovation with the help of rapid Fintech growth [16], and enhancing better banking practices [17] and so on. Comprehensive and data-driven evaluations show that the improvement in scholarly contributions in this field of study, specifying the most notable authors and countries, mapping new topic groups, is known very little despite a wide range of work in this field. Policymakers, practitioners, and scholars might find it difficult to get a comprehensive grasp of trends, relationships, and future research objectives in the absence of such a compilation.

Using information from the Scopus database, this study fills this gap by conducting a bibliometric analysis of FinTech–sustainability literature from 2015 to 2025. The study maps publication growth trends, prominent authors, important regional contributors, and main themes using tools like VOSviewer and RStudio. Combining theme mapping with quantitative performance analysis represents the novelty of this study as it provides a macro- and micro-level perspective of the field's evolution over the past decade. The study clearly outlines the research questions as follows:

RQ1: How has research on Fintech and sustainability developed over time?

RQ2: Which authors, institutions, and countries have made the most significant contributions to this field?

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RQ3: What are the key thematic clusters in Fintech and sustainability research, and how do they reflect the integration of technology, environmental sustainability, and financial inclusion?

The paper is structured as follows: section 2 describes the study background while section 3 illustrates the methodological design. On the other hand, section 4 discusses the analysis of data extracted from the Scopus database and the subsequent section 5 shows discussion. Finally, the conclusion and future research direction have been added to section 6.

II. STUDY BACKGROUND

The relationship of Fintech and Sustainability has been on the rise as a major domain for research over the last 10 years, which testifies that the world is shifting towards environmentally responsible finance practices and innovation [18]. Fintech or Financial Technologies aim at innovating and improving financial services [1]. It consists of a variety of activities such as mobile banking, blockchain, AI-driven tools, and peer-to-peer lending, etc. which ultimately results in an improved operational efficiency and effectiveness with total financial inclusion [19], [20].

On the other hand, sustainability in finance consists of frameworks of ESG (Environmental, Social, and Governance), which aim at creating long term value for not only the shareholders but also the society and environment. In this regards, Faizulayev [21] assesses the impact of different macroeconomic factors and confirms that ESG and Fintech factors ensure financial sustainability of conventional and Islamic banks.

Together, these two notable domains merge into Sustainable FinTech, a promising area for study from both economic and environmental perspective. Arner et al [9] presented their study by depicting how financial processes and systems can be merged with sustainable goals through the use of innovation and various financing tools and methods specially for green investment and the tracking of environmental as well as digital footprints.

Regarding initiatives of green finance and environmental performance, numerous studies have explored FinTech and Sustainability from their own perspectives and domains. One of those, Doghan and Chong [11], stress that FinTech can lead to both Green Investments and ensure optimum use of resources. Likewise, Gao et al [16] highlight the influence FinTech might have on the ESG outcomes of firms, that is, resulting in much better reporting and compliance of firms sustainability.

Looking into financial inclusion and socio-economic impact, several studies indicate that significant improvement can be seen in developing economies where FinTech contributed to financial inclusion. The study of Hiew et al [22] in Malaysia find that tech-based financing activities might fill the existing gap (such as limited access to all of the financial services), by ensuring participation from marginalized communities and people. Similar to this, Offiong et al [23] show that if an economic system adopts FinTech there is a good chance for positive impact in both environmental and social aspects of sustainability. Anshari et al's [24] work is another study that depicts how green initiatives of Fintech help to maintain better and responsible consumption and production. In his work Othman (Othman, 2025) assessed the alignment between green finance and sustainable practices conducting a thorough analysis of data from 300 customers and 100 bank professionals. His paper reports that FinTech plays a vital role in transforming ethical banking in Jordan by advancing ESG objectives, reducing financial access disparities, and enhancing customer loyalty, thereby contributing to sustainable, inclusive, and customer-centric banking practices.

Despite the major rise of study in this area, some gaps and voids still remain for further research that this paper has tried to explore. One is the very low to none integrated research themes on this domain where technological innovation, financial inclusions, and lastly environmental impact is shown into a single bibliometric approach. Next, most studies focus on specific countries or regions, which might restrict the understanding of global research patterns and collaboration networks. Finally, while thematic groups have been identified in several separate studies, only a few have mapped their evolution over time so that new emerging research aspects can be revealed.

In order to fill these gaps, this study uses the Scopus database to provide a thorough bibliometric analysis of FinTech-sustainability research from 2015 to 2025. Where other studies explored a narrow set of themes, this study goes on to explore and understand the notable authors, trends of publication, collaboration patterns, and thematic structures as well, by integrating performance analysis with scientific mapping. Therefore, this will result in getting an overall view of this field of study altogether through this bibliometric approach and leave suggested key areas for further research in the future.

III. METHODOLOGY

As the main objective of this research is to figure out current status, emerging trends, research clusters, prominent authors and countries, this study has adopted a bibliometric and systematic review technique. Bibliometric study was introduced by Pritchard [25] in order to assess the evolution of any scientific field. It gained momentous attention to map any research domain with focus on emerging boundaries and fields. This method is commonly applied in various fields, including finance [26], management [27], healthcare [28], technology adoption [29], marketing [30], also in arts and humanities. We followed a similar approach to that of Tandon et al. (2021). A multistep approach was followed to collect, sort, and review articles from the Scopus database.

Authors such as [31], [32], [33] suggested using the Scopus database because of its comprehensive collection of high-end, top quality research works. First, we extracted the keywords related to fintech and sustainability using google scholar. We looked for keywords used in ABS 3 or 4

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publications. We found “Financial Technology” and “Fintech” words as the mostly used keywords in top quality publications related to fintech. We also figured out “Sustainable Investment”, “Eco-friendly Finance”, and “Green Finance” keywords widely used for sustainability issues in finance.

We then invited 2 experts in the field of Fintech to finalize our keywords. Based on their suggestions, we incorporated the keywords "Financial Technology" or "Fintech" and "Sustainability" or "Sustainable investment" or "Eco-friendly Finance" or "Green Finance" for the final search. We started our search on 12 June 2025 and identified 715 records. The scope of the search was title, abstract, and keywords. We limited our study domain to Economics, Econometrics and Finance, Business, Management and Accounting, Humanities, and Social Science.

We focused solely on articles for this study and excluded other categories such as books, chapters, and conference papers due to their lack of peer-reviewed rigor and limited relevance to the specific research objectives, which required comprehensive, high-quality empirical studies. Therefore, 237 items were excluded from the list. Another 6 articles were removed since those are not published in English. Therefore 472 articles were screened before the final review. One author meticulously examined the titles and abstracts, excluding 34 articles that fell outside the scope and topic of this study. 438 documents, finally, were reviewed to map the intersection of fintech and sustainability (Figure 1).

We’ve used RStudio and VOSViewer to map the research field. RStudio was used to determine the data overview, contribution of authors, countries, and journals, thematic mapping, country collaboration maps etc., whereby VOSViewer was used to assess keyword analysis and cluster-mapping.

IV. ANALYSIS & RESULT

4.1 Descriptive Statistics

In this section we illustrate the findings from the bibliometric analysis conducted from 2015 to 2025 on 438 documents, specifically on the research field of Sustainable FinTech. Table 1 narrows down the findings from the analysis. It outlines that we have investigated a detailed explanation of sustainability issues in fintech as the annual growth rate of documents found here is 60.3%. On average, the documents collected from the Scopus database have an average of 18.25 citations.

As a combined, 1252 authors made contributions by publishing documents, of which 51 are single-authored documents. According to the number of authors, co-authors, and published papers, there is a mean number of 3.34 authors working on each document. In simple words, the data indicates a substantial number of international relationships, supported by 40.68% of international co-authorships. The authors collaborated extensively in FinTech, as evidenced by their findings.

TABLE I: OVERVIEW OF DATA

Description	Results
Timespan	2015:2025
Sources (Journals, Books, etc.)	187
Documents	438
Annual Growth Rate %	60.3
Document Average Age	1.48
Average citations per doc	18.25
References	28084
DOCUMENT CONTENTS	
Keywords Plus (ID)	1387
Author's Keywords (DE)	1262
AUTHORS	
Authors	1252
Authors of single-authored docs	48
AUTHORS COLLABORATION	
Single-authored docs	51
Co-Authors per Doc	3.34
International co-authorships %	40.64
DOCUMENT TYPES	
article	438

4.2 Annual Scientific Production

Figure 2 illustrates the trend in annual scientific production over the period of 2015 to 2025. As it shows, initially, production remained relatively low with a slight increase. Between 2019 and 2021, the yearly publishing in the field of FinTech started to gain momentum. The number of articles started to rise steadily, followed by a significant, sharp rise in 2023. The growth peaked approximately in 2024.

Subsequently, a decline is observed in the following years. The rapid implications of FinTech worldwide can justify the research numbers depicted. The intellectual agenda during these years centered on financial technologies, banking innovations, digital banking infrastructures, and financial inclusion, which collectively form the thematic core of contemporary FinTech research.

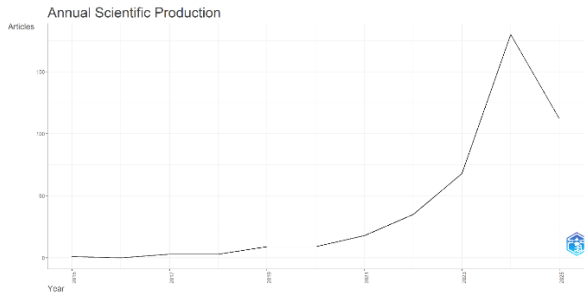


Fig. 2: Annual Scientific Production

The annual citations of FinTech-related publications over the period 2015-2025 are depicted in figure. It reveals the initial stability between 2015-2017, with approximately

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10 papers on average. A sharp decline can be observed, recording the lowest level in 2018, which is only 5 papers. The exponential growth in annual citations pivoted to peak in 2020. Contrarily, A significant decline in 2020 can be attributed to Covid19 pandemic. The decline throughout the year till 2025.

4.3 Top Journals and Sources

Figure 4 demonstrates the publications among the leading academic journals sorted from the Scopus dataset. Among all Resources Policy emerges as the top contributor to this field, recording 93 documents. It has established itself as the leading source of contributions in this field. Followed by Sustainability (Switzerland) and Finance Research Letters with publications of 47 and 11, respectively. Further noteworthy journals include Technological Forecasting and Social Change, the Journal of Cleaner Production, and the Journal of Open Innovation: Technology, Market, and Complexity, each has contributed significantly to the dissemination of FinTech research. Overall, these journals outputs describe that they are truly focused on policy, sustainability, innovation, and financial management. Emphasizing the interdisciplinary nature and cross-sectoral relevance of FinTech.

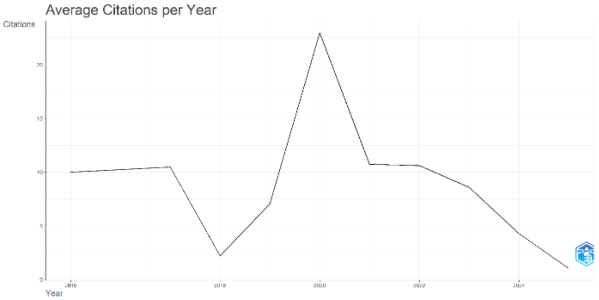


Fig. 4: Most relevant sources



Fig. 5: Sources' local impact by H index

Fig. 5 showcases the local impact as measured by H-index and the contributing journals. Findings suggest that Sustainability (Switzerland) exhibits the highest number of local impacts with an H-index of 20, closely followed by Resources Policy with an H-index of 19. These two journals are the most influential sources. In the mid-range, Technological Forecasting and Social Change with (H=5) and four journals, Journal of Cleaner Production, Journal of Open Innovation: Technology, Market, and Complexity, Journal of Risk and Financial Management, and Research in International Business and Finance and all with H=4. Overall, the figure demonstrates a highly skewed distribution of impact, with two journals dominating in local influence, while most of the source's cluster at lower H-index values.

The previous figures show articles and leading journals. Now, Figure 6 represents the source's production overtime. Research In International Business and Finance pivoted itself to the most crucial role in production starting from 2023. Simultaneously, Sustainability (Switzerland) trend upwards gradually over time, proof of presence in production increasing every year. Besides these two, other sources experienced steady growth over time.

Fig. 6: Sources' production overtime

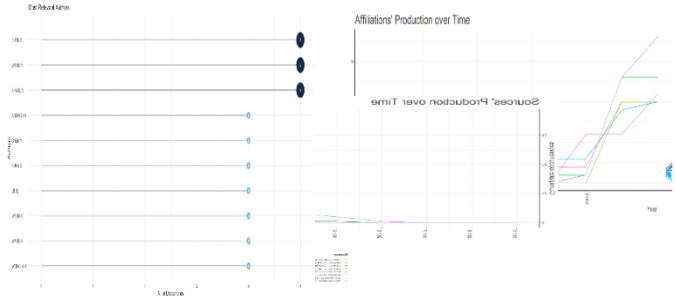


Fig. 7: Most relevant authors

4.4 Most Influential Authors and Documents

Figure 7 portrays the most relevant authors in FinTech. CHEN Z, WANG Y, and ZHANG Y are the most prominent, with 5 articles each. Other notable top contributors are Arshed N, Chen Y, Khan S, all others in this figure have produced 4 papers each.

4.5 Co-authorship or Country Collaboration Analysis

Following figure presents the top institutions for the Most Relevant Affiliations of the article produced. An astounding 18 publications have been produced by Sunway University, followed by King Saud University with 13 articles. Asia University, Hubei University of Automotive Technology, and Sichuan University produce

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similar 10 outputs, respectively. The rest of the universities produced 9 articles each.

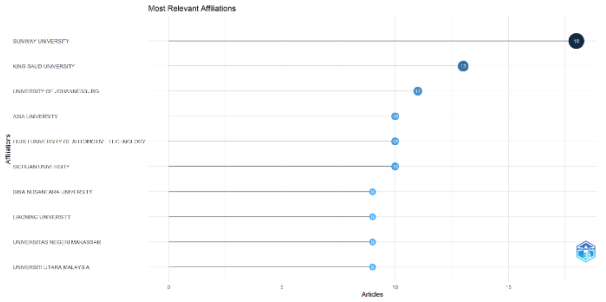


Fig. 8: Most relevant affiliations

The temporal evolution of scientific production (measured in the number of articles) from the Scopus dataset in the time frame of 2017-2025 has been demonstrated in figure 9. Initially, a slight inactivity between 2017 to 2020 is observed only by King Saud University, showing a small rise in publications. But the gradual emergence started in late 2020, Asia University and Hubei University of Automotive Technology began to increase their output, our research shows China and Southern Asia ramped up their research because of the rapid reshaping of their FinTech industry was undergoing. In 2023, onwards sharp output hike began, the University of Johannesburg showed the steepest growth and suppressed all others by 2025, with more than 17 cumulative publications. Hubei University of Automotive Technology has stabilized around 13-14 and 10-11 publications, respectively. Overall, there was a delay but accelerating engagement in scientific output among the institutions after 2023. This suggests new collaborative initiatives, funding availability, or emerging research trends that have simultaneously motivated productivity across multiple affiliations.

4.6 Keyword Co-occurrence Analysis

We conducted a keyword co-occurrence analysis with 10 keywords and figured out a total of 83 items (Figure 10). As shown in table 2, we examined the intersections of four distinct clusters related to sustainability in fintech issues. These clusters have been designed to offer a clear framework for understanding the interplay between technological progress, financial systems, and the advancement of sustainability.

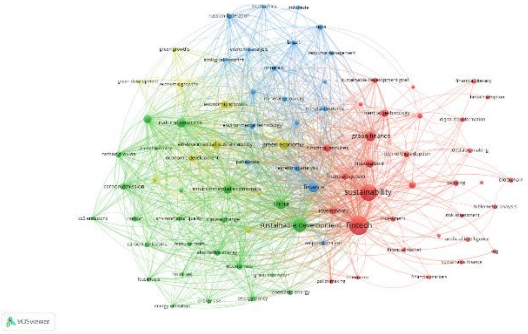


Fig. 10: Keyword cooccurrence map

TABLE II
IDENTIFIED CLUSTERS ACCORDING TO COOCCURRENCE ASSESSMENT

Identified Cluster	Keywords	Unified Themes
Cluster 1 (31 items)	Artificial Intelligence, Banking, Bibliometric Analysis, Blockchain, Commerce, Decision Making, Developing World, Digital Transformation, Digitalization, Digitization, Financial Inclusion, Financial Literacy, Financial Market, Financial Markets, Financial Services, Financial System, Financial Technology, Fintech, Fintech Adoption, Green Finance, Innovation, Investment, Investments, Machine Learning, Policy Making, Risk Assessment, Sustainability, Sustainable Development, Sustainable Developer, Technology Adoption	Technological Integration and Financial Systems
Cluster 2 (24 items)	Alternative Energy, Carbon, Carbon Dioxide, Carbon Emission, Carbon Emissions, China, Climate Change, Co2 Emissions, Economics, Energy Policy, Energy Use, Energy Utilization, Environmental Economics, Environmental Quality, Environmental Regulation, Fossil Fuel, Fossil Fuels, Global Warming, Green Innovation, Natural Resource, Natural Resources, Renewable Energy, Resource Rents, Sustainable Developer	Environmental Sustainability and Green Energy
Cluster 3 (19 items)	Ecological Footprint, Economic Analysis, Empirical Analysis, Environmental Management, Environmental Technology, Finance, India, Indonesia, Method of Moments, Mineral Resource, Mineral Resources, Brazil, Minerals, Panel Data, Quantile Regression, Regression Analysis, Resource Management, Russian Federation, South Africa	Economic and Environmental Analytics
Cluster 4 (9 items)	Economic And Social Effects, Economic Development, Economic Growths, Environmental Policy, Environmental Sustainability, Green Development, Green Economy, Green Growths, Technological Development	Socio-Economic Growth and Development

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Cluster 1: Technological Integration and Financial Systems
The first cluster necessitates how digital technologies such as machine learning, blockchain, and artificial intelligence are integrated into financial systems to transform the old practice of financial markets into modern domains. Keywords such as Fintech adoption, policy making, green finance, and financial inclusion highlight both opportunities and challenges in ensuring sustainable financial ecosystems. In developing countries, the emphasis on innovation and efficiency aims at broadening access to finance for everyone [9].
Cluster 2: Environmental Sustainability and Green Energy
In the second cluster, keywords such as renewable energy, environmental regulation, and green innovation highlight a strong focus on aligning financial technologies with energy transitions. It shows how Fintech can be a climate-related mechanism used to promote cleaner, eco-friendly focus. Furthermore, Finance-driven mechanisms such as green bonds, ESG financing, and carbon credit trading's role in accelerating low-carbon development pathways are highlighted here as well.
Cluster 3: Economic and Environmental Analytics
Cluster 3 groups together an empirical and econometric approach of connecting sustainability and Fintech. Terms such as panel data, quantile regression, economic analysis, resource management, and ecological footprint suggest that, across countries such as India, Brazil, Russia, Indonesia, and South Africa, researchers are testing measurable associations between financial practices and environmental outcomes. The emphasis is on giving policymakers evidence-based advice using quantitative methods.
Cluster 4: Socio-Economic Growth and Development
The last cluster focuses on macro-level impacts of sustainable Fintech application. This cluster highlights that the concept of Fintech innovations is comprehensive and inclusive, with key terms like economic growth, green growth, technological advancement, and eco-friendly present. This cluster focuses on harmonizing financial development with long-term societal and economic objectives such as green growth, employment generation, and social well-being.

V. DISCUSSION

This bibliometric study provides useful information on the prevailing interrelation between Fintech and sustainability, highlighting the development of literature, the role of leading authors and institutes, and the key themes that emanates from the scholarly works. The paper's initial research topic included was to examine the emergence of sustainability research based on FinTech. It has been noted that research in this field has experienced a rapid expansion, particularly since 2019, which is indicative of the growing recognition of possibilities for FinTech to address global challenges such as climate change, scarcity and financial exclusion [34], [35]. The findings of this research deliver valuable insights into the evolution of Fintech that has evolved beyond conventional financial inclusion, transitioning into the digital space and making a vital contribution to the establishment of a more sustainable global financial system. Our research indicates that there is a global increase in publications concerning sustainability in Fintech, with an annual growth rate of 60.3%. The surge is indicative of rising global interest in sustainability and digital finance has been driven by the rapid evolution of Fintech advancements, including artificial intelligence, blockchain, digital banking, and sustainable financial offerings [18], [36], [37]. The spike in publications in 2024 focuses on how global pressures associated with sustainability, climate change, regulatory issues, and digital transformation have enhanced the concerns regarding Fintech. Hence, the rapid proliferation of publications presents a growing expression of academic interest, and a broader recognition of Fintech's potential for positive environmental and social impact.
The second question of this study was related to key people, institutions and countries who are contributing to this field. According to our research, writers such as Chen Z, Wang Y, and Zhang Y, who has made a remarkable impact on the theme of financial technology integration with the sustainable concept. Analysis of these authors addresses themes that involve financial inclusion, green finance, and the use of blockchain in sustainable investment. Their findings have been impactful for the academic discourse on sustainable Fintech.
Institutions like Sunway University (18 articles) and King Saud University (13 articles) are now playing a significant role, especially in areas such as Asia, where adoption in Fintech is accelerating rapidly [4]. Increasing attention to the Fintech ecosystem in the leading regions indicates a growing interest in the role that Fintech can play for sustainability.
Our final question was to assess the thematic clusters in Fintech and sustainability research. We conducted a keyword cooccurrence analysis with 10 keywords and identified four research clusters including technological integration and financial systems, environmental sustainability and green energy, economic and environmental analytics, and socio-economic growth and development. The analysis highlights key issues around how technology can be embedded in financial systems as the cornerstone of sustainable Fintech research. Blockchain, AI, and digital banking are constantly touted as tools with which to mobilize green finance programs and provide transparency on sustainable investments. Moreover, the trend of incorporating ESG factors into financial decision-making is equally aligned with rising need for sustainable products such as green bonds and other sustainable financial instruments [4], [38]. Another progressive area is how Fintech is addressing environmental sustainability, particularly through producing renewable energy and cutting carbon emissions [7]. In this regard, this study emphasizes how important Fintech is to promote sustainability in both developed and developing nations worldwide.

VI. Conclusion & Future Research Directions

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Sustainability has emerged as an essential concern for every nation worldwide in recent years. It has been working as a catalyst for transforming the world towards sustainability goals. Fintech not only focuses on transforming traditional financing activities into digital form but also aims at integrating technologies to leverage efficiency, inclusivity, and transparency in financial services. This study offers valuable insight in the intersection of Fintech and sustainability with concern to technology, environment, and economy. However, future research avenues prevail.

First, it has been found that most sustainable fintech related research has been conducted in developed countries which cover little insight from emerging markets. Therefore, more research on the pattern of growth in Fintech adoption should be conducted. Second, since policymakers around the world have been working to create an environment conducive to the growth of green finance and digital financial services, further studies could highlight regulatory frameworks for supporting sustainable financial initiatives. Third, more research is necessary to fully understand the ethical ramifications of Fintech innovations. Fairness, transparency, and inclusivity are important topics to investigate as financial technologies advance, especially when it comes to the use of AI-driven financial products.

In summary, Fintech has contributed significantly to promote sustainable financial systems and advance global sustainability goals. However, more study is required to examine the ethical, legal, and economic aspects of this developing field to fully realize its potential.

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Does Investment Climate Matter to Foreign Direct Investment? Evidence from OECD Countries

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Abstract – **This study aims to examine the impact of investment climate, along with its macroeconomic determinants, on foreign direct investment (FDI) inflows using a panel data analysis for a sample of 38 OECD countries by considering the level of economic freedom (EFI), as provided by the "Heritage Foundation." By employing the two-step system GMM technique, our findings robustly demonstrate a strong positive link between EFI and FDI inflows, highlighting the crucial role of investment climate in attracting foreign investment. The findings suggest that labor force participation and trade openness have a significant positive impact on FDI inflows, whereas the inflation rate has a significant negative impact. However, domestic investment shows no significant impact on FDI inflows. Therefore, the study emphasizes the significance of strengthening economic institutions to attract FDI. To sustain FDI inflows, policymakers in OECD nations should prioritize regulatory efficiency, property rights protection, macroeconomic stability, and human capital development.**

Keywords – **Economic Freedom, Foreign Direct Investments, OECD Economies, Panel Data Analysis, Two-step System GMM**

I. INTRODUCTION

Foreign Direct Investment (FDI) denotes the capital allocated by individuals or entities from one nation into another, either directly or via affiliated firms, wherein the foreign investor maintains substantial control. It enhances productivity and generates employment, hence fostering sustainable economic development. Considering the benefits derived from FDI, firms typically possess many motivations for pursuing foreign direct investment (FDI), as elucidated by Dunning's OLI Model [1], which encompasses ownership-specific variables, location-specific factors, and internalization advantages as the key determinants guiding investment decisions.

Despite these well-established theoretical underpinnings, actual global FDI trends reveal fluctuations that highlight the influence of broader macroeconomic and institutional conditions. For example, within the OECD region, FDI inflows rose by 11% to USD 501 billion, a headline increase largely explained by significant disinvestments in Luxembourg in 2022. However, this conceals the reality that over two-thirds of OECD economies had diminished FDI inflows in 2023. The nations experiencing the most significant decline (exceeding USD 20 billion) were Australia and the United States, due to reduced reinvestment of earnings in both, diminished stock flows in Australia, and fluctuations in intra-company loans in the United States. Sweden also experienced significant declines, primarily attributed to reduced equity inflows. Significant disinvestments were observed in the Netherlands in 2023, alongside notable disinvestments in Luxembourg the preceding year, while the United Kingdom also experienced substantial disinvestments [2].

These patterns suggest that while firm-level factors remain important, they are insufficient on their own to sustain long-term FDI inflows. Instead, the investment climate and policy framework of host countries play a decisive role in shaping investment outcomes. In particular, economic openness emerges as a critical determinant in attracting FDI, which in turn delivers both wealth and expertise to the countries that are receiving it, as well as introducing modern technologies [3].

While much of the literature has traditionally focused on the direct impact of several variables, including infrastructure, trade openness, return on capital, labor costs, political instability, and domestic macroeconomic policies on FDI inflows, fewer studies have explored the role of domestic investment climate in facilitating FDI inflows up to this point because there is generally a lack of a consistent and accurate set of numerical information on the investment climate. This study contributes to that gap by positioning economic freedom as provided by the "Heritage Foundation," not merely as an outcome of development but as a proactive determinant in attracting foreign capital and fostering international economic integration. Therefore, the study has the following specific objectives:

- To examine the impact of economic freedom on FDI inflows in OECD countries.

Consequently, we utilize data on 38 OECD nations from 2004 to 2024 and employ the two-step system GMM.

The selection of OECD countries for this study is motivated by their composition as a diverse group of both advanced and emerging economies, exhibiting a wide spectrum of economic freedom levels. This diversity

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provides an ideal context for analyzing the multifaceted relationship between economic freedom and FDI inflows.

II. METHODOLOGY

A. Variables and Data Sources

This study examines the macroeconomic impact of domestic investment climate, inflation rate, domestic investment, labor force, and trade openness on foreign direct investment inflows. The sample size comprises 38 OECD countries over the period 2004 to 2023. Table 1 displays a summary of these variables together with their sources.

B. Model Specification

The investigation's model can be expressed as follows:

lnFDIit=α+ 1EFIit+2INFit+ 3GFCFit+4lnLFit+5TOit+it #1

Where,

FDI = Foreign Direct Investment inflows in a country i and period t;

EFI = Economic Freedom Index in a country i and period t;

INF = Inflation in a country i and period t;

GFCF = Gross Fixed Capital Formation in a country i and period t;

LO = Labor Force in a country I and period t;

TO = Trade openness in a country i and period t.

A dynamic panel regression model is given below:

Yit=δYi,t-1+βXit+it #2

In this case, the dependent and independent variables are denoted by Y, X, and Yt-1 respectively; the term it is the sum of the time-invariant and unobserved effects (ui) and the random disturbance term (vit); and ui~NID(0,2); vit~NID(0,2). For us to write,

it=ui+vit 3

Therefore, equation (1) can be converted as follows:

lnFDIit=δlnFDIi,t-1+1EFIit+2INFit+ 3GFCFit+4lnLFit+5TOit+it 4

Here, lnFDIi,t-1 is the lagged value of the FDI inflows. Using the lagged dependent variable as an independent variable in the regression equation's right-hand side can help with a few econometric issues. The primary issue in this case is that it produces autocorrelation. Therefore, an endogeneity problem arises when there is a link between the explanatory variables and the error term, which goes against the homogeneity assumption. The results will be biased and inconsistent when unit effects and a lagged dependent variable are present in the model. The Generalized Method of Moments (GMM) is thus the most suitable estimating technique that can resolve the endogeneity issue.

There are two distinct varieties of GMM: Difference GMM and System GMM. Arellano & Bond [4] have developed Difference GMM, whereas Arellano & Boverb [5] and Blundell and Bond [6] have developed System GMM. According to Difference GMM, the instrumental variables can be used to address the endogeneity issue that results from employing the lagged-dependent variable as an explanatory variable. The first difference of the model, which can remove unobserved country-specific effects (ui) is employed for this purpose. The adoption of the lagged values of the independent variables as instruments removes the possibility of endogeneity and the link between the lagged dependent variable and the new error term, which makes it superior to the 2SLS model and instrumental variable (IV) estimators. Nevertheless, the country-specific effects will eventually disappear, and the correlation between the lagged dependent variable and the error term will become negligible when the time series units (T) are greater than the cross-section units (N) [7]. In that instance, using the Generalized Methods of Moments is not necessary.

lnFDIit-lnFDIi,t-1=δlnFDIi,t-1-lnFDIi,t-2+1(EFIit-EFIi,t-1)+2(INFit-INFi,t-1)+3(GFCFit-GFCFi,t-1)+4(lnLFit-lnLFi,t-1)+5(TOit-TOi,t-1)+(εit-i,t

1) *(5)*

This leads to a new statistical difficulty arising from the first difference technique. The lagged levels of these variables are regarded as a weak instrument that lowers the efficiency of the outcomes when the endogenous variables are persistent over time. However, Arellano & Boverb [5] and Blundell and Bond [6] demonstrate that the lagged values of the independent variables as instruments could result in biased estimators. Therefore, they offer the System GMM to get around this problem; this method produces more useful results than the difference GMM. Two equations are used by the System GMM to construct a system; one equation is differentiated, while the other is left level. While the lagged levels are utilized as instruments for the differenced equation, the lag differences "(5)" are employed as tools for the level equation "(4)."

Two specification tests must be performed to demonstrate the consistency of the System GMM estimators: (i) the joint validity test of every instrument, and (ii) the absence of second-order autocorrelation AR(2). In this case, first-order autocorrelation can be expected, but autocorrelation in second-order autocorrelation should not be expected. The presence of a significant AR(2) indicates an issue of autocorrelation.

Using Hansen's J-statistic, the validity of the instruments can be evaluated. It is implied that parameter estimates are consistent and that the parameters are orthogonal to errors when the null hypothesis is adopted [8].

III. RESULTS

A. Descriptive Statistics

The descriptive statistics that comprise of mean, standard deviation, min, and max value of the selected variables are presented in Table 2.

B. Correlation Matrix

The correlation matrix of the selected variables is presented in Table 3.

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C. *Estimation Results of Dynamic Panel Data Estimators*

The results are summarized in Table 4. To demonstrate the accuracy of the System GMM results, we must first justify the outcomes of a few diagnostic tests. the number of instruments shouldn't exceed the number of groups [9]. There are 37 groups and 25 instruments in this model, which satisfy the condition. The probability values of AR(1) and AR(2) are 0.004 and 0.527, respectively, suggesting first-order autocorrelation but not second-order correlation.

The Hansen test assesses the validity of the instruments in the regression model. The table indicates a p-value of 0.163. This signifies that the Hansen test fails to reject the hypothesis, indicating the instruments are valid at a 5% significance level. Since these results are legitimate, we may now proceed with our interpretation. However, as we are now addressing the lagged variables, the magnitude of each coefficient has become smaller than the coefficients from the fixed-effect model.

The results for OECD member countries obtained from the two-step system GMM show that, except for one variable, all the other variables are significant, but the level of significance varies among variables. The substantial coefficient of lagged FDI is 0.1779994, indicating the self-reinforcing impact of FDI; precisely, the level of lagged FDI considerably influenced foreign investment for the current year.

An enhancement of one unit in the overall EFI (Economic Freedom Index) results in an approximately 4.98% increase in FDI inflows, and it is statistically significant at 1% significance level. By the same token, an enhancement of 1% in the inflation rate results in an approximately 0.0234% decline in FDI inflows. Analogously, an increase of 1% in the labor force causes FDI to increase by approximately 0.83 % in the case of OECD countries. Similarly, A 1 unit improvement in trade openness leads to a 0.99 increase in lnFDI inflows, and it is statistically significant at a 1% significance level. But there is no significant relationship between domestic investment and FDI inflows.

IV. DISCUSSION

The study shows a significant impact of economic freedom on foreign direct investment (FDI) inflows. It is well-documented and robustly corroborated by multiple studies [10], [11], [12], indicating that increased economic freedom improves the investment climate and attracts greater foreign direct investment (FDI). Because a stable, transparent, and business-conducive condition mitigates investment risks and augments profitability.

The inflation rate is found to have a significant negative relationship with FDI inflows in OECD countries in our study. Because rising inflation will erode the currency's value and lower investors' returns. The outcomes correspond with previous research [13], [14].

Our study fails to show any significant relationship between domestic investment and FDI inflows. OECD nations often possess advanced infrastructure and substantial domestic investment levels. Excessive domestic investment may suggest that local enterprises prevail in the market, hence restricting chances for foreign investors. This outcome of the study is aligned with previous studies [15] and [16].

The labor force has been found to have a positive relationship with FDI inflows in our study. For foreign investors looking for efficient production, a competent workforce is essential since it increases efficiency. This outcome supports what some authors [17], [18] have said.

Similarly, FDI is found to be responsive to trade openness in OECD countries. Decreased obstacles indicate a pro-business climate, promoting foreign direct investment in manufacturing and export-focused industries. It is robustly corroborated by multiple studies [19], [20].

V. CONCLUSION

The findings demonstrate that investment climate is a positive and statistically significant factor influencing FDI. This study's further noteworthy findings indicate that labor force, inflation rate, and trade openness are generally crucial predictors of FDI in OECD nations, while local investment is negligible. This confirms that OECD countries can attract greater FDI if their economies are more liberalized.

These findings of the current study have some fascinating policy implications, which are:

- To encourage FDI inflows, this study recommends that governments should implement economic freedom-improving policies and procedures that foster an enabling investment climate that are customized to the economic and geoeconomic features of the host nations.
- Countries should invest in education and training programs to improve the skills of their workforce to attract increased FDI inflows.
- To attract FDI, they should strengthen regional economic cooperation projects like the EU or NAFTA to give investors broader integrated markets.
- It is recommended that policymakers sustain a reduced inflation rate using several strategies, including monetary, fiscal, and exchange policies, as investors like stable economies over volatile ones.

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APPENDIX

TABLE I
SUMMARY OF THE VARIABLES & DATA SOURCES

Variables	Indicators	Unit of measurement	Symbol	Data source
Foreign Direct Investment	Foreign Direct Investment	Current US$	FDI	WDI
Economic Freedom	Economic Freedom Index	-	EFI	US Heritage Foundation
Inflation Rate	CPIt-CPIt-1CPIt-1×100	-	INF	WDI
Domestic Investment	Gross Fixed Capital Formation	% of GDP	GFCF	WDI
Labor Force	Labor Force	Total	LF	WDI
Trade Openness	Exports+Imports GDP	-	TO	WDI

Source: World Bank, 2023 & The Heritage Foundation, Washington DC

TABLE II
DESCRIPTIVE STATISTICS

Variables	Mean	Std. Deviation	Min	Max
lnFDI	23.22212	1.602875	17.32819	27.32154
EFI	71.18763	6.452574	50.6	84.4
INF	3.096838	4.347336	-4.447547	72.30884
GFCF	22.66497	4.101063	10.97046	53.22203
lnLF	15.67136	1.486983	12.06405	18.95551
TO	.9838528	.5905516	.2307978	3.942207

Source: Author's estimation

TABLE III
CORRELATION MATRICS

Variables	FDI	EFI	INF	GFCF	LF	TO
FDI	1.0000					
EFI	0.1330*	1.0000				
INF	-0.0625	-0.1570*	1.0000			
GFCF	-0.0872*	0.2094*	0.2040*	1.0000		
LF	0.5634*	-0.0233	0.0156	-0.0539	1.0000	
TO	-0.1782*	0.1509*	-0.0003	0.0115	-0.4104*	1.0000

Note. The significance level of 5% is indicated by "*".

TABLE IV
RESULTS OF TWO -STEP SYSTEM GMM

Dependent Variable: lnFDI					
Explanatory Variables	Coeff.	Corrected Std. Err.	t	p>|t|	[95% conf. interval]
lnFDI (lagged)	.1779994**	.0867558	2.05	0.048	.0020505 .3539482
EFI	.0498049***	.0114797	4.34	0.000	.0265231 .0730867

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INF	-.0234343**	.0104162	-2.25	0.031	-.0445593	-.0023093
GFCF	.0228151	.0139404	1.64	0.110	-.0054574	.0510876
lnLF	.8287631***	.1471538	5.63	0.000	.5303213	1.127205
TO	.9960933***	.2550269	3.91	0.001	.4788747	1.513312
Constant	1.254705	1.875701	0.67	0.508	-2.549392	5.058803
No. of observations: 576						
No. of groups: 37						
Diagnostic Tests						
F Statistic Prob > F = 0.000						
Arellano-Bond test for first order autocorrelation AR (1): z = -2.84 Prob > z = 0.004						
Arellano-Bond test for second order autocorrelation AR (2): z = 0.63 Prob > z = 0.527						
Hansen test of over identifying restrictions chi2(18) = 23.77 Prob > chi2 = 0.163						
No. of instruments < No. of groups: 25 < 37						

Notes. Variables with "*," "**," and "***" are significant at p<10%, p<5%, and p<1% respectively.

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Impact of Loan Default on the Sustainability of Financial Health: A Study on Selected Private Commercial Banks in Bangladesh

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Abstract - **This study aims to examine the influence of loan default over the sustainability of financial health of selected private commercial banks listed on Dhaka Stock Exchange (DSE) in Bangladesh. The banking sector of the country faces significant challenges in terms of loan defaults. The study applies panel data analysis to investigate how non-performing loan ratio (NPLR), capital adequacy ratio (CAR), provision maintenance ratio (PMR), credit deposit ratio (CDR), and cost-to-income ratio (CIR) influence the sustainability of bank performance, as measured by a profitability indicator- return on assets (ROA). The study utilizes secondary data of 19 private commercial banks over a 16-year period (2008-2023), representing strongly balanced panel data. Hausman specification test recommends fixed effect regression model which reveals that NPLR has a significant negative influence over ROA, whereas CDR shows a significant positive impact. This study provides valuable insights for bank management in Bangladesh to better manage non-performing loans and optimize credit strategies to maintain profitability.**
Keywords - **Credit deposit ratio, fixed effect regression, non-performing loan ratio, profitability**

I.INTRODUCTION

Economic growth of a country relies on the sustainability of its financial sector. Without ensuring the financial health of that industry, a country faces numerous challenges to develop its economic performance. Specifically, when an effective allocation of resources and capital is needed to be executed, a nation's banking system must be sustainable enough to safeguard its financial health. Reference [6] executes the application of panel GMM to investigate and reveals that financial instability has a significant negative influence on economic development. Not only effective fiscal policy, but also regulation of the financial institutions and markets plays a vital role to derive higher financial sustainability, leading toward economic growth [13].

To be more specific, banking sector plays a critical role in implementing such financial sustainability for an economy. Return on assets (ROA), one of the bank profitability measures, is used to assess a firm's ability to create profits by comparing profits generated and costs incurred within a given period. In this empirical research, non-performing loans (NPLs) are examined as a significant variable that negatively influences commercial banks' profitability [10]. Another study focuses on credit risk to be found as one of the specific risks faced by commercial banks because of the nature of their facilities provided. This emphasizes the association between credit risk management (NPLs and capital adequacy ratio) and commercial banks' profitability (return on assets and return on equity) [5]. A study on Chinese banks incorporates both macroeconomic (gross domestic product, inflation rate, foreign exchange rate, and effective interest rate) and banking industry-specific (banks' type, risk-taking behaviour, ownership concentration, debt, and credit quality) variables to specify the determinants of NPLs [15]. A study on Pakistan Stock Exchange examines that operating efficiency and profitability have significant negative association with NPLs, whereas capital adequacy and income diversification have insignificant positive association with NPLs [9].

To represent the company's success (profitability), non-performing loan ratio (NPL ratio), liquidity ratio, capital adequacy ratio (CAR ratio), gross domestic product (GDP), and bank size can be used as significant determinants [4]. In line with this study, there is strong positive association between CAR and profitability of Deposit Money Banks in Nigeria [12]. Another study on Indonesia reveals how economic condition, business risk, lending interest rate, and NPLs are associated with corporate financial sustainability [2].

Bangladesh has been a growth focused country where the banking industry has played a pivotal role in facilitating economic growth and advancement through financial intermediation. One of the significant challenges faced by this industry has been the looming issue of loan defaults, also known as non-performing loans. According to a latest report from Bangladesh Bank, it has been disclosed that aggregated NPLs indicate approximately 24.13% of the total loans that have been disbursed by 61 commercial banks. This designates around 25% of the total loans disseminated by the banking industry are going to be classified as troubled or have already been defaulted [7].

Reference [1] investigates how increasing volume of NPLs is leading toward a negative turn into the banking industry and the overall economy of Bangladesh. The researcher also mentions about higher percentage of NPLs that exists in Bangladesh, being compared to the worldwide standard (to be 2% or less). Another panel data analysis conducted on the corporate governance practices and NPLs of Bangladeshi banking sector reveals that banks with effective corporate governance (e.g. board size, number of independent directors, independence of audit committee chairman), can reduce the NPLs of Bangladesh [3].

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When extensive study has been conducted in explaining the factors influencing non-performing loans in Bangladesh, there has been limited literature in explaining the important variables representing default that impact profitability of Bangladeshi private commercial banks. This study is expected to guide investors, policymakers, and researchers into understanding the measures to prioritize for evaluation and decision-making. It also promotes the practice of making objective and evidence-based decisions by the users. The objective of the study is: i) to identify the significance of the association between NPLs and profitability, and ii) to determine the significant variables that influence the selected banks' profitability.

II. METHODOLOGY

The study employs a quantitative ex post facto design to examine how the selected financial indicators influence the private commercial banks' profitability in Bangladesh. The methodology is grounded in secondary data extracted from 19 listed private banks' annual reports over a 16-year period (2008-2023), resulting in a balanced panel dataset of 304 observations. The banks have been chosen considering their availability and consistency of their published financial reports over the mentioned period. Incorporating panel data allows for the tracking of both cross-sectional (across banks) and time-series (across years) variations, enabling more precise estimation by controlling for unobserved heterogeneity at the firm level.

A. Panel Regression Model Development

According to the Hausman test results, the fixed effect model has been selected and the fixed effect estimations applied to explain the relationship and impact of the explanatory variables (NPLR, CAR, PMR, CDR, and CIR) on the dependent variable ROA.

Here, subscript *i* signifies the cross-sectional dimension and *t* signifies the time series effect, α stands for constant and ε_{it} is the error term,

NPLR = Non-Performing Loans Ratio,
CAR = Capital Adequacy Ratio,
PMR = Provision Maintenance Ratio,
CDR = Credit deposit ratio,
CIR = Cost-to-income ratio.

Regression equation:

$$\boldsymbol{ROA}_{it} = \boldsymbol{\alpha}_{it} + \boldsymbol{\beta}_1\boldsymbol{NPLR}_{it} + \boldsymbol{\beta}_2\,\boldsymbol{CAR}_{it} + \boldsymbol{\beta}_3\,\boldsymbol{PMR}_{it} + \boldsymbol{\beta}_4\,\boldsymbol{CDR}_{it} + \boldsymbol{\beta}_5\,\boldsymbol{CIR}_{it} + \boldsymbol{\varepsilon}_{it} \quad (1)$$

TABLE I: MEASUREMENT OF VARIABLES
Note: Yearly data is collected for all the dependent and independent variables

Variable	Measurement	Expected Sign	Reference
ROA	ROA is calculated as the percentage of net income over the total assets.	Not applicable	
NPLR	Non-performing loans ratio gives the total amount of NPLs as a percentage of the total amount of loans outstanding.	-	[8,10]
CAR	Capital adequacy ratio represents the proportion of the bank's regulatory capital as a percentage of its risk-weighted assets.	+	[4,12,16]
PMR	Provision maintenance ratio is the percentage of loan provision maintained to the required loan provision of the banks.	-	[11]
CDR	Credit deposit ratio is the percentage of total loans to the total deposits of a bank.	+	[11]
CIR	Cost-income ratio calculates the proportion of operating expenses incurred as a percentage of the operating income earned.	-	[14]

III. RESULTS

Preliminary Analysis

Table II provides the summary statistics describing the pattern of the one dependent variable ROA, and five independent variables- NPLR, CAR, PMR, CDR and CIR. The average return on assets across the 19 banks over the span of 16 years is 1.025% with a standard deviation of 1.028. The range of minimum value (-5.87%) to maximum value (4.553%) indicates that certain banks suffered substantial losses while others experienced remarkably above average profits. The mean NPL ratio is relatively high, reflecting asset quality issues with maximum NPLR reaching 50.39%. The mean CAR of 12.21% and the negative minimum value (-22.79%) suggests that several banks may have failed to maintain the Bangladesh Bank prescribed 12.5% while certain bank's capital was even negative.

Variables	No. of Observations	Mean	Std. Dev.	Minimum	Maximum
ROA	304	1.025	1.028	-5.87	4.553
NPLR	304	6.083	7.399	0.44	50.39
CAR	304	12.212	4.606	-22.79	20.45
PMR	304	64.902	33.344	0	179.51
CDR	304	84.129	8.619	51.11	109.967
CIR	304	54.825	16.644	29.83	182.4

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TABLE II: DESCRIPTIVE STATISTICS OF THE VARIABLES

Based on the correlation matrix in Table III, the strongest positive correlation of 0.580 is between ROA and CAR. Both NPLR and CIR have a negative correlation with ROA, the former being strong and the latter being moderate. Between the explanatory variables, only NPLR and CAR have a Pearson correlation coefficient of -0.7397 exceeding the -0.7 to 0.7 range.

TABLE III
PEARSON CORRELATION MATRICES

Variable	ROA	NPLR	CAR	PMR	CDR	CIR
ROA	1.000					
NPLR	-0.7367	1.000				
CAR	0.5795	-0.7397	1.000			
PMR	0.3095	-0.3508	0.1988	1.000		
CDR	0.4356	-0.4576	0.3587	0.2758	1.000	
CIR	-0.3954	0.4087	-0.3245	-0.3462	-0.188	1.00

Based on the Hausman specification test in Table IV below, the chi-squared value of 21.43 and Prob>chi2 = 0.0007 rejects the null hypothesis, thereby supporting the application of fixed effect model due to the non-systematic changes in coefficient.

TABLE IV
HAUSMAN SPECIFICATION TEST

Variables	(b) Fixed	(B) Random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
NPLR	-0.963241	-0.846218	-0.0117023	0.0078382
CAR	0.0101244	0.0129121	-0.0027877	0.0021121
PMR	0.0022988	0.0011759	0.0011228	0.0009481
CDR	0.0215239	0.016249	0.0052748	0.0035297
CIR	-0.009312	-0.007381	-0.0019318	0.0019754

Followed by the Hausman Test, Table V below depicts the fixed effect regression model that gives the regression equation following (1): ROA = 0.0379 – 0.0963NPLR + 0.0101CAR + 0.0023PMR + 0.0215CDR – 0.0093CIR. ROA or profitability has a positive relation with or tends to experience an increase when CAR, PMR and CDR increase. Whereas ROA experiences a decrease as NPLR and CIR rise. The fixed effects model yields an R^2 value of 0.5648 or 56.48% indicating a moderately good fit for within bank variations over time. It is the amount of variation in the dependent variable being explained by the five explanatory variables. The rest of the percentage variation is due to other factors not included in our model and by related error term. The validity or fitness of the model can be confirmed by the F-value which is 114.74 or the p-value of 0.000. Based on this, we can infer that there is an overall meaningful influence by the explanatory variables on the profitability of the 19 banks included, at the 5% level of significance.

TABLE V
FIXED EFFECT REGRESSION MODEL

Variables	Fixed Effect Panel Regression		
	Coefficients	t-value	p-value
Constant	0.037898	0.04	0.968
NPLR	-0.0963241	-3.04	0.007
CAR	0.0101244	0.25	0.805
PMR	0.0022988	0.89	0.386
CDR	0.0215239	3.87	0.001
CIR	-0.0093129	-1.34	0.195
R2	0.5648		
Adj. R2	0.4076		
F-Stat	114.74		0.0000

According to Table VI below, the modified Wald test for group-wise heteroskedasticity revealed a significant result of chi2 value 1193.38 and p-value of 0.0000, suggesting the presence of heteroskedasticity in the data. Furthermore, the statistically significant skewness and kurtosis test for normality reveals that residuals are also not normally distributed (chi2=196.65 and p-value=0.0000).

TABLE VI
SUMMARY OF POST-DIAGNOSTIC TESTS

Tests	Statistics	p-value
Modified Wald Test	1193.38	0.0000
Skewness and kurtosis tests for normality	196.65	0.0000

To control the issues with heteroskedasticity where variance of the error term is not constant across observations and non-normal distribution of residuals, the regression has been run with the robust option given in Table IV above. Under the robust option, NPLR and CDR continue to have significant impact on ROA based on their p-values (0.007 and 0.001) and statistically significant t-values. The notable change is observed in the variable CIR which becomes insignificant after incorporating robust test. The other variables experienced no major changes other than slight differences in their t-values and standard error.

Based on the VIF test in Table VII below, it is concluded that there is no sign of multicollinearity as the mean VIF is 1.76.

TABLE VII
VARIANCE INFLATION FACTORS TEST

Variables	VIF	1/VIF
NPLR	2.71	0.368819
CAR	2.24	0.445829
PMR	1.29	0.772708
CDR	1.28	0.782172
CIR	1.25	0.800294
Mean VIF	1.76	

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IV. DISCUSSION

A. Non-performing loans (NPLR) and ROA

NPLR has a coefficient value of -0.0963, t-value of -3.04 and p-value of 0.007. The analysis shows a significant negative association between NPL ratio and bank profitability across all model specifications. This finding aligns with existing literature [8,10] which views rising NPLs as a direct drain on earnings due to higher provisioning costs and reduced interest income.

B. Capital adequacy ratio (CAR) and ROA

CAR has a coefficient value of 0.0101, t-value of 0.25 and p-value of 0.805. While theory supports that higher capital buffers enhance resilience and investor confidence [4,12,16], CAR did not show a statistically significant positive influence on profitability.

C. Provision maintenance ratio (PMR) and ROA

PMR has a coefficient value of 0.0023, t-value of 0.89 and p-value of 0.386. Although provisioning is a critical part of a bank's risk management framework intended to absorb expected credit losses [11], it appears that variations in PMR across banks or over time were not sufficient to explain changes in profitability.

D. Credit deposit Ratio (CDR) and ROA

CDR has a coefficient value of 0.0215, t-value of 3.87 and p-value of 0.001. CDR shows a significant positive influence on profitability [11], suggesting that more aggressive credit deployment relative to deposits contributes positively to returns.

E. Cost-to-income Ratio (CIR) and ROA

CIR has a coefficient value of -0.0093, t-value of -1.34 and p-value of 0.195. Reference [14] suggests that higher CIRs correlate negatively with ROA as cost inefficiencies erode bank profitability. However, this relationship was found to be statistically insignificant possibly due to the impact not being consistent or strong enough in this dataset to draw firm conclusions.

V. CONCLUSION

One of the major problems existing in the banking industry of Bangladesh has been the problem of non-performing loans. There are many factors that instigate loan default and create the environment for this problem to sustain. Lack of strict regulatory policy building and monitoring allows for banks to be lax about their lending and provision policies. Lending huge funds based on informal and personal relations have caused major credit risk to many banks in Bangladesh, eventually pushing them towards bankruptcy.

Banks have also shown lenient recovery practices and scheduling policies that allow more potential defaulters to thrive causing a spike in the volume of non-performing loans in our country. Thus, the significant measures from this study should be taken under consideration to increase the private commercial banks' profitability and to ensure the overall economic growth of the country.

VI. RECOMMENDATION

To combat this issue, strict policy measures including above-mentioned variables must be implemented and monitored by the central bank, besides strengthening and intensifying the internal control and risk management of the banks themselves.

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Import Dependency of Export – A Study oF RMG Sector in Bangladesh

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Abstract: **Looked at from the point of view of dependency of an export sector on imported components and given its various vulnerabilities to external politico-economic dynamics - disruptions in global supply chain, cost of production, net foreign exchange earnings - the proposed study shall focus on the experiences of the readymade garment sector of Bangladesh (RMG) with a view to highlighting respective implications for net foreign exchange earning of the sector and for future policy planning. Specifically, the study shall appraise the nature and level of import dependency of the RMG sector in Bangladesh with a view to underline different factors associated thereof and to highlight policy options towards redeeming such dependency for the greater good of the sector. As a backdrop to the exercise, the study shall provide an overview of the of readymade garment sector in Bangladesh. Level, composition and direction of RMG exports from Bangladesh apart, the major focus here shall be on different RMG related imports. These include, in particular, raw cotton, yarn, textiles and articles thereof, staple fiber, dyeing and tanning materials, silk, knitted or crocheted fabrics, etc. Goal here shall be to compare and contrast RGG exports with related imports, and respective trend over time.**

Methodologically, the study shall deploy, in particular, three research tools: literature review, key informant interviews, and analysis of secondary data. An exhausted literature review shall focus on conceptual issues, determinants and consequences of import dependency, and tools and techniques that can be used to estimate import dependency. Similarly, select key Informant Interviews shall enable insights into various aspects of import dependency of the RMG sector particular its reasons, implications, and possible options. The study, however, shall rely mostly on the analysis of secondary data to be available from different sources, particularly from the Bangladesh Bank (BB), Bangladesh Bureau of statistics(BBS), and Bangladesh Economic Review. The collected data shall be analyzed using statistical tools such as tables, charts, co-variance, and multi-variate analysis. Exports earnings of the RMG sector shall be contrasted against different elements of imports related to the sector. Whilst simple correlation shall demonstrate possible links – one on one, multiple regression exercise shall estimate the level of correspondence between import of related items and RMG exports – individually and combined. The estimated value of the coefficient of determination – R^2, shall point to the percentage variation in RMG export with respect to imports thereof, therefore, the level of dependence of the sector on imports. The importance of the exercise shall lie in the implications of its findings for: (a) net foreign exchange earnings of Bangladesh from the RMG sector – export earnings adjusted for the related imports, (b) effects of such import dependency for the future of the sector, and (c) options to redeem import dependency of the sector moving forward. Together, the study shall contribute both academically and policy wise.

Keywords**: Import dependency of exports; RMG sector in Bangladesh; elements of import dependency; determinants of import dependency.**

I.INTRODUCTION

1. Perspective

Ready-made Garments (RMG) sector stands as the cornerstone of Bangladesh's industrial landscapes. It has significantly shaped the country's economic trajectory and societal transformation [1]. Capitalizing on low labor cost and Bangladesh strategic location for global trade, the RMG sector gained a huge momentum in the late 1980's supported by prudent government policies [2, 3].

The RMG industry now directly employs around 3.5 to 4 million people, making it the largest formal employment sector in the country, with women accounting for approximately 60% of the workforce [4, 5]. In FY1983-84, apparel accounted for less than 4% of Bangladesh's total exports [6]. Over the next few decades, this share grew exponentially. Between 2002 and 2022, the RMG sector's contribution to GDP nearly doubled from 11% to 22% [7]. Today, Bangladesh is the second-largest exporter of garments globally, trailing only China [8].

In FY2022–23, RMG exports made up 84.5% of the country's total export earnings, generating approximately $47 billion and supporting between 3.5 and 4 million jobs [9, 10, 5, and 11]. The sector has played a transformative role in female employment, providing economic opportunities and challenging traditional gender norms. To sustain export performance, the government offers various incentives such as cash support, bonded warehouse facilities, low-interest loans, and reduced bureaucratic hurdles [12].

2.Import Dependency of RMG Exports

Despite being a global leader in RMG exports, Bangladesh surprisingly imports ready-made garments worth approximately Tk 5 billion each year, reflecting a notable level of import dependency [13]. Key import sources include India, China, and Pakistan [14]. According to data from the National Board of Revenue (NBR), the country legally imported around 23.5 million units of garments in the previous year, valued at

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approximately Tk 5.02 billion [13]. More crucially, the industry is heavily reliant on raw material imports such as cotton, yarn, dyes, chemicals, and fabrics—particularly in the woven and high-end knitwear segments. In 2024, cotton yarn imports rose by 39%, totaling $2.28 billion, while fabric imports for knitwear increased by 38%, adding another $2.59 billion to the import bill [14]. This import dependency exposes the sector to risks such as customs delays, transit inefficiencies, theft, and irregularities in dumping and valuation [12].

A significant concern arises from the cost structures. For instance, while the average import cost per garment was Tk 214, customs duties inflated the final cost to Tk 475 per piece [13]. However, many industry leaders argue that imports remain financially advantageous. One company managing director claimed that importing 800 tonnes of yarn saved them $208,000—compared to just $56,000 in savings from local purchases, even after cash incentives—resulting in a net gain of $148,000 [14].

3. Purpose and Scope

While there is a substantial body of research on the RMG sector's contributions to economic growth and employment, limited attention has been given to its import dependence. To the best of the author's knowledge, no prior studies have specifically explored import dependence per unit of export in Bangladesh's RMG sector. This study aims to fill this critical gap by analyzing the extent, structure, and implications of import dependency in the RMG sector. The broader objective is to understand how this dependency affects export competitiveness, net foreign exchange earnings, and long-term sustainability.

II.METHODOLOGY

Different research instruments have been utilized in the current report. Important among these are: literature review, use of secondary data, key informant interviews, and bi-variate and multi-variate analysis. Use of these different instruments varied across different types of analysis carried out.

Analytical tools and techniques utilized by the study are varied. Descriptive methods have been commonly used. This includes tables, charts and graphs. Discussions related to level, composition, and trend of RMG exports, related imports, etc. relied heavily on descriptive statistical tools.

Towards enabling better insights into the dependence of the RMG sector on imported materials, analysis of secondary data has been complemented by views and opinions of those with years of experience in RMG sector in the context of Bangladesh. These Key Informants Interviews (KPI) – drawn from different areas of expertise in the RMG sector, though very limited in number, provided valuable insights into the issue of import dependency of the sector. Perceptions of KPIs regarding import dependency and various options to redeem it moving forward has been particularly important.

The study utilized – in a limited way though, correlation and regression tools to analyze the nature and extent of association between export of RMG products from Bangladesh and imports associated thereof.

Pearson's correlation coefficient – "r", between RMG export and select list of imports associated with such exports – called RMG related imports was estimated. It was applied for total RMG exports and total RMG related import, and variations in total with respective individual items.

III.RMG SECTOR IN BANGLADESH

From a humble beginning in early 1980, the readymade garment (RMG) exports from Bangladesh has gone up to become the second largest in the world; next to China only. As of 2024 RMG export earnings reached US$ 36 billion; accounting for about 84% of country export receipts. Both the level and relative importance of RMG sector increased steadily over time. For instance, in 1990 RMG export was 1.2 billion; this grew to 12.5 billion in 2010, and 31.45 billion in 2020. And its relative share of total export grew from less than 60% in 1990 to about 81% in 2024 [19].

The growth of the RMG sector, and its progress over times, has been supported by prudent government policy at home and preferential trade arrangements offered by the major export markets such as the European Union (EU) and the USA. Domestically, cash incentives, bonded warehouse, back to back LCs, etc. redeemed greatly costs of production and international competitiveness of the sector boosting its growth over time. Similarly, Bangladesh benefitted immensely from GSP – until recently, in the case of the USA and the European Union countries. What underlined most, however, has been Bangladesh's comparative advantage in lower labor costs.

Two broad commodity groups comprise RMG exports from Bangladesh namely - woven products and knitwear. Knitwear and woven products account for 19 and 17 billion of RMG exports – out of a total RMG export of 36 billion as recently as FY 23-24. Their shares of total RMG exports are 53% and 47% respectively.

Whilst a list of countries account for the export of RMG products from Bangladesh, three major destinations alone, however, account for almost 80% of total exports from Bangladesh. These include the European Union countries, USA and UK.

European Union countries are the single most important destination for RMG exports from Bangladesh; more than half of the RMG exports go to these countries. Important among these countries are Germany, Spain and

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France. Next important destination is the USA; accounted for a fifth of RMG exports in 2024. Country wise, the USA is the single most important importer of RMG products from Bangladesh. Historically, the prominence of these two geographical destinations consistently remained the same.

Notably, government efforts to diversify the destinations of RMG products has led to the emergence of some non-tradition markets. Important among these emerging markets are countries like Japan, Australia, India, Turkey and Russia. These five countries together account for about 10% of total RMG exports in 2024.

IV.IMPORTS OF RMG RELATED PRODUCTS

RMG related imports refer to those import items which are used mostly but not necessarily only by the RMG sector. Based on 'Trade Map', published by ITC, United Nations level of RMG related imports is estimated at $12.29 billion in 2024. In 2001 RMG related imports were 1.36 billion increasing to 8 billion in 2015, and 12.29 in 2024.

Six broad commodity groups account for the bulk of the imports related to the RMG sector. Most import among these re raw cotton. In 2024, Bangladesh imported an estimated US$ 7.7 billion worth of cotton from numerous sources. Historically, raw cotton imports consistently remained one of the major items of the country. Man-made staple fiber stands as the second important RMG related import item. It cost about US$ 2.2 billion worth of materials in 2024, and the value of such imports has been increasing consistently.

Relatively speaking, cotton accounts for almost three fifths of RMG related imports, and it has been so most consistently. Similarly, import of man-made stable fiber accounts for about a fifth of total import, followed by import of dying extracts and related items.

IV DEPENDENCY OF RMG SECTOR ON IMPORTED MATERIALS

1. Level of RMG related imports

RMG exports from Bangladesh depends heavily on imported materials. The extent of such dependence is significant both in absolute and relative terms. It involves some of the most critical inputs; trend in dependency has been significantly positive.The value of imports related to the RMG sector is estimated at US$ 12 billion as of 2024, and this accounts for more than one third of total RMG export US $ 36 billion in that year. Both the value and relative importance have been increasing over time.

Moreover, RMG related imports have a significantly positive association with total RMG exports from the country. Between 2020 and 2024, relative importance of the RMG related imports increased from 27% to 34%

The differential changes in RMG exports and import dependency, could be traced back to the nature of goods imported related to the RMG sector and changes in respective importance over the years. Both the volume and composition of imports associated with RMG changes similar changes in RMG exports.

The RMG sector is alleged to depend on various services sourced from outside the country. For example, the sector depends on expatriate experts in various capacities, and drawn from countries such as India, Sri Lanka, China, Pakistan and South Korea, in particular.

Unofficial estimates suggest the number of such expatriates – mostly undocumented, could range in millions. This is particularly important with respect to expatriates from India. What is most important is out remittances sent by these expatriates. Unofficial sources suggest this amount to be USD 5-7 billion. If all this could be duly adjusted with the volume of imports related to RMG exports, the extent of import dependency of the sector could exceed above 40%.

2. Variance and co-variances

For a deeper understanding of the nature and extent of import dependency of the RMG sector on imported materials, both bivariate and multi-variate analysis has made using correlation and regression tools. This will underscore extent of relationship between export of RMG products from Bangladesh and major elements of imports related to this.

Based on Pearson correlation between RMG exports from Bangladesh and major components of related imports. RMG related imports demonstrate a significant covariance with total RMG exports from Bangladesh.

To investigate how much of the total variation in RMG exports is explained by the select RMG related imports, a multiple regression exercise is made. The estimated values the simple R^2 and adjusted R^2 are estimated at 0.97 and 0.96 respectively. This underscores the high explanatory power of the selected RMG related imports in explaining for total RMG export from Bangladesh.
The following shows the salient features and results of the multiple regression exercise.

V.CONCLUSIONS

RMG sector has been the cornerstone of the Bangladesh economy, generating employment, alleviating poverty and generating various linkages to move forward and sustain growth and development. The sector, however, is highly dependent on imported material which is estimated at between 30% and 40% of total export earnings. Such dependence relates to import of raw cotton, woven fabrics, man-made staple fibers, articles of apparel and clothing accessories, dyeing chemicals, etc.

This high import dependence underscores the importance of countries in terms of sources of the required imported

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materials and associated uncertainties associated. The extent of such dependency on different countries varies in terms of nature and volume of such imports. For RMG related industrial raw materials Bangladesh depends mostly on China and India. For items like cotton, however, the dependence is on a wide range of countries given the volume of such imports per year.

Dependence on imported materials – especially when it involves large volume, critical nature and geographical concentration, leads to the risks and uncertainties in production and exports. It all adds to the costs of production and international competitiveness of the sector. Appreciation of level and nature import dependency are critical shall key elements in future policy planning.

RMG related imports significantly underscore the net foreign exchange earnings from the sector. The higher such imports the less foreign exchange from the sector shall be. Adjusted accordingly, net foreign exchange earnings from RMG shall be much than lower than official estimates.

That being the case, for 1$ of RMG export. 0.4$ will be required for import payments, giving a net foreign exchange earning of only 0.6$. Overall, therefore, net foreign exchange from the RMG sector - out of estimated 38 billion in 2024, will stand at 27 billion.

Import dependency makes the sector vulnerable to politico-economic dynamics in the global economy. It underscores supplies, price of imports, costs of production, therefore, ultimately country's international competitiveness.

Product diversification in the RMG sector could be geared up in an effort to reduce import dependency. Import intensive products could be discouraged against products with greater domestic input components. Most important more studies shall be conducted to understand the nature and level of import dependency of the RMG sector, underlying factors and ways and means towards redeeming such import dependency in the future.

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Green Human Resource Management Practices in the RMG Sector of Bangladesh: A Path to Sustainability

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Abstract- **Bangladesh's Ready-Made Garment (RMG) sector is a cornerstone of the national economy yet faces increasing demands to operate sustainably. This study explores how Green Human Resource Management (GHRM) practices including recruitment, training, performance appraisal, and workplace initiatives, are being applied in the sector and their influence on environmental sustainability. A quantitative survey of 48 employees from five garment factories was conducted with responses analyzed using SPSS. The Findings reveal a moderate positive relationship between GHRM practices and sustainability outcomes, although most individual practices lacked strong statistical significance. Limited awareness, budget constraints, and inadequate policy incentives emerged as key barriers. Despite these challenges, employees generally recognized the value of green practices for both environmental performance and corporate reputation. The research underscores the need for integrating GHRM into routine operations, enhancing employee training, and embedding environmental criteria in performance evaluations to strengthen the sector's path toward sustainable growth.**

Keywords: Ready-Made Garment (RMG) sector, Green Human Resource Management (GHRM), Sustainability, GHRM Practices, Bangladesh.

I.INTRODUCTION

In today's world, environmental protection becomes more important. Businesses around the world are now required to operate ethically and decrease their negative environmental impact [6],[9]. One method they might accomplish this is to practice Green Human Resource Management (GHRM). This includes incorporating eco-friendly and sustainable practices into various HR tasks such as hiring, training, reviewing, and rewarding staff [11],[6].

In Bangladesh, the Ready-Made Garment (RMG) sector is an important element of the economy. It generates more than 80% of the country's export income and employs around 5 million people, the majority of whom are women (BGMEA, 2024; World Bank, 2022). But this sector also has major environmental consequences. Many factories consume a lot of energy and water, generate a lot of chemical waste, and don't adopt sustainable labor practices [11],[9] This jeopardizes both the environment and worker safety [8].

As international buyers and organizations are now focusing on sustainability, Bangladeshi garment factories need to make changes [1].[2] Green HRM is a significant step in that direction. It can help factories become more environmentally conscious while also boosting their image and employee satisfaction (Jabbour & de Sousa Jabbour, 2016).

So, the purpose of this study is to explore how Green HRM practices are applied in Bangladesh's RMG sector and their impact on environmental sustainability. Also, the study covers only four variables-green recruitment and selection, green training and development, green performance appraisal, and green workplace initiatives. It is based on data from a limited number of factories and may not reflect the entire industry. Time and resource constraints also limited the sample size and the study mainly relies on the selected variables without covering other possible factors that could influence sustainability.

1.1: Objectives

The objectives of this study are threefold. First, it aims to examine the current status of Green Human Resource Management (GHRM) practices in Bangladesh's Ready-Made Garment (RMG) factories. Second, it seeks to assess the perceptions of HR managers regarding the value and necessity of GHRM practices within the RMG sector. Finally, the study intends to identify and analyze the key factors that influence both the successful implementation and the limitations of GHRM practices in Bangladesh's RMG industry.

Literature Review

Green Human Resource Management (GHRM) has become an important part of making organizations last by adding environmental concerns to standard HR tasks including hiring, training, evaluating performance, and rewarding employees. GHRM not only helps the environment, but it also makes employees more motivated and improves the culture of the firm [5]. The theoretical foundations of GHRM are frequently based on the Ability -Motivation-Opportunity (AMO) theory and the Resource-Based View (RBV), which elucidate how HR systems can enhance employee skills and promote environmentally friendly behavior for competitive advantage [15].

GHRM and Organizational Sustainability

Studies indicate that GHRM can substantially impact environmental and organizational performance by promoting eco-friendly employee behaviors. For instance, [3] discovered that the adoption of green recruiting, training, and performance appraisal resulted in enhanced environmental results within Bangladeshi enterprises, facilitated by sustainability-oriented behaviors. Their research shows that employees who are taught about environmental issues and given green

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incentives are more likely to act in ways that are good for the environment, which helps the firm stay sustainable.

GHRM in Bangladesh's RMG Sector: Current Status and Challenges

Even though people all over the world are paying attention to sustainable practices, Bangladesh's RMG industry has been hesitant to implement GHRM concepts. The terrible collapse of Rana Plaza in 2013 led to a number of regulations aimed at making workplaces safer. However, many factories still didn't care much about environmental sustainability [5]

[3] found that there are many reasons why GHRM techniques aren't being used in the RMG sector. These include not having enough money, HR professionals not knowing about them, the government not giving enough incentives, and factories not having strategic environmental goals. [17] also said that many RMG manufacturers put reaching production goals ahead of investing in green initiatives because they see GHRM as an extra expenditure instead of
a way to generate value.

Big factories that make things for export and are typically closely watched by international purchasers have started using fundamental GHRM practices, like eco-friendly training modules and green job descriptions. Nonetheless, these actions are mostly motivated by compliance and do not fit strategically with the sustainability objectives of the firm [14]

Key Dimensions of GHRM Practices and Their Relevance to RMG Sector

Green Recruitment and Selection: Green recruitment involves attracting candidates who possess environmental awareness and are committed to sustainable practices [12] In the RMG sector, integrating environmental responsibilities into job roles can help build a workforce aligned with sustainability objectives. However, due to a lack of structured green recruitment frameworks, most factories in Bangladesh focus on hiring based on productivity metrics rather than environmental values [9]

Green Training and Development: Green training enhances employee competencies in areas like waste management, energy conservation, and eco-friendly production techniques [3], [10] observed that while some RMG factories provide environmental training to satisfy buyer requirements, these programs often lack depth and are treated as a one-time compliance measure.

Green Performance Appraisal: Evaluating employees based on environmental performance
fosters accountability and reinforces green behavior [10]. However, in Bangladesh's RMG sector, performance appraisals remain heavily focused on quantitative production targets, with minimal emphasis on environmental contributions [2].

Green Workplace Initiatives: Green workplace initiatives are changes to the way a business runs and the way its buildings are set up that are meant to make the workplace more environmentally friendly. This includes using energy-efficient lighting, technology that save water, methods for recycling garbage, and encouraging paperless documentation [2]

Although global studies highlight the advantages of Green HRM, there is a scarcity of research examining its practical implementation in Bangladesh's RMG industry. Most extant literature addresses its conceptual significance but fails to provide a comprehensive study of implementation issues within the socio-economic context of Bangladesh (Rupa et al., 2023). Furthermore, the perspectives of HR managers regarding the value of GHRM have not been thoroughly investigated, despite their crucial role in its implementation. This study seeks to address these deficiencies by evaluating existing GHRM practices and pinpointing factors that affect their implementation within Bangladesh's RMG sector.

1.3: Conceptual Framework:

IndependentVariable
Dependent Variable

Fig 1. Conceptual Framework of the Study

Independent Variable	Source
Green recruitment and selection	(Ahmad et al.,2021); (Islam,2020)
Green training and development	(Rahman et al.,2021); (Renwick et al.,2023)
Green performance appraisal	(Kim & Kim, 2020); (Haque & Hossain, 2022)
Green workplace initiatives	(Renwick et al.,2023)

II. METHODOLOGY

This study uses a quantitative and descriptive approach to examine how Green Human Resource Management (GHRM) practices influence organizational environmental sustainability in Bangladesh's Ready-Made Garment (RMG) sector. Data were collected using a structured questionnaire with a 5-point Likert scale, distributed digitally to employees from five garment factories in Dhaka, Gazipur, Narayanganj, and Savar. The population included 55 employees working in managerial and operational roles who were directly or indirectly involved in HR, training, operations, sustainability, or environmental compliance. Based on the Krejcie and Morgan (1970) table, a sample of 48 respondents was selected using convenience sampling which allowed easy access to participants. The study focuses on organizational environmental sustainability as the dependent variable, while the independent variables include green recruitment and selection, green training

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and development, green performance appraisal, and green workplace initiatives. Along with the survey responses (primary data), relevant secondary sources such as academic journals, industry reports, BGMEA and ILO publications, sustainability reports, and government and NGO documents were reviewed. The collected data were analyzed using Microsoft Excel and IBM SPSS Statistics 25, including Demographic statistics, Multiple linear regression and Cross Tabulation to understand how GHRM practices contribute to sustainability outcomes in the RMG sector

III. HYPOTHESIS

H1	H0: Green Recruitment & Selection has no significant impact on Organizational Environmental Sustainability in the RMG sector of Bangladesh. HA: Green Recruitment & Selection has a significant positive impact on Organizational Environmental Sustainability in the RMG sector of Bangladesh.
H2	H0: Green Training & Development has no significant impact on Organizational Environmental Sustainability in the RMG sector of Bangladesh. HA: Green Training & Development has a significant positive impact on Organizational Environmental Sustainability in the RMG sector of Bangladesh.
H3	H0: Green Performance Appraisal has no significant impact on Organizational Environmental Sustainability in the RMG sector of Bangladesh. HA: Green Performance Appraisal has a significant positive impact on Organizational Environmental Sustainability in the RMG sector of Bangladesh.
H4	H0: Green Workplace Initiatives have no significant impact on Organizational Environmental Sustainability in the RMG sector of Bangladesh. HA: Green Workplace Initiatives have a significant positive impact on Organizational Environmental Sustainability in the RMG sector of Bangladesh

IV.RESULTS

i.Demographic Statistics:

Table 1

Demographic variables

Variables	Values	N	%	Mean	Range	Standard Deviation
Gender	Male	22	45.8%			
	Female	26	54.2%			
Years of Experience in RMG Sector				2	3	1
Department	Human Resource Management	14	29.2%			
	Production	4	8.3%			
	Compliance	5	10.4%			
	General Administration	4	8.3%			
	Others	21	43.8%			

The demographic profile of respondents reveals that a slightly higher proportion of participants were female (54.2%) compared to male (45.8%) which is consistent with the gender composition of the Bangladeshi RMG sector, where women form the majority of the workforce. The average length of experience among respondents was approximately two years which indicate that many employees are relatively early in their professional careers. Departmental representation shows that 29.2% of respondents were from Human Resource Management, followed by Compliance (10.4%), Production (8.3%), and General Administration (8.3%), while 43.8% were classified under Others. This diverse departmental distribution ensures that the perspectives captured are not limited to HR professionals, thereby allowing for a more comprehensive assessment of GHRM practices across operational functions.

ii. Multiple Linear Regression

Table 2

Model Summary of Multiple Regression Analysis

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.607[a]	.369	.240	.783

a. Predictors: (Constant), Waste is divided into recyclable, reusable, and hazardous categories, The factory uses energy-efficient lighting and equipment where possible, Candidates with prior knowledge or experience in eco-friendly practices are given preference in hiring, Training programs encourage employees to suggest eco-friendly improvements in work processes , Environmental responsibilities are clearly stated in job descriptions, Employees receive training on waste management, energy conservation, and eco-friendly production techniques, Employees are rewarded or recognized for sustainable practices, Employee performance appraisals include evaluation of environmental contributions

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The model shows an R value of 0.607, indicating a moderate positive relationship between Green Human Resource Management (GHRM) practices and Organizational Environmental Sustainability. The R^2 value of 0.369 means that about 36.9% of the variation in Organizational Environmental Sustainability can be explained by these practices. The adjusted R^2 of 0.240 indicates that other external factors also influence sustainability performance.

Table 3

ANOVA Results

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13.990	8	1.749	2.850	.014[b]
	Residual	23.927	39	.614		
	Total	37.917	47			

a. Dependent Variable: Implementing Green HRM practices improves our organization's environmental sustainability

b. Predictors: (Constant), Waste is divided into recyclable, reusable, and hazardous categories, The factory uses energy-efficient lighting and equipment where possible, Candidates with prior knowledge or experience in eco-friendly practices are given preference in hiring, Training programs encourage employees to suggest eco-friendly improvements in work processes , Environmental responsibilities are clearly stated in job descriptions, Employees receive training on waste management, energy conservation, and eco-friendly production techniques, Employees are rewarded or recognized for sustainable practices, Employee performance appraisals include evaluation of environmental contributions

The ANOVA results ($F = 2.850$, $p = 0.014$) indicate that the regression model is significant at the 5% level. This means that GHRM practices together have a meaningful influence on Organizational Environmental Sustainability.

Table 4

Coefficients of Multiple Regression

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.772	1.016		1.744	.089
	Environmental responsibilities are clearly stated in job descriptions	.070	.194	.058	.361	.720
	Candidates with prior knowledge or experience in eco-friendly practices are given preference in hiring	-.178	.156	-.196	-1.141	.261
	Employees receive training on waste management, energy conservation, and eco-friendly production techniques	-.114	.183	-.126	-.622	.538
	Training programs encourage employees to suggest eco-friendly improvements in work processes	.344	.185	.344	1.863	.070
	Employee performance appraisals include evaluation of environmental contributions	-.074	.208	-.074	-.357	.723
	Employees are rewarded or recognized for sustainable practices	.120	.185	.131	.650	.519
	The factory uses energy-efficient lighting and equipment where possible	.133	.179	.118	.747	.460
	Waste is divided into recyclable, reusable, and hazardous categories	.310	.165	.356	1.877	.068

a. Dependent Variable: Implementing Green HRM practices improves our organization's environmental sustainability

The results show that the overall model is significant; however, individual predictors vary in their effects on Organizational Environmental Sustainability.

H1: Green Recruitment & Selection - Both "Preference for candidates with eco-friendly experience" ($B = -0.178$, $p = 0.261$) and "Environmental responsibilities stated in job descriptions" ($B = 0.070$, $p = 0.720$) have p-values greater than 0.05 which is indicating no statistically significant effect. So, we accept the null hypothesis (H_0) and reject the alternative hypothesis (H_1) for both variables.

H2: Green Training & Development - "Training on waste, energy, and eco-friendly production" ($B = -0.114$,

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p = 0.538) is not statistically significant (p > 0.05). In contrast, "Training encouraging eco-friendly suggestions" (B = 0.344, p = 0.070) is not significant at the 5% level but is close to significance at the 10% level. So, we accept H_0 for both at 5% level but partial support for H_1 at 10% level for the second variable.

H3: Green Performance Appraisal - "Environmental contributions in appraisals" (B = –0.074, p = 0.723) and "Recognition for sustainable practices" (B = 0.120, p = 0.519) have p-values greater than 0.05 which means they are not statistically significant. So, we accept the null hypothesis (H_0) and reject the alternative hypothesis (H_1) for both variables.

H4: Green Workplace Initiatives – Energy-efficient lighting and equipment" (B = 0.133, p = 0.460) shows no significant effect (p > 0.05), so H_0 is accepted and H_1 is rejected and "Waste separation into recyclable, reusable, hazardous categories" (B = 0.310, p = 0.068) is not significant at the 5% level, so H_0 is accepted at 5%, but it approaches significance at the 10% level, giving partial support to H_1.

iii. Cross Tabulation

Table 5

Years of Experience * Environmental Contributions in Performance Appraisal

Years of Experience in RMG Sector * Employee performance appraisals include evaluation of environmental contributions Crosstabulation

Count

		Employee performance appraisals include evaluation of environmental contributions				
		Disagree	Neutral	Agree	Strongly Agree	Total
Years of Experience in RMG Sector	Less than 1 year	1	3	12	5	21
	1–3 years	0	3	5	5	13
	4–6 years	3	2	4	2	11
	More than 6 years	0	0	1	2	3
Total		4	8	22	14	48

The cross-tabulation indicates that employees with less than 3 years of experience show higher agreement that environmental contributions are included in performance appraisals. Employees with longer service show less agreement, which may reflect reduced engagement over time. So, this result implies that newer employees are likely more open to green performance appraisals, possibly because they've recently been exposed to sustainability policies.

Table 6

Department * Candidates with prior knowledge or experience in eco-friendly practices are given preference in hiring Crosstabulation

Count

		Candidates with prior knowledge or experience in eco-friendly practices are given preference in hiring						
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total	
Department	Human Resource Management	0	1	1	6	6	14	
	Production	0	0	1	2	1	4	
	Compliance	0	0	1	1	3	5	
	General Administration	0	0	1	0	3	4	
	Others	2	0	4	12	3	21	
Total		2	1	8	21	16	48	

Department * Preference for Eco-Friendly Hiring

The results reveal that HR staff have the highest agreement on giving preference to eco-friendly candidates. Other departments and especially Production show more mixed responses with some neutral or low agreement levels. This disparity may indicate a policy practice gap where HR recognize the importance of green recruitment but operational departments may not prioritize it during actual hiring decisions.

Table 7

Gender * Perceived Impact of GHRM on Environmental Sustainability

Gender * Implementing Green HRM practices improves our organization's environmental sustainability Crosstabulation

Count

		Implementing Green HRM practices improves our organization's environmental sustainability					
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total
Gender	Male	0	2	1	8	11	22
	Female	1	0	1	12	12	26
Total		1	2	2	20	23	48

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The results reveal that both male and female employees mostly agree or strongly agree that GHRM practices improve Organizational Environmental Sustainability but female employees showing slightly higher strong agreement. This result reflects a broadly positive perception across genders and supporting the potential for organization-wide acceptance of GHRM initiatives.

V. DISCUSSION

This study set out to understand how Green Human Resource Management (GHRM) practices affect environmental sustainability in the Bangladeshi RMG sector. The results show a moderate positive relationship between GHRM practices and sustainability outcomes. In other words, when factories apply green practices in HR areas like recruitment, training, appraisals, or workplace initiatives, their sustainability performance improves but the effect is still not very strong. This means that the RMG sector has started to move in the right direction, but there is still a long way to go.

Looking more closely at the results, most individual practices did not have a significant effect on sustainability. For example, green recruitment such as hiring people with eco-friendly knowledge or adding environmental duties to job descriptions did not show a meaningful impact. This is not surprising because, as earlier studies point out (Islam, 2020), most RMG factories still prioritize productivity and cost over environmental values when hiring.

Green training gave a mixed picture. General training on waste and energy management did not make a difference, but when employees were encouraged to suggest their own eco-friendly ideas, the results were close to significant. This tells us that people respond better when they feel included and listened to, rather than when training is just about following instructions.

Green performance appraisal also turned out weak. Factories are still more focused on meeting production targets than rewarding sustainable behavior. However, the data showed that newer employees those with less than three years of experience were more likely to say that environmental performance is considered in appraisals. This could mean that younger or newer workers are more open to sustainability, possibly because they are more recently exposed to these ideas.

Green workplace initiatives, like using energy-efficient lighting or separating waste, showed partial influence. Waste separation was especially close to being significant, which suggests that practical and visible actions may be easier for employees to notice and support compared to policies that feel distant or symbolic.

The demographic analysis added some extra insights. Female employees showed slightly stronger belief in the positive impact of GHRM, which might reflect their greater concern for long-term well-being and workplace improvements. Differences were also seen between departments. HR staff strongly supported eco-friendly recruitment, but production staff were less convinced. This gap shows that while HR may see the value of green hiring, it does not always translate into real decisions on the ground.

Overall, these findings suggest that GHRM in the RMG sector is still in an early stage. Factories have started to adopt certain green practices, often because of buyer pressure, but they are not yet embedded as part of daily operations. Limited budgets, lack of awareness, and weak government incentives continue to slow down progress. At the same time, the moderate overall relationship shows that if these practices are applied more consistently and strategically, they could make a real difference.

For the future, the sector needs to go beyond treating GHRM as a compliance activity and instead see it as an opportunity for growth. Proper training programs, fair appraisals that reward environmental contributions, and stronger support from both government and international buyers can help make sustainability a natural part of RMG operations. If these steps are taken, GHRM could become a key tool not only for protecting the environment but also for building the reputation and competitiveness of Bangladesh's garment industry in the global market.

VI.CONCLUSIONS

This research explored how Green Human Resource Management (GHRM) is being used in Bangladesh's Ready-Made Garment (RMG) sector and how it could help the industry work in a more environmentally friendly way. From what we found, some factories have started taking small steps, like including environmental duties in job descriptions, giving basic eco-friendly training, and trying to manage waste better. But in most cases, these actions are done mainly to meet buyer requirements, not because of a strong long-term plan for sustainability. The survey results show that GHRM can have a positive impact on environmental sustainability, but right now the effect is still small. A lack of awareness, limited budgets, and not enough government support are some of the reasons why it isn't more common. Even so, many managers and employees agree that green practices are important and could make both the work environment and the company's image better. For the future, the RMG sector needs to make GHRM a normal part of everyday operations instead of treating it like an extra task. That means offering proper training for workers, making environmental responsibility part of performance evaluations, and building a culture where sustainability is valued. If factories, the government, and global buyers work together, GHRM can become a key way to protect the environment while helping the industry grow in a responsible way. In addition, future study can expand this work by including a larger and more diverse sample across different regions and factory sizes, which would strengthen the generalizability of findings. Qualitative research through interviews with HR managers, policymakers, and buyers could provide deeper insights

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into motivations and barriers. Moreover, investigating the role of digital tools, automation, and green technologies can shed light on how innovation supports GHRM. Finally, longitudinal studies would be valuable to track how GHRM practices evolve over time and whether they bring sustained improvements in environmental and organizational performance.

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Next-Generation Entrepreneurship in Bangladesh: Globalization Strategies for the EdTech Sector

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Abstract- **Global learning is being quickly transformed by educational technology (EdTech), yet obstacles to worldwide expansion include legal restrictions, cultural differences, digital inequalities, and sustainability issues. In order to create borderless organizations, this paper looks at sustainable models for EdTech companies of the future. The study uses case studies, surveys, and interviews with international players such as Coursera, Khan Academy, and 10 Minute School. It concludes that growth is driven by decentralized structures, hybrid commercial models, and culturally relevant material. Nonetheless, issues with digital access and compliance still exist. The report provides a strategic road map for investors, entrepreneurs, and legislators to support EdTech businesses that are sustainable and competitive on a global scale.**

Keywords: **EdTech, Globalization, Sustainable**

I. INTRODUCTION

The emergence of EdTech businesses is drastically altering the educational environment by changing the way that education is obtained and provided [44]. These businesses use digital tools and platforms to build scalable learning environments that make education accessible everywhere [2] But the path to international growth is not without its difficulties [3].EdTech companies have to deal with complicated regulatory environments, cultural differences, technical inequalities, and sustainability [3].These obstacles emphasize the necessity of strategic frameworks that permit cross-border scalability while guaranteeing long-term viability [7]. The purpose of this article is to investigate and suggest sustainable business models that facilitate the establishment of international EdTech companies [8]. By focusing on the triple bottom line—economic viability, social inclusion, and environmental responsibility—this study aims to provide useful strategies for EdTech companies of the future [40]. It emphasizes how important it is to combine innovation and sustainability, especially in a field tasked with influencing the future [29]. Models such as the Collaborative Consumption Model [33], Freemium Model (Anderson, 2009), and Impact Investing Model [21] offer additional frameworks for creating EdTech companies that are socially conscious, scalable, and inclusive.

II. LITERATURE REVIEW

Both incredible potential and difficult problems are brought about by the quick globalization of education technology, or EdTech [16].Existing research in entrepreneurship, international business, and strategic innovation provides vital insights i

nto the elements driving global scalability and sustainability, which is important given that EdTech efforts want to become borderless and sustainable [16].The main theoretical frameworks that influence our comprehension of EdTech's strategic development in a global setting are highlighted in this overview [26],[24],[27].

1. Resource-Based View (RBV)
Businesses utilize their internal resources that are valuable, rare, unique, and non-substitutable (VRIN) in order to gain and preserve a competitive advantage, according to the Resource-Based View [30].
EdTech use case:
EdTech companies create digital assets (including content libraries, proprietary platforms, and data analytics) and human resources to enable them differentiate themselves from competitors and expand globally (Wernerfelt, 1984). Sustainable innovation is fueled by the efficient utilization of these internal resources [33].

2. Disruptive Innovation Theory
According to this thesis, which was first put forth by Clayton Christensen, new rivals use simpler, less costly inventions to overthrow established market incumbents .
EdTech is disrupting traditional educational institutions by providing tech-driven, scalable, and accessible learning [10] Sustainable EdTech models are often developed by focusing on underserved markets, and these models gradually make their way into mainstream education [7],[24].

3. Dynamic Capabilities Theory
To deal with situations that are changing quickly, businesses need to constantly integrate, restructure, and adjust their internal and external skills [13],[33],[18]
EdTech businesses must contend with evolving cultural norms, technology advancements, and regulatory changes in a dynamic global setting (Eisenhardt & Martin, 2000). Successful companies are able to modify their ideas and content for various markets because to strategic agility [4]

4. Internationalization Theory (Uppsala Model)
According to this theory, businesses grow globally in

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small increments, beginning with geographically and culturally close markets before progressively accumulating experience and lowering [7],[15]. Before expanding internationally, EdTech companies typically start in well-known areas, honing localization tactics based on market research and reducing risk through alliances and teamwork [17],[15].

5. Network Theory

Businesses can access and build a reputation overseas with the aid of social networks, alliances, and cooperative connections with key stakeholders [10]. By working with educators, governments, non-governmental organizations, and local institutions, EdTech businesses can improve their market relevance and circumvent legal obstacles, especially in new locations .

6. Effectuation Theory

Entrepreneurs start with the resources that are available and work with stakeholders to co-create opportunities rather than constantly depending on predictive methods [36] Many new EdTech companies are subject to resource limitations and unpredictability [35]. In contrast to strict long-term planning, effective thinking enables them to test ideas locally, iterate rapidly, and develop through feedback [41]. The theoretical framework of this study is founded on several theories pertaining to entrepreneurship and international business [33]. The Uppsala Model explains the incremental and experiential approach to internationalization, which is in line with EdTech companies' steady entry into new markets through learning and adapt according to the Resource-Based View (RBV), a company's distinctive assets, like digital infrastructure, intellectual capital, and proprietary platforms, can provide it with a competitive edge when it expands internationally[43]. Since EdTech entrepreneurs frequently upend established educational systems with low-cost, innovative alternatives, Clayton Christensen's Disruptive Innovation Theory is especially pertinent today [40] [35]. The notion that EdTech companies must continuously modify and reorganize their tactics in response to quickly shifting global circumstances is supported by the dynamic capabilities theory [22].

According to network theory, developing strategic partnerships with local governments, organizations, and educational institutions is necessary to acquire credibility and local knowledge [11].

Finally, Effectuation Theory emphasizes that in unpredictable situations, resource-driven, flexible decision-making is more important than meticulous strategic preparation [8].

The Triple Bottom Line (TBL) Model, which encourages the alignment of social, economic, and environmental goals, is essential to sustainability .EdTech businesses are encouraged by the Circular Economy Model to provide renewable and reuse learning solutions .

The Shared Value Model promotes the connection between economic performance and favorable social outcomes through collaborations with governments and non-governmental organizations.

III. METHODOLOGY

This study uses a mixed-methods approach to provide a thorough understanding of sustainable plans and the difficulties associated with worldwide expansion [39],[36] 15–20 important stakeholders, including EdTech innovators, investors, educators, and legislators, will be interviewed in-depth during the qualitative phase [21],[27] The purpose of these Interviews Is to learn more about the driving forces, difficulties, and decision-making procedures of sustainable scaling.

Case studies of internationally renowned EdTech businesses like Coursera, BYJU'S, 10 Minute School (Bangladesh), and Khan Academy will be included to supplement the interviews [23] These illustrations will provide well-founded perspectives on successful growth tactics and environmentally friendly procedures (Yin, 2018).More than 100 EdTech professionals from different areas will get structured surveys as part of the quantitative phase [36]. Data on market dynamics, scalability indicators, and regulatory obstacles will be gathered through these surveys [14]. Statistical methods like factor analysis and regression analysis will be used to examine the data [18]

In order to find trends in the qualitative responses, thematic analysis will also be employed [18],[11].Triangulation between surveys, interviews, and case studies will guarantee the validity and dependability of the results [17].

IV.RESULTS

The study found a number of sustainability elements that are essential for EdTech businesses looking to grow internationally [29]. Hybrid business models, which included subscription, certification, and partnership revenue, were used by successful [20].To guarantee scalability and customisation, many made use of platform-based economies and modular content [16] In order to respond to the many demands of the market, operational strategies placed a strong emphasis on decentralized management, digital infrastructure, and agile development teams . Accessibility, affordability, and tailoring learning experiences to each learner's requirements were the main value propositions [2].

However, there were a number of difficulties with global expansion [3].Significant obstacles were presented by inconsistent regulations, especially those pertaining to data privacy and content licensing [5]. User reach was restricted by technological inequalities, such as poor internet penetration and device accessibility in some areas [4]. Cultural variations necessitated a great deal of content localization, including different expectations for language and learning styles [7]. Differentiation became difficult in crowded markets, particularly as competition .Financial models also needed to adjust to different economic

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conditions and local price assumptions Some EdTech businesses were able to put into practice successful worldwide strategies in spite of these obstacles Joint ventures and strategic alliances were employed to lower entrance risks and take advantage of local expertise [1].

User engagement and relevancy rose when learning systems and material were culturally customized [7]. Cloud computing, artificial intelligence, and data analytics are examples of technological enablers that have made it possible for businesses to grow effectively without sacrificing consumer customization .

Businesses were able to handle cross-regional operations more nimbly by implementing a borderless organizational model, which featured connected teams and decentralized leadership [10].

V. DISCUSSION

The results demonstrate how important it is to integrate sustainability concepts and entrepreneurial theory when creating cross-border EdTech initiatives (Elkington, 1997).

EdTech companies were able to grow thanks to internal strengths including innovation culture and technology infrastructure, as stated by the Resource-Based View and Dynamic Capabilities Theory (Barney, 1991; Teece, 2007).

The significance of strategic partnerships and adaptability in breaking into culturally and legally varied markets was emphasized by network and effectuation theories (Gulati, 1998; Sarasvathy, 2001).

The necessity of sustainable strategies that go beyond profit was highlighted by models such as TBL and Shared Value (Elkington, 1997; Porter & Kramer, 2011). EdTech companies like RushPath and ScholarsBangladesh demonstrated how socially conscious learning environments that are in line with regional cultural norms may lead to long-term success (Sawyer, 2022).But there are still issues, particularly with handling technological disparities, complying with global data laws, and creating material that is widely adaptable (Livingstone, 2019; van Dijk, 2020).By applying traditional theories to the field of digital education, the study contributes to the body of literature on entrepreneurship (Autio, 2017).

It also provides policymakers and startups with useful advice by outlining a methodical strategy for growing EdTech companies in a variety of international markets (Knight, 2015).

VI. CONCLUSION

This study offered a strategic framework for nascent EdTech companies hoping to expand internationally while preserving sustainability (Cavusgil et al., 2014). It emphasized how combining sustainability models with entrepreneurial theories can offer a strong basis for managing global expansion (Christensen, 1997; Teece, 2007). In order to comply with the triple bottom line, EdTech enterprises need to decentralize management, leverage digital skills, and create inclusive, adaptable business models (Elkington, 1997).This report offers a road map for EdTech companies hoping to transform education globally by concentrating on the nexus of innovation, sustainability, and global scalability (Adams et al., 2016).The insights provided here can help future EdTech investors, entrepreneurs, and policymakers create socially responsible and globally competitive educational businesses (Porter & Kramer, 2011).

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Bridging Talent and Sustainability: Aligning the Students Early Recruitment Scholarship Program with Global HRM Trends

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Abstract- **In order to close the knowledge gap between academia and business in Bangladesh, the Students Early Recruitment Program (SERP) prepares students for the workforce prior to graduation. In contrast to conventional scholarship programs, SERP offers financial assistance together with early industry exposure, leadership development, sustainability-focused education, and mentorship. This study assesses how SERP helps students develop into uncommon, valuable, and morally upright talent that can provide companies with a sustainable competitive advantage. It is based on the Resource-Based View and Human Capital Theory.Using a mixed-method approach, surveys of 200 students and interviews with 50 businesses show that most firms strongly support early recruitment and mentorship, while students who are keen for early professional exposure also exhibit better levels of flexibility and confidence. The results demonstrate SERP's potential as a long-term talent pipeline, which is consistent with SDGs 4 and 8 and worldwide HRM trends. For greater scale, however, issues including resource intensity, equal access, and cultural opposition must be resolved. All things considered, SERP proves to be more than just a scholarship program; it is a strategic HRM intervention that benefits both parties by producing graduates who are self-assured and prepared for the workforce and employers that are looking for motivated, future-ready personnel.**

Keywords: **SERP, Resource-Based Theory, Sustainability**

I.INTRODUCTION

The Students Early Recruitment Program (SERP) is a cutting-edge program created to close the knowledge gap between academics and business by preparing college students for the workforce at an early age. Through specialized skill development, leadership training, mentorship, and internship opportunities, SERP equips high-potential students with the knowledge and self-assurance necessary to succeed in a labor market that is changing quickly.With a twofold value proposition, SERP caters to both companies and students. It gives students a competitive edge in the job market, early career exposure, industry insights, and networking opportunities. Employers benefit from a sustainable talent pipeline since it finds and nurtures applicants who are ready for the workforce, fit in with the company's culture, and can lead innovation right away. SERP is a progressive concept that combines workforce sustainability, professional preparation, and academic quality with its strategic ambition to become the leader in early recruitment programs in Bangladesh. Different staff involvement and development plans might make HCF possible. The purpose of this study is to connect global HRM trends, early requirement scholarship programs, sustainability, and talent.

II.LITERATURE REVIEW

Theories related with SERP

Human Capital Theory (Becker, 1964):

According to this fundamental principle, spending money on education and training improves both organizational and individual output. In order to regard students as valuable future assets whose early development provides significant returns for both students and companies, SERP funds technical training, leadership seminars, and scholarships.

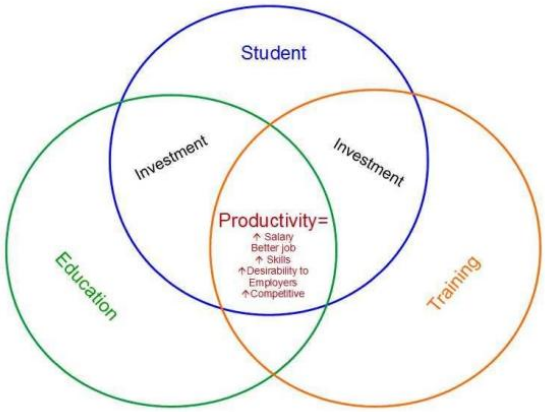


Fig.1.Human Capital Theory [3].

Talent Management Framework [1]:

Global best practices place a strong emphasis on methodically luring, developing, and keeping high-potential people. As a strategic talent pipeline, SERP keeps hiring going and makes sure that companies have an internal talent pool that is prepared for the future and in line with long-term objectives.

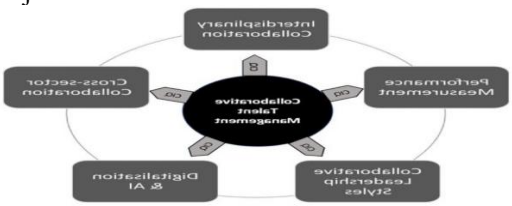


Fig.2.Talent Management Framework [1].

Resource-Based View (Barney, 1991):

A firm's competitive edge often comes from possessing rare, valuable, inimitable, and non-substitutable (VRIN) resources. SERP contributes to the development of unique internal talent by early recruitment of high-achieving

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students, hence enhancing organizational capacities and maintaining performance advantages over time.

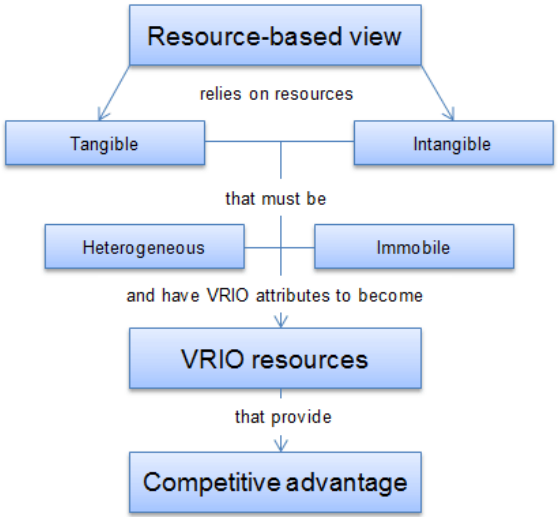


Fig.3.Resource-Based View [3].

Psychological Contract Theory [4].

SERP creates implicit expectations. While students anticipate mentorship, skill development, and job offers, corporations desire engagement, loyalty, and alignment with company values. Fulfilling these implicit psychological contracts improves long-term retention, devotion, and job satisfaction.



Fig.4.Psychological Contract Theory (Rousseau, 1989)

Sustainable HRM Theory (Jabbour & Santos, 2008; Ehnert, 2009):

SERP integrates its operations with sustainability goals (SDG 4&8) by incorporating environmental, social, and governance (ESG) concepts into training programs, ranging from green ethics to CSR-aligned projects. In Bangladesh, it has been empirically demonstrated that green HRM frameworks enhance organizational sustainability.

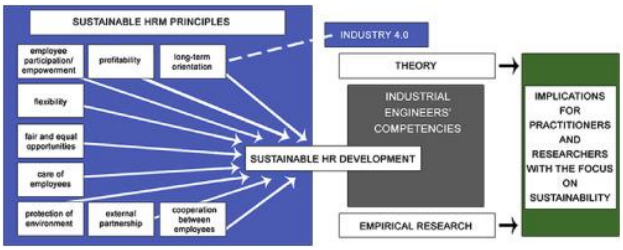


Fig.5.Sustainable HRM Theory (Jabbour & Santos, 2008; Ehnert, 2009)

Resource-Based View (RBV): Variables and Relation to SERP

Independent Variables (Strategic Talent Development Activities):

Selective Hiring of Students with High Potential
Before they graduate, SERP finds students who are motivated to lead and have great academic credentials. Talent that has the potential to become a unique and valuable resource for future employers is the focus of this early selection process. [3].
Personalized Training and Guidance
Students undergo a distinctive educational process that includes exposure to the real world, values education, and one-on-one mentorship, which makes their growth unique[3].
Integrating Green and Ethical Values
By educating students about ethics, sustainability, and ethical conduct, SERP makes sure that these future workers share the organization's long-term objectives[3]
Alignment of Strategic Careers
SERP reduces mismatch and improves fit with potential employers by bringing students' goals and abilities into line with market demands[3]

Dependent Variables (Strategic Resource Outcomes):

Talent Rarity

Graduates from SERP belong to a small, exceptional group that is uncommon among all graduates.[3]

Value of Talent

Because of their strong ethical foundation, leadership abilities, and practical capabilities, employers value SERP graduates more [3]

Unmistakable

These graduates are strategically unique since it is difficult for other programs to provide the comprehensive SERP experience (skills, values, mentoring, exposure[2].

Ethical and Cultural Fit

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Graduates blend in well with corporate cultures that place a high importance on long-term value generation, sustainability, and accountability[2]

Long-Term Competitive Advantage

Employers who hire SERP graduates receive devoted, moral, productive workers who support long-term objectives[2]

How This Relates to SERP:

The way that SERP improves organizational performance is supported by the Resource-Based View. Employers get a sustained advantage in developing a top-tier workforce by utilizing SERP to transform students into VRIN resources—Valuable, Rare, Inimitable, and Non-substitutable. These graduates give companies strategic human resources that are difficult to replace in addition to helping them fill jobs.(Barney, 1991)

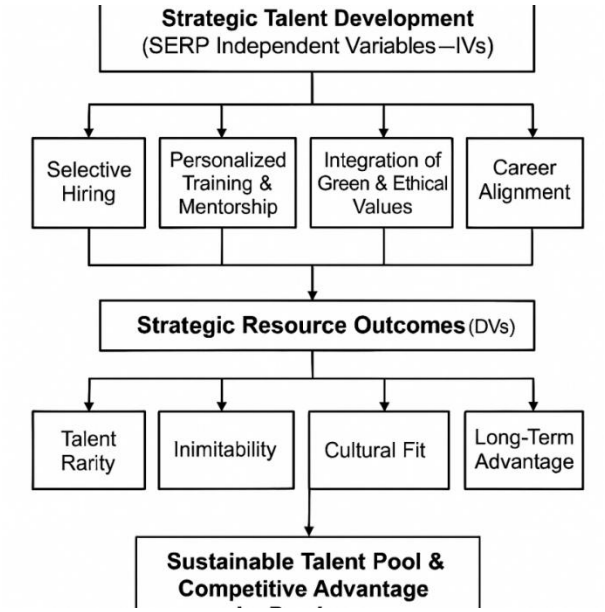


Fig.6.Independent and Dependent Variables

Pioneering student programs in Bangladesh inspired the creation of SERP as a structured talent pipeline.

The Students Early Recruitment Scholarship Program (SERP) shares goals with several national and commercial initiatives in Bangladesh that integrate education, skills training, mentorship, and sustainability-focused HR practices. While YES (PKSF) and BYLC encourage leadership, ethical growth, and vocational training, programs like SEIP and BDJobs Training offer upskilling that is career-focused and aligned with industry standards. While BITM focuses on digital readiness and green skills, Youth Co:Lab places more emphasis on social responsibility and innovation that is connected with the SDGs. Internship programs like BYLCX and Grameenphone Explorers replicate the early recruitment and mentoring model of SERP. These programs offer useful standards for SERP-style talent development initiatives.

III.METHODOLOGY

Research Design

Using a mixed-method approach, this study evaluates the Students Early Recruitment Scholarship Program's (SERP) efficacy and alignment with global HRM trends and sustainable development goals using both quantitative and qualitative approaches. The Resource-Based View (RBV) [3] and Human Capital Theory [2] serve as the foundation for the study framework, which directs the choice of factors and the examination of their effects on talent outcomes.

Data Collection

The survey was completed by 200 students, including undergraduates students from a number of public and private universities in Dhaka. Field trips and interviews were used to acquire qualitative information. PRAN Group was the site of one such visit, and other conversations were had with HR specialists from six significant Bangladeshi businesses: PRAN Group, Grameenphone, BRAC-Aarong, ACI Limited, bKash, and Walton Group. These businesses were carefully chosen due to their proactive participation in mentorship programs, youth employment initiatives, and environmentally friendly hiring procedures.

Academic literature, HRM journals, global workforce studies, and organizational publications were the sources of secondary data. Additionally, case studies of current youth development initiatives in Bangladesh, including BYLC, PKSF YES, and SEIP, were examined. The study's theoretical and practical framework was further supported by an analysis of strategic development resources, such as UNDP Bangladesh's SDG-related material, and CSR reports from a few chosen companies.

Sampling Method & Size

Employers and students who are directly involved in or aware of early recruiting and career development efforts were chosen using a purposive sample technique. The entire sample consisted of 200 students who answered the questionnaire and 50 employers took part in the questionnaires and interviews.A targeted examination of SERP's conformity to academic and industry standards was made possible by this sampling.

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Variables of the Questionnaire

The questionnaire for the Students Early Recruitment Program (SERP) collects both quantitative and qualitative data across several key variables. For students, the main variables include the level of interest in early professional exposure, desired skill development areas, confidence in adapting to professional work culture, motivational factors for joining SERP, and interest in mentorship from industry experts. These variables are designed to assess students' readiness, aspirations, and engagement with early career development opportunities. For employers, the variables include the perceived importance of early talent development, expected competencies from young recruits, challenges in hiring fresh graduates, willingness to offer mentorship or training, and anticipated benefits of partnering with SERP. These variables help gauge employers' strategic alignment, recruitment preferences, and openness to collaborating with talent development initiatives.

Data Analysis Techniques

In order to interpret the data from employers and students using SERP, we employed a variety of methods in this study. We started by counting and characterizing the data, such as the proportion of firms who believed early recruiting was crucial or the number of students who desired internships.Next, we examined whether the relationships we observed in the data—for example, the relationship between students' confidence and their interest in SERP—were genuine and applicable to different groups.We also looked at the effects of key SERP components, such as matching careers, ethics, training, and student selection, on factors like the rarity and value of the talent. These techniques enabled us to test our hypotheses and evaluate the effectiveness of SERP.

Ethical Considerations

The purpose of the study was explained to each participant, and participation was completely optional. Throughout the process, secrecy and anonymity were strictly maintained to protect the participants' identities. Only academic research and strategic reporting made use of the collected data.

IV. RESULTS

In keeping with global HRM and sustainability trends, the Students Early Recruitment Scholarship Program (SERP) effectively identifies and develops rare, valuable talent by selecting high-potential students early and providing them with individualized training, mentorship, and integration of ethical and green values. Strong employer sponsorship and student involvement in the program result in a long-term talent pipeline that gives businesses a competitive edge.Cultural resistance to new hiring practices, the possibility of unequal access for disadvantaged students, sustaining student engagement over time, evaluating long-term effects, and possible misalignments between employer and student demands are some of the challenges that come with implementing SERP, which takes a lot of resources. To ensure SERP's scalability, efficacy, and inclusion in Bangladesh's changing labor market, these issues must be resolved.

Student (Based on 200 Students)

Students who are very interested in internships are also confident they can handle the work culture. Eighty (40%) of the 200 students stated that they would be extremely interested in gaining early professional experience through internships or part-time work. Of the same sample, 56 students (28%) identified as Extremely Confident and 71 students (35.5%) as Very Confident about adjusting to a professional work culture.

This demonstrates that students who are enthusiastic about early employment possibilities are also confident in their ability to adapt to real-world work environments.

Most students want mentorship from industry experts. Just 35 students (17.5%) stated they would not be interested in mentorship possibilities, compared to 165 students (82.5%) who said they would.

What it means: This shows that most students think that gaining knowledge from seasoned professionals will help them advance in their jobs.

Confident students are more interested in joining SERP. The capacity to adjust to a professional work atmosphere was rated as Very Confident by 71 students (35.5%). It's interesting to see that 80 students (40%) said they were really interested in SERP and the publicity it provides.

This implies that kids are more inclined to participate in early career-building programs like SERP if they have greater self-confidence in their talents.

Employer (Based on 50 Employers)

Employers who care about early talent also want to mentor students.
Out of the 50 employers who responded, 15 (30%) said they place a high value on early talent development, and 17 (34%) said they place a high value on it. 42 employers (84%) responded in the affirmative when asked whether they would be willing to mentor students under the SERP program.

This is a direct correlation: businesses that place a high importance on developing young talent are also prepared to devote time to mentoring them.

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Most employers support early recruitment. For their long-term plan, 47 (94%) of the 50 firms stated that early recruitment is either Very Important, Moderately Important, or Critically Important. Just three employers thought it was either not important or rather important.

V. DISCUSSION

The findings support the fundamental tenet of the Resource-Based View (RBV), which holds that human capital can provide long-term competitive advantage when it is developed through deliberate development initiatives. Future employees have been shown to develop VRIN (Valuable, Rare, Inimitable, Non-substitutable) traits thanks to SERP's organized approach to early recruitment, ethical training, and career alignment.

The ability of selective hiring to produce talent rarity validates earlier research showing that early talent investment pays off (Becker, 1964; Armstrong, 2006). In addition to improving cultural fit and inimitability, the personalized mentoring and green HRM alignment also represent the larger movement toward sustainable HR practices (Ehnert, 2009). Crucially, long-term workforce stability and ethical alignment—two essential components in today's purpose-driven organizations—were brought about by the deliberate alignment of business demands with student aspirations.Additionally, the SERP model closely aligns with SDG 4 (Quality Education) and SDG 8 (Decent Work & Economic Growth) by combining early recruitment with ethical and environmental development, while also reflecting successful aspects of other Bangladeshi initiatives like BYLC, PKSF YES, and Grameenphone Explorers.

Bridging Talent Sustainability

The goal of sustainability in HRM is to generate long-term benefits for businesses and workers alike. In order to enable this, SERP prepares students early, guarantees a consistent supply of skilled professionals, and lessens recruitment difficulties. By providing training in sustainability and corporate social responsibility, it also encourages ethical and green practices and responsible business conduct. Moreover, graduates who are engaged and well-prepared are less likely to quit, which reduces turnover and decreases hiring and training costs for businesses.

Students Early Recruitment Program

One strategic HR strategy that connects academia and industry is the Students Early Recruitment Program (SERP). In addition to offering scholarships and development opportunities like financial support, mentorship, and leadership training to make sure students are capable and motivated, it gives the early career exposure through internships, projects, and industry seminars. In addition, SERP establishes a strategic talent pipeline that enables businesses to find and develop candidates before to graduation, guaranteeing cultural fit and alignment with corporate objectives. Because of this, SERP generates graduates who are highly employable, morally oriented, and prepared to contribute successfully, which streamlines and expedites the employment process.

Global HRM Trends:

Programs such as SERP are shaped by global HRM trends, which encourage proactive and strategic approaches. These include diversity and inclusion for equitable chances, employer branding to draw in top students, and strategic talent management through early identification and development. Additionally, contemporary methods place a strong emphasis on continuous learning, digital HR tools, and integration of sustainability and CSR. In order to prepare students for a competitive, dynamic workforce, they also place a strong emphasis on employee engagement and well-being and promote global mobility through cross-border internships and international exposure.

VI.CONCLUSION

The Students Early Recruitment Scholarship Program (SERP) is not just a scholarship initiative but a strategic HRM intervention designed to bridge the gap between student development and sustainable organizational needs. By embedding the principles of Human Capital Theory and the Resource-Based View, SERP develops future employees who are valuable, rare, ethically grounded, and strategically aligned with organizational goals.In the context of Bangladesh’s evolving labor market, SERP offers a forward-thinking model that other educational and corporate institutions can replicate. It addresses both local employment challenges and global HR expectations, proving that early talent development—when ethically and strategically implemented—can yield long-term advantages for organizations and society.A strategic HRM intervention, the Students Early Recruitment Scholarship Program (SERP) aims to close the gap between long-term organizational requirements and student growth. The Resource-Based View and Human Capital Theory are included into SERP to create future workers who are rare, valuable, morally sound, and strategically in line with company objectives. With Bangladesh's labor market changing, SERP provides a progressive model that other corporate and educational institutions might adopt. It proves that early talent development, when done ethically and effectively, may have long-term benefits for businesses and society. It tackles both local employment issues and worldwide HR standards.

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Challenges in Implementing Green Human Resource Management in The Jute Industry of Bangladesh

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Abstract— **This study examines the obstacles in implementing Green Human Resource Management (GHRM) in Bangladesh's jute industry. Data were collected through semi-structured interviews with six HR professionals from three jute industries, using a qualitative, exploratory approach. Thematic analysis revealed barriers such as the absence of green HR policies, financial constraints, operational limitations, limited employee awareness, and inadequate managerial support. The study draws on Sustainable HRM, the Resource-Based View (RBV), and Stakeholder Theory to explain factors influencing GHRM in resource-constrained industries. However, the results highlight the organizational culture, employee engagement, and leadership commitment in integrating environmental concerns into HRM functions. This research contributes to the limited literature on sustainable HR practices within Bangladeshi contexts and offers practical recommendations for managers, policymakers, and industry regulators seeking to improve environmental performance through effective GHRM strategies.**
Keywords- **Bangladesh, Environmental Sustainability, Green Human Resource Management, Jute industry, Resource-Based View, Stakeholder Theory, Sustainable HRM**

I.INTRODUCTION

Bangladesh is the second-largest jute producer in the world, contributing substantially to the national economy with annual export earnings exceeding US $1 billion and accounting for approximately 42% of the global supply [1]. Jute, which is frequently referred to as the "Golden Fiber," is renowned for its environmentally beneficial properties. It is naturally decomposed, consumes minimal energy during processing, and captures carbon dioxide during cultivation. Nevertheless, the industry is still plagued by systemic inefficiencies, outdated infrastructure in government-owned mills, and a general dearth of modernization and forward-thinking policy development. At the same time, environmental risks like air and water pollution and increased risks of climate are on the rise in Bangladesh, which puts sustainable industrial practices as a pressing need. The jute industry is facing a turning point with the growing interest in green products around the world. Its long-term success depends on the ability to implement sustainable practices supported by enterprise and institutional change. In this context, Green Human Resource Management (GHRM) is a very important strategy that offers a framework for integration of environmental considerations into human resource functions and the development of a culture of sustainability in the workforce [2], [17].

The jute industry in Bangladesh is considered to be a golden fiber, which has long been a substantial contributor to the economy of Bangladesh, making the country among the leading producers and exporters of jute in the world [1]. Although the global demand for sustainable products is on the rise and it has the features of environmental protection, the industry still faces numerous internal difficulties. These include, in general, a relative lack of innovation in strategic operations, inefficiencies of management, especially in the state-run industries, outdated technologies and lack of investment in human development. The need for transformation of the jute sector has come into increasing importance against the backdrop of international awareness around environmental sustainability (UNCTAD,2020; World Bank,2022). The human resource management and development practices used by organizations in alignment with environmental goals is an important part of this change. Green Human Resource Management (GHRM) is a strategic management model that enables the incorporation of environmental awareness in various aspects of HR functions such as employee training, performance management, reward system and employment [2] GHRM has been successfully applied in different industries of Bangladesh, such as banking, garment, and hospitality, and made organizations more efficient and sustainable. However, these initiatives are often hampered by various factors, including lack of financial resources, low level of support from top management, poor environmental awareness and lack of formal green policies [4] Despite the prevalence of these general insights into GHRM practices, there is a notable gap in the literature in terms of their usage in the context of the jute sector [6]. Much of what has been written about VRM is focused on industries that operate within more structured human resource systems, and doesn't account for jute's idiosyncratic workings and constraints. Organizations whose nature is relatively unknown This leads to a question which needs to be examined critically: what are the particular challenges that jute enterprises in Bangladesh face in attempting to adopt GHRM practices?

The present study is intended to examine the current practices or non-practises of different green HRM components in the jute sector and the constraints that restrict their successful implementation. These barriers can be due to financial limits, resistance to change, technology gaps, or lack of knowledge about sustainable practices. Through the careful investigation of these factors, the research aims to

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produce practical understandings that can point HR practitioners and policy makers towards more sustainable and inclusive practices in the sector. This research is beneficial in both the domain of academics and in practice. On the academic front, it extends the scope of GHRM literature to a conventional and under-researched sector. In practical terms, it provides a deeper understanding for decision-makers in the jute industry on how HR strategies can be executed in line with environmental goals to foster long-term sustainability. The study's ultimate objective is to facilitate the green transformation of the jute sector, thereby guaranteeing its competitiveness and relevance in a global market that is becoming increasingly propelled by sustainability. The study's detailed information

will be described in the literature review, methodology, discussions, and other sections of the report.

Scope: This study is confined to examining the barriers to adopting Green Human Resource Management (GHRM) in Bangladesh's jute sector. It focuses on HR practices such as recruitment, training, and performance management, highlighting financial, organizational, and policy-related constraints. The findings are limited to qualitative insights from selected jute industries and are intended to provide guidance for managers and policymakers in promoting sustainable HR practices.

II. LITERATURE REVIEW

Over the past decade, Green Human Resource Management (GHRM) has emerged as a strategic framework for embedding environmental objectives within core HR functions such as recruitment, training, appraisal, and reward systems. Their main premise is that by aligning HR policy with sustainability measures, organisations can foster pro-environmental behaviour of employees, build corporate reputation and eventually achieve improved environmental performance [17], [2]. Basic research has focused on how human resource (HR) practices, especially green HR, training and performance appraisal, can build ability, motivation and opportunity (AMO) for employees to participate in environmental citizenship actions [19].

These theoretical assertions are supported empirically by the analysis of data from Bangladesh. For example, (Karmoker, Zannat, and Roy 2020) found green training practices, appraisal and reward practices to be significant drivers of pro-environmental behaviour among the hotel employees of Khulna. Extending this line of inquiry, Karmoker et al. (2021) showed in the ready-made garment (RMG) industry that GHRM not only affected employee behaviour at the workplace but also that employees with higher levels of environmental awareness were more open to green initiatives. Similar results are found in research outside the RMG industry: Rupa, Alam and Sultana (2023) examining responses from 310 Bangladeshi employees using PLS-SEM found that while green recruitment and compensation had a direct positive effect on environmental performance, training and appraisal needed a stronger cultural fit to make an impact. These findings are in line with more general evidence

indicating that managerial commitment, green infrastructure and employee environmental literacy are important facilitators of successful GHRM [20].

Despite such positive outcomes, there are many challenges to implementation in practice. In the banking sector, financial technology constraints like lack of e-HRM infrastructure, top management lack of support, high initial cost, and data security have been reported as constraints to digitalizing the green practices . Such limitations are also found in the manufacturing and service sectors, which strengthens the argument that, in addition to good policies, successful GHRM necessitates organisational capacity building and change management strategies and supportive governance mechanisms.

Importantly, the literature is focused on industries with relatively organised HR systems such as banking, apparel and hospitality, leaving traditional industries under-examined. Despite the production of a natural fibre that is largely biodegradable but also low in carbon, the jute sector is largely missing from the discourse of GHRM. Jute organisations are characterised by archaic management practices, lack of technological up-gradation and fragmented supply chains, possibly posing unique challenges in terms of integrating green HRM practices.

Theoretically, the Sustainable Human Resource Management (SHRM) framework is of special relevance in this context. SHRM defines HRM as a driver of organisational sustainability where economic, social and environmental dimensions are in balance. It focuses on integrating sustainability objectives into recruiting, training, performance evaluation, and employee engagement practices. Within the frame of the jute industry, SHRM offers a channel for orientation of HR practices toward sustainability goals while being operationally constrained.

In addition, the Resource-Based View (RBV) emphasises human capital as a resource that is valuable, rare, inimitable and non-substitutable with the potential to give long-term competitive advantage [3]. By fostering employees' green skills and knowledge through targeted HR practices, firms can respond effectively to environmental challenges and strengthen sustainability outcomes even in resource-constrained settings. In traditional sectors such as jute, RBV highlights the potential of leveraging human resources as strategic assets when technological investments are not feasible .

Drawing on both SHRM and RBV, this study frames GHRM not simply as a set of operational interventions but as a strategic mechanism for advancing long-term sustainability in Bangladesh's resource-constrained,

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traditional industries, particularly the jute sector.

III. RESEARCH QUESTIONS

1. What are the organizational and managerial obstacles associated with the implementation of GHRM practices in the jute sector of Bangladesh?
2. What is the perception of the significance of GHRM initiatives in the organizations of Business Managers?
3. What are the institutional, policy, and infrastructural obstacles that impede the effective implementation of green HRM practices in the Bangladeshi jute industry?

IV. METHODOLOGY

Research Approach

This study focuses on the challenges of implementing Green Human Resource Management (GHRM) practices in the jute industry of Bangladesh, using a qualitative research approach. This approach allowed an in-depth exploration of the participants' experiences, perceptions, and challenges, providing detailed insights into a less-studied industrial context.

Research Design

An exploratory qualitative design was implemented, using semi-structured, in-depth interviews as the primary data collection method. This design ensured that key topics related to GHRM were addressed while allowing flexibility to explore participants' unique perspectives. The study was informed by the Sustainable Human Resource Management (SHRM) theory and the Resource-Based View (RBV), complemented by insights from Stakeholder Theory.

Sampling Method and Participants

Purposive sampling was used to recruit six participants from three prominent jute industries in Bangladesh. All participants were senior HR officers or managers directly involved in HR functions, with experience in environmental or sustainability-related initiatives. This ensured informed and relevant perspectives on the implementation of GHRM.

Data Collection Procedure

Face-to-face semi-structured interviews were conducted over a two-week period in July 2025. With prior consent, each interview was audio-recorded using a secure digital device to ensure accurate capture of responses. During the interview, field notes were also taken to record immediate observations, tone, and key phrases. Each interview lasted approximately 15–20 minutes. The interviews followed six open-ended guiding questions focusing on:

- Current GHRM practices
- Organizational and structural obstacles
- Leadership and managerial support
- Employee engagement
- Functional and operational limitations
- Suggestions for improvement

Data Processing and Axial Coding

After data collection, the recordings were carefully replayed, and detailed verbatim transcriptions were created. The transcription process included cross-checking with field notes to ensure contextual accuracy. Following transcription, the data was analyzed using Axial Coding. This involved:

Open Coding: Breaking down the transcripts into discrete units of meaning and assigning initial codes to phrases, sentences, and key expressions.

Axial Coding: Grouping related codes into categories by identifying relationships between concepts, causes, contexts, and consequences.

Theme Development: Linking the categories to broader themes that directly answered the research questions.

Integration with Discussion: The final themes (e.g., financial constraints, lack of awareness, outdated machinery) were then used to structure the Analysis and Discussion section of this report.

Analysis of Data

In accordance with the six-phase framework developed by Braun and Clarke [6], the data were subjected to thematic analysis. We manually created the first codes based on key phrases, concepts, and recurrent themes found in the participant responses after transcription. Following that, these codes were grouped into more general themes that captured the main obstacles, organizational dynamics, and operational difficulties associated with the implementation of GHRM.

To improve the findings legitimacy and dependability, a peer debriefing was carried out with an academic supervisor who independently checked the coding framework and emerging themes for coherence and pertinence. Stakeholder theory helped us understand how various groups, like employees, managers, regulators, and buyers, influence the use of environmentally friendly HR practices in the jute industry.

Ethical Considerations

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The study was conducted with strict adherence to ethical standards. These purposes were explained to the participants and the participants were assured of anonymity and confidentiality. Prior to each interview, written consent was obtained. Subjects were also informed that they have the right to drop out of the study at any time without any consequences.

V. DISCUSSION & ANALYSIS

A common thread through the interviews was that managers and staff did not have much exposure to the concept of Green Human Resource Management.

One HR manager, from Industry A, commented: "We deal with training, recruitment and performance reviews, but we've never discussed green HR policies formally." Another interviewee said, "Most of our people feel that environmental issues are a production or compliance issue - not for HR." The findings are in line with previous studies that stated that environmental awareness of employees is an important aspect in sustainability measure adoption. Without specific awareness programs and well-defined guidelines, GHRM continues to be a concept in the jute industry, lost in the every-day operational focus.

Several participants reported that green practices are often resisted due to established management practices and operating habits.

One senior HR officer from Industry B said, "We have done it like this for decades and changing the system means extra work and possible disruptions." Others said that people are afraid that new environmental policies will decrease production or increase costs. Such resistance is consistent with Milliman et al. [15], who have emphasised that cultural inertia can be one of the major impediments to sustainability-oriented change. In the case of the jute sector, which has operated with little change in its business model, the critical issue is how to reform the organisational culture so that environmental policies are viewed as investments in long-term efficiency and competitiveness rather than disruptive. All of the interviewees expressed concerns over the financial sustainability of green HR practices.

A manager from Industry C said: "We can barely afford to operate on a daily basis, so investing in green training or equipment is hard." Another commented, "Profit margins are low and the management's focus is on short-term production needs versus environmental programmes." These statements are consistent with Daily and Huang's [7], observation that financial constraints would normally downplay sustainability in resource-scarce industries. In the case of the jute sector in Bangladesh, lack of specific budget directed toward green HR measures means even where there is willingness, there is a delay or reduction in implementation.

Participants also repeatedly mentioned that old, resource-hungry equipment prevents environmentally-friendly work-system improvements.

One HR manager commented, "Our production lines still run machines from the 1980s; they're more energy-hungry and they generate more waste." Read another: "We can't fully implement green operational policies without upgrading our equipment." This issue is worsened by the low level of technological modernization of the sector: according to Longoni and Cagliano [11], this characteristic makes more problematic the integration of sustainability, due to the infrastructural backwardness. It is suggested that mechanisation in the form of phased investment and public-private partnership will make it possible to improve the viability of GHRM based operations.

In particular, a number of interviewees felt that the lack of sector-specific regulatory frameworks and incentives is a key obstacle.

One of the managers commented, "No specific guidelines are given by the government on green HR in the jute sector." Another said, "If there were incentives or low-interest loans to do green things, we could move more quickly." This echoes Delmas and Toffel [8] who found a major factor in increasing the speed of environmental practices is policy support. Without enforceable standards or market incentives, jute mills are uncertain about how they can couple human resource (HR) functions with sustainability goals.

Finally, several respondents noted leadership's lack of prioritisation of environmental issues, along with low employee-level engagement in green practices.

An HR officer shared, Environmental projects are more distant in an organisation's mind than production. Another told me, we don't need incentive programmes to get people to do green stuff. This is supported by the work of Jabbour and Santos [14], who put forward the view that commitment of leadership and involvement of employees is essential for the incorporation of sustainability into HR functions. In the jute sector, leadership commitment is needed to not only allocate resources but to set an example in environmentally responsible behaviour, whilst employee incentives can enable a sense of collective responsibility towards sustainability.

VI. CONCLUSION

The purpose of this study was to investigate the problems of the application of Green Human Resource

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Management (GHRM) practices in the jute industry of Bangladesh through qualitative interviews with HR managers of three major companies. The findings identified six key barriers: low level of awareness to the existence of GHRM, resistance to change, fundamental limitations of finances, outdated machinery, lack of incentives from the government and weakness of leadership commitment to change and lack of commitment from the employees. To overcome these challenges, specific training and awareness-raising programmes must be addressed to HR professionals and employees, leadership must be developed to enable environment-related objectives to be incorporated into the company's strategic vision, and government-funded incentive schemes, such as tax reimbursements or low interest loans for green projects, are necessary. In addition, incremental infrastructure upgrade, employee-led environmental activities, and partnership with industry bodies and NGOs will improve sustainability outcomes.

By bringing a Sustainable HRM and Resource-Based View perspective to a conventional sector that has not been well explored in the research literature, this research has theoretical and practical implications. With a particular emphasis on the human capital as a powerful catalyst for environmental performance in resource constrained industries, it provides actionable strategies for HR managers, industry leaders and policy makers. Lastly, the green transformation of the jute sector will rely on strong leadership commitment, cultural change

and continuous collaboration across all stakeholders.

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Assessing Dimension of the Business Relationship: Integrating Symmetric and Asymmetric Approaches

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Abstract – **The principal intent of the study was to explore the measurement of the B2B Relationship through integrating symmetric and asymmetric analysis. This study applied a mixed-method research approach and used 320 sample responses to validate the research model. Finally, this study explored six measures: trust, commitment, cooperation, power, communication, and satisfaction to build B2B relationships through symmetric analysis. Finally, fsQCA analysis provides a unique configuration with maximum consistency and coverage, which is a configuration with four dimensions, like Cooperation, Power, Communication, and Satisfaction. Finally, this study integrated two outcomes based on symmetric and asymmetric analysis and refined the research model as cooperation, power, communication, and satisfaction as core and sufficient conditions for the B2B relationship. This study contributes to the existing theory of relationship marketing and managerial insight.**
Keywords – **B2B Relationship; Linear and nonlinear analysis; Mixed method; fsQCA; PLS-SEM**

I.INTRODUCTION

Business relationships are a new and complex dimension of 'marketing' and it's maintained within the relationship marketing framework. Organizations aim to develop long-term, sustainable relationships with their stakeholders to increase profitability and reduce vulnerability [1]. In the twenty-first century, increased competitiveness and strategic diversity have posed challenges for organizations to maintain and satisfy customers using traditional methods. Business relationships now emphasize engagement and relationship building to identify and meet customer needs at a profit. For example, relationship marketing may help to build a sustainable competitive advantage [2], [3].

Further, an earlier study addressed how enterprises emerge to manage the sustainable competitive advantage formed during the continuing channel relationships [4]. In terms of business-to-business (B2B) relationships, authors contextualize marketing channel relationships (MCR) as a form of B2B relationship. MCR refers to the connections between various members of a marketing channel, including suppliers (farmers), middlemen, and retailers. The scope of business relationships is wider; this study focused on the Agri-marketing channel in Bangladesh. In this manuscript, the author conceptualizes business-to-business (B2B) relationships as "the process of developing emergent cooperative and shared relationships with business customers and other market actors" [5].

While business-level relationships have a complex and extensive influence, no universally accepted framework that establishes standardized building blocks for these relationships has been published to date. To evaluate these facts, the author conducted an extensive literature review of articles published between 1990 and June 2025 in indexed journals and used popular search engines like "Google Scholar, JSTOR, Scopus," among others. After completing the literature review, the author did not find any research specifically focused on business relationship measures or their dimensions. However, this manuscript compiles several key studies that have enriched relationship marketing literature in recent decades, such as [2], [6], and [7].

A review of relationship marketing literature has found that the main variables predicting relationships have mostly been validated conceptually rather than empirically, except [2]. However, their study validated the model using linear analysis without considering dynamic or non-linear methods, considering the limits of the linear model. In the theoretical review, key frameworks like the commitment–trust theory and social exchange theory are referenced to define the dimensions for measuring relationships. Despite the fragmented nature of relationship marketing literature, existing work offers both theoretical and methodological contributions that could lead to meaningful advances in marketing, specially [2], [7].

Given the current gaps in theory and method, this manuscript addresses the main research question (RQ): What are the measuring dimensions of B2B relationships? To answer this, the study establishes specific research objectives (ROs): (a) to identify and explore the key dimensions of B2B relationships, (b) to empirically validate the proposed B2B relationship model, and (c) to determine which configuration leads to building the B2B Relationship.

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II. METHODOLOGY

For exploring dimensions, this study follows the research process recommended by [8] and [9]. This study applies the mixed-method concepts as suggested by [10] for dimension exploration. In addition, the mixed-method research approach comprises at least one qualitative method (to gather words) and one quantitative method (to collect numbers) [11]. According to previous studies, the B2B Relationship and its indicators have attributes that support the author in conceptualizing it as a reflective construct.

Qualitative study: This study collected field study data from the agricultural sector, particularly in the dairy industry in Bangladesh. In a qualitative study, we selected 22 samples through a judgment sampling technique. This technique is appropriate for collecting information during the exploratory research project [12] and involving experienced participants in the relevant field [13]. A detailed semi-structured interview was conducted with dairy managers, policy makers, and stakeholders; each interview lasted for 20–30 min (approximately). All respondents' responses were coded (prior coding, open coding, and indigenous coding) and analyzed to explore the relevant dimensions and items. To analyze the qualitative data and establish a link relationship among the concepts of studies, interview responses, and theoretical context, this study applied content analysis through NVivo 14.

The qualitative study was conducted in two phases: inductive and deductive assessment to meet the exploratory study intent.

Quantitative study: In the quantitative analysis, this manuscript employed two approaches: i) Symmetric Approach, ii) Asymmetric Approach

Symmetric Approach: The PLS based SEM analysis is applied as a symmetric analysis tool. This study follows the entire measurement scale development process as per the guidelines of [8] and applied by [9]. For this study, the author created items through an extensive literature review. Finally, the author prepared a primary questionnaire, including all dimensions (SAT, COMT, POW, SAT, COMU, and COOP) and their items. All items were assessed using the Likert scale (5-point scale: strongly disagree: 01'; strongly agree: 05'). A face-to-face questionnaire-based survey was conducted in Bangladesh, particularly in Sirajgonj and Chittagong districts. Finally, a total of 420 participants were chosen from the survey areas as prospective respondents. In the end, 320 (76% of total samples) responses were used to validate the proposed research model, and this sample size was sufficient for PLS-based SEM analysis, according to [14]. As a symmetrical analysis tool, this study employed the Partial Least Squares-Based Data Analysis, particularly PLS-SEM under the support of SmartPLS-4 Software as a reference to [15] and [16] for the first-order and second-order reflective constructs, and it was validated. Therefore, this study used PLS-based SEM analysis based on [17] to validate that the proposed model was rational and empirically logical.

Asymmetric Approach: Considering limits regarding SEM application [14], the author planned to verify the symmetrical analysis outcomes with an asymmetrical analysis, which is another novelty of this research. As an asymmetrical analysis tool, this study used a complex dynamic model, Fuzzy-Set Qualitative Comparative Analysis (fsQCA), which is an asymmetric analytical method that explores the relationship between conditions and outcomes in a configurational way [18]. In this study, the author strictly followed the fsQCA analysis guidelines proposed [18]. Their study motivated the integration of fsQCA with PLS-SEM. For data calibration, this study used the latent variable scores from SEM-PLS as raw data for fsQCA. To simplify the truth table, the consistency cut-off was set at 80% or higher [19], and PRI (Proportional Reduction in Inconsistency) was set above 60%. The frequency threshold was set at 2, considering the small sample size [18]. To assess necessary and sufficient conditions, this study applied thresholds [20].

Operationalization of Approaches

To make the model operational, all dimensions (first order) and second-order construct B2B Relationships were reflective measurement constructs. These constructs were examined by appraising the item reliability, internal consistency, average variance extracted (AVE), and discriminant validity as per the references [15]-[17], [22]. The structural model was evaluated by analyzing the t-values of the path coefficients to validate the proposed research hypotheses. Finally, the second-order construct of B2B Relationship was measured by using a two-stage approach. For fsQCA, this study conducts NCA, truth table, and sufficiency tests to find the best configuration as mentioned the references [18], [20].

III. RESULTS

A. Qualitative Study (Study -1)

The outcomes of the qualitative study have explored the B2B Relationship, which is reflected by dimensions that are demonstrated in Table 1. This study used frequency analysis and discovered the most cited dimensions as a measure. In the retrieval coding of the sample response, the author found frequent codes in favor of a few dimensions, like trust, commitment, satisfaction, cooperation, communication, and power.

Table-1
SUMMARY OF QUALITATIVE FIELD STUDY

B2B Relationship Measurments	Participants																					Freq	%
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22		
Trust (TRT)	y		y	y	y	y	y	y	y	y	y		y	y		y	y	y	y		y	y	18	81.8
Commitment (COMT)	y	y	y	y	y	y	y	y	y	y	y	y		y	y	y		y	y	y	y	y	20	90.9
Communication (COMU)		y	y	y		y	y	y		y		y	y	y	y	y	y		y	y		y	16	72.7
Satisfaction (SAT)	y	y	y		y		y		y		y	y	y		y		y	y		y	y		14	63.6
Power (POW)	y	y		y		y		y		y		y	y	y		y			y		y	y	13	59.1
Cooperation (COOP)		y	y		y		y		y		y		y		y		y	y		y		y	12	54.5

Source: Created by author

In this study, the author noted some infrequent responses in other dimensions, like adaptation,

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company reputation, trade association membership, etc. But these dimensions were not mentioned frequently. Thus, it was not included in the further study.

B. Quantitative Study (Study 2)

Symmetrical Approach (PLS based SEM analysis)

a) Assessment of the Reflective Measurement Model

Psychometric properties of the first-order reflective construct— TRT, COMT, SAT, COMU, POW, and COOP are presented in Table 2.

TABLE-2
PSYCHOMETRIC PROPERTIES OF FIRST-ORDER RELECTIVE CONSTRUCT

Construct	Item Codes	Item Loading	Mean	St. Dev	t.S-Value
Commitment (COMT) AVE=0.500, CR=0.743	COMT1	0.71	0.71	0.05	13.15
	COMT2	0.67	0.67	0.06	11.54
	COMT3	0.72	0.71	0.06	12.36
Communication (COMU) AVE=0.593, CR=0.741	COMU2	0.65	0.65	0.06	11.45
	COMU6	0.87	0.87	0.02	37.34
Cooperation (COOP) AVE=0.620, CR=0.760	COOP1	0.91	0.91	0.03	28.99
	COOP5	0.65	0.63	0.09	7.30
Power (POW) AVE=0.569, CR=0.796	POW2	0.66	0.66	0.05	12.82
	POW3	0.72	0.72	0.04	18.67
	POW5	0.86	0.86	0.01	61.29
Satisfaction (SAT) AVE=0.578, CR=0.804	SAT2	0.71	0.71	0.04	19.28
	SAT5	0.81	0.81	0.02	35.51
	SAT6	0.76	0.76	0.03	27.08
Trust (TRT) AVE=0.508, CR=0.755	TRT5	0.68	0.67	0.06	11.67
	TRT6	0.76	0.76	0.03	22.47
	TRT1	0.70	0.69	0.05	13.44

*Source: Created by author. Note: *Missing items were discarded due to lower loading less than 0.65 as per [15],[16]* .Measurement model shows under indices — item reliability, internal consistency, and discriminant validity — as suggested [14]-[17], [21]. For this study, the author adopts [16] principles to select a 0.65 cut-off value for item reliability, also 0.60 for exploratory research [15]. All items corresponding to t.S-values found 7.30 to 61.29, which is much more than the threshold value for 1% level of significance. Along with reliability, this study satisfied composite reliability (CR) and AVE with threshold readings of 0.70 and 0.50 as suggested [15], [22].Moreover, the discriminant validity test is a core principle of the SEM-PLS test. In this study, the author followed the Fornell-Larcker criterion (square AVE root greater than off-diagonal values). Finally, it has been statistically evident that the measurement model has satisfied all normative values of reliability, convergent validity and discriminant validity as well.

b. Assessment of Structural Model

The uses of a structural model for the assessment of the relationship between exogenous and endogenous constructs. This study proposed six (06) research hypotheses Ha to validate the proposed model. This study proposed that all measurements (TRT, COMT, SAT, POW, COMU, COOP) have a positive impact on the B2B Relationship. We used the bootstrap method to test all hypotheses. Table 3 presents an evaluation of the structural model reflecting the statistical evidence for model validation. Firstly, this study revealed the coefficients of dimensions and their corresponding t-statistic values. This test result validates the research model and statistically proves that the research hypotheses are accepted. Secondly, this study stated f-squared (f^2) values to outline exogenous constructs' effect on the R-squared. In the validation model, all have a strong effect on the R^2 value of 0.950 as per reference [23]. Finally, this study outlined measures that explained 95% variance and 99.9% predictive relevance of the model.

TABLE-3
EVALUATION OF STRUCTURAL MODEL

Path Link	β	t.S_ Value	Decisions	f-square
COMT -> Relationship	**B** 0.154	10.49	H0 Rejected*	0.392**
COMU-> Relationship	**B** 0.174	9.21	H0 Rejected*	0.373**
COOP -> Relationship	**B** 0.164	10.00	H0 Rejected*	0.452**
POW-> Relationship	**B** 0.303	16.85	H0 Rejected*	1.161**
SAT -> Relationship	**B** 0.360	18.04	H0 Rejected*	1.522**
TRT -> Relationship	**B** 0.240	13.39	H0 Rejected*	0.916**

R^2 (Variance Explained) = 0.950
Q2 (Predictive Relevance) = 0.999

Source: Created by author

Noted: *There is no statistical evidence to accept the null hypothesis (H0) and A t.S- Values are significant at the level 1%; ** F-square is an effect size that measures the change in R^2 when an exogenous (independent) variable is removed from the model. Thus, f-square> 0.35 is considered a strong effect.

Asymmetrical Approach (fsQCA-based analysis)

The intent is to test the combined effect of constructs on outcome variables and find a configurational recipe. Firstly, calibration of crisp values of the data to find fuzzy values through transforming the latent variables calculated. In this calibration process, this study followed full membership and full non-membership and used the percentile (90th = full membership, 10th = full non-membership, and 50th = crossover point) of the latent variable score as per the reference [18].

Subsequently, the author conducted a necessary condition analysis (NCA) to confirm which causal conditions are necessary for the outcome variable. From the analysis of NC, this manuscript shows the NCA report in Table 4. This study found that the causal condition is not necessary, but all are sufficient conditions for desired outcomes for B2B relationships, as per [20].

Table-4
NCA FOR B2B RELATIONSHIP

Casual Condition	Consistency	Coverage
fCOMT	0.756	0.777
fCOMU	0.762	0.864
fCOOP	0.819	0.765
fPOW	0.899	0.732
fSAT	0.862	0.853
fTRT	0.729	0.803

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Source: Created by author

Lastly, the author conducted sufficiency analysis. This analysis seeks to explore all the different configurations that consistently lead to the outcomes. The process of sufficiency analysis was carried out with the use of the boolean minimization algorithm "Quine-McCluskey". This study generates three types of solutions (Complex, parsimonious and intermediate) to analyze the sufficiency of research conditions. The author used an intermediate solution to find an aggregate configuration that is representative of both conditions' "core" and "peripheral" [24]. Based on the true table and Quine-McCluskey algorithms, this study found that three (03) configurations were derived based on the model developed. Table 5 presents causal recipes. The model f(B2BREL)=f(fCOMT*fCOMU*fCOOP*fPOW*fSAT*fTRT). The intermediate solution reported configuration 2 is fCOMU*fCOOP*fPOW*fSAT with consistency 0.983 and coverage of 0.576, the most suitable recipe for B2B Relationship. Moreover, the solution consistency reported that the consistency of the configuration is 96% and its coverage is 66%. Thus, it has been proved that a multifactorial configuration is relevant and satisfactory.

TABLE-5
CONFIGURATION FOR THE B2B RELATIONSHIP

	Raw Coverage	**Unique Coverage**	**Consistency**
Model: B2B Relationship f(B2BREL)=f(fCOMT, fCOMU, fCOOP, fPOW, fSAT, fTRT)			
Configuration			
1. fCOMT*fCOOP*fPOW*fSAT	*0.555*	*0.065*	*0.976*
2. fCOMU*fCOOP*fPOW*fSAT	*0.576*	*0.086*	*0.983*
3.fCOMT*fCOMU*fCOOP*fPOW *fTRT	*0.434*	*0.022*	*0.989*
Solution coverage: 0.662875			
Solution consistency: 0.965371			

Source: Created by author

IV. DISCUSSION

A. Summary of Findings

Business relationship or B2B Relationship was measured by the diverse nature of measures that support building a sustainable relationship. To explore this confined outcome, this study conducted multi-method and mixed approach research with integration of symmetric and asymmetric methods.

The results of the qualitative study explored six dimensions, such as trust, commitment, cooperation, communications, power, and satisfaction, that have influenced managers to build long-term B2B relationships in the agricultural sector in Bangladesh. This study introduced some other issues, but these issues were not replicated by other respondents. Finally, this study supports preparing a research framework and an extensive field study.

Outcomes of the symmetric analysis were validated by the proposed research model, and statistically proved that explored dimensions like trust, commitment, cooperation, communications, power, and satisfaction have a significant impact on B2B Relationship. This study revealed that dimensions, namely power, satisfaction, and trust, highly influenced building B2B relationships in the context of the agricultural sector. The other three dimensions have less impact on the value of the coefficients.

Finally, the outcomes of asymmetric analysis were to disclose an intermediate solution with three configurational recipes through the application of fuzzy-set Qualitative Comparative Analysis (fsQCA) as depicted in Table 5. As per Pappas and Woodside (2021), reference configuration 2 is more suitable and statistically accepted. This configuration consistency was 98.3% and raw coverage was 57.6%. Configuration 2 revealed that a business relationship developed with a multifactorial recipe. This configuration defines that sometimes trust and commitment do not matter for developing business relationships. The four other core conditions, like communication, cooperation, power, and satisfaction, were considered as core conditions that are sufficient to develop business relationships. But commitment and trust do not provide substantial conditions for business relationships, as mentioned in configuration 2. It has been remarked that present research findings stand in reverse position to the theory Commitment and Trust developed [2] and compiled a list of variables for relationships [7].

B. Implications

The outcomes of the present study are relevant to relationship marketing theory and its implications in the context of B2B relationships. In the following, it contributes to the diverse sectors:

Theoretical Implication: This study theoretically contributes to the domain of relationship marketing through exploring B2B Relationship measurements. Through an integrated research approach, this study validates a new theoretical dimension in the relationship marketing in the context of business-level relationships. Theoretically, this study contributed to the existing research published [2], [7]. Finally, this study explored a new theory or model for business-level relationship marketing.

Managerial Insight: The Present study contributes to existing managerial practices through the development of business relationship building dimensions or measurement. This study will support managers in guiding how they can establish long-term, sustainable relationships with the channel members. This study also contributed to managerial wisdom through new insights of relationship marketing theory, which proved that in the agricultural sector or vulnerable value chain process channel members' trust and commitment do not matter as

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a core condition for building business-level relationships.

Future Research: This study guides future researchers to test this model in other sectors and multicultural sectors to find the generalizability of the model. This study guide for conducting a similar study further proves the research model with a large number of samples and other relevant research designs.

C. Limitations

This study was conducted in a single industry and with a comparatively small sample, based on the industry size. Secondly, this study also collected data by purposive sampling. Finally, this study was conducted based on limited resources. Thus, the author hopes future research will contribute to the sector by overcoming this defined limitation. It has been noted that defined limitations did not impact or negatively hamper existing research outcomes that I present as a novelty study.

V. CONCLUSION

This study presented a B2B Relationship theory and empirically evaluated its measurements. Present literature implicitly focuses on the relationship in context to business, but the relationship in context to B2C is more emphasized. This theoretical partiality motive is the reason for the conduct and design of this research. This study robustly explored and statistically proved that B2B Relationship or business level relationship is mostly developed based on proper communication with partners, extended cooperation with partners, positive uses of power, and mutual satisfaction. This study also proved that trust and commitment between partners were not core conditions.

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Post COVID-19 Impact in RMG Sector

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Abstract- **The COVID-19 pandemic severely disrupted the Ready-Made Garments (RMG) sector, especially in countries like Bangladesh, where the industry is a major source of income and employment. The sudden halt in global trade exposed deep vulnerabilities in the sector.**
During the peak of the crisis, international buyers canceled or suspended orders worth billions of dollars. Thousands of factories shut down temporarily, leading to mass layoffs and wage cuts. Many workers, particularly women, faced uncertainty, with limited access to healthcare or social support. Although the sector has gradually reopened & exports have begun to recover, many factories now operate under financial strain, and working conditions remain fragile. The pressure to meet new health protocols and shifting buyer expectations has also increased operational challenges.While the RMG sector is slowly recovering, long-standing issues like poor labor rights, low wages, and lack of social security demand urgent attention for a more resilient and fair industry future.Aim of this paper is to examine the impact of the COVID-19 pandemic on Bangladesh's Ready-Made Garment (RMG) sector by systematically reviewing existing literature, using descriptive theory to understand what happened and how it unfolded.
Keywords- **"COVID-19 and RMG Bangladesh", "garment factory lockdown impact", "female garment workers", "RMG supply chain disruption", "labor rights", "SMEs pandemic".**

I.INTRODUCTION

The Ready-Made Garments (RMG) sector often described as the lifeline of Bangladesh's economy. It employs more than 4.1 million workers, nearly two-thirds of whom are women, making it not only a driver of economic growth but also a cornerstone of women's empowerment and social mobility. The sector contributes approximately 84% of the country's export earnings and around 20% of GDP [11]. With this scale, Bangladesh has earned its place as the second-largest apparel exporter in the world after China, shaping its industrial identity and global competitiveness around this labor-intensive industry [16].

The COVID-19 pandemic, however, exposed the sector's deep vulnerabilities. Global brands canceled billions of dollars' worth of orders within weeks, international supply chains broke down, and over 1,100 factories shut down, some permanently [13]. The result was devastating: millions of workers suddenly found themselves without wages, healthcare, or job security. RMG exports plummeted—85% in April 2020 and 62% in May 2020 compared to the same months the previous year—while national GDP projections declined by nearly 3% [11,9]. For many families, particularly women-led households, this collapse meant not just loss of income but loss of dignity and survival. Protests over unpaid wages and bonuses revealed long-standing structural weaknesses, especially regarding workers' rights and wage protection[16]

In response, the Government of Bangladesh, BGMEA, and civil society organizations introduced a range of interventions, including emergency stimulus packages, wage support schemes, and reopening guidelines to stabilize the industry. By mid-2020, factories cautiously reopened, balancing the urgent need to resume production with the health risks to workers. While far from seamless, this intervention prevented a deeper collapse and helped restore buyer confidence[9]

The post-pandemic years have highlighted both resilience and transformation. By FY 2022–23, exports rebounded to USD 47billion, consolidating Bangladesh's global apparel market position[16]. Furthermore, Bangladesh now leads the world in green garment manufacturing, hosting more than 200 LEED-certified factories, a milestone that strengthened its reputation for sustainable production [16]. Investments in modern machinery, digital compliance systems, and workplace safety have improved competitiveness. However, critical challenges persist: wages remain among the lowest in the global garment industry, inflation has eroded real incomes, and automation threatens low-skilled employment. In addition, shifting global trade policies—such as the recently announced 35% U.S. tariff on Bangladeshi apparel (effective August 2025)—pose fresh risks to export competitiveness.

Today, the RMG sector stands at a crossroads. It has proven resilient in the face of COVID-19, regaining lost ground and maintaining its global standing. Yet, the crisis underscored the urgent need for stronger worker protections, equitable wage structures, and long-term strategies for diversification and technological adaptation. The story of Bangladesh's RMG industry is therefore not only one of survival but also of

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transformation—an industry that must continue to evolve to remain competitive and socially responsible in a post-pandemic global economy.

Specifically, the paper seeks to:

*Document the economic shocks (supply chain breakdown, export collapse, factory closures).

*Analyze the labor disruptions and human costs, particularly focusing onworkers' livelihoods.

*Highlight the gendered vulnerabilities, since women bore the greatest burden.

*Assess the institutional and policy responses by the government, NGOs, and buyers.

*Explore the sector's resilience and pathways of recovery, including sustainability efforts and long-term risks.

In short, the paper aims to provide a comprehensive, reality-based understanding of how COVID-19 affected the RMG industry—economically, socially, and institutionally—while also reflecting on what lessons can guide a more resilient, fair, and worker-centered future.

II. LITERATURE REVIEW

This study aims to understand these impacts through a systematic literature review (SLR), guided by descriptive theory. Unlike prescriptive frameworks, descriptive theory focuses on understanding what happened and how it unfolded—without assigning blame or predicting future scenarios. It helps us piece together the lived realities of workers, factory owners, and policymakers during this unprecedented time.

A. Supply Chain Shock: A Collapse Without Warning
The onset of COVID-19 saw global brands cancel or delay billions of dollars' worth of orders. According to Anner (2020), Bangladesh lost more than $3 billion in expected exports. Factories were left with unpaid inventories and no way to recover costs. [6] noted that Bangladesh's dependence on fast fashion and low-margin deals made the industry particularly vulnerable to global crises.

B. Labor Disruption: Jobs Lost, Lives Displaced
[9] estimated that more than 2 million workers were temporarily unemployed during factory shutdowns. Women, who form 80% of the workforce hit hardest. Many sent back to their rural homes, often without wages or severance pay. [1] observed, the lack of formal contracts and social security pushed these workers into extreme poverty.

C. Health and Safety: A Cost Few Could Afford
When production resumed, factories expected to enforce new safety protocols—temperature checks, distancing, ventilation, and PPE. Larger factories managed. Smaller ones did not. According to [14], many small and medium-sized enterprises (SMEs) lacked the financial and technical ability to comply, leaving workers exposed and productivity compromised.

D. State and NGO Response: Too Little, Too Late
The government rolled out stimulus packages, including a $588 million fund to help pay worker wages. However, the Centre for Policy Dialogue (2021) highlighted major gaps in implementation—delays, lack of transparency, and political influence. NGOs like BRAC and ActionAid stepped in with emergency food and health aid, but these efforts were localized and temporary.

E. Gendered Burden: Women Paid the Highest Price
As with many crises, women bore the brunt. [15] revealed that many female workers lost income, faced food insecurity, and exposed to gender-based violence. Without on-site childcare or digital wage systems, they had no fallback.Though women were the core of the recovery workforce, their well-being neglected in most policy responses.

F. Future Risks and Fragile Hopes for Reform
The pandemic laid bare long-ignored problems: weak labor protections, buyer-supplier power imbalances, and governance gaps. [4] called for more sustainable trade relationships and social dialogue mechanisms. [8] stressed the need for wage digitization, health insurance, and stronger labor laws—changes that could turn crisis into opportunity.

III. RESEARCH METHODOLOGY

A. Research Design: This research based on a qualitative Systematic Literature Review (SLR), guided by descriptive theory, which avoids assumptions and instead focuses on documenting real-world experiences and outcomes as they unfolded during the pandemic.

B. Theoretical Lens: Descriptive Theory: Descriptive theory used to explain and interpret observed behavior, patterns, and institutional responses. Rather than offering recommendations or solutions, it provides a grounded lens through which to understand the reality of post-COVID conditions in the RMG sector.

C. Data Collection and Search Strategy:

Databases Used: Google Scholar, JSTOR, Scopus, Web of Science, ILO Library, BGMEA reports, World Bank.
Keywords: "COVID-19 and RMG Bangladesh", "garment factory lockdown impact", "female garment workers", "RMG supply chain disruption", "labor rights", "SMEs pandemic".

Time Frame: January 2020 – March 2024

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D. Selection Criteria

Included: Peer-reviewed journals, policy briefs, NGO reports, qualitative and descriptive works focused on Bangladesh/South Asia.
Excluded: Quantitative-only studies and pre-COVID reports lacking comparative insight.

D. *Data Analysis:* A thematic content analysis was applied. From 42 reviewed texts, 28 high-quality sources were selected and categorized into Six areas: Supply chain breakdown, labor displacement, gendered vulnerability, institutional response, health compliance, and reform narratives.

IV. ETHICAL CONSIDERATIONS

This study based entirely on secondary data. There were no human participants, so no formal ethical clearance was required. All cited materials properly referenced and used in accordance with academic standards.

V. DETAILED FINDINGS AND ANALYSIS

The impact of COVID-19 on Bangladesh's Ready-Made Garment (RMG) industry can best understood by examining the intersection of economic shocks, labor disruptions, gendered vulnerabilities, and institutional responses. The evidence reveals a complex reality: while the industry demonstrated resilience in bouncing back, the recovery remains fragile and uneven, particularly for workers at the bottom of the supply chain.

A. Supply Chain Breakdown: From Global Cancellations to Local Crisis

At the height of the pandemic in 2020, global retailers canceled orders worth over USD 3.18 billion within weeks [10]. Bangladesh's garment exports plunged by 85% in April and 62% in May 2020 compared to the previous year, leaving thousands of factories with unsold inventory and mounting debts. For many factory owners, especially small and medium enterprises (SMEs), the shock was existential: over 1,100 factories shut down, some permanently [5].
The supply chain crisis revealed Bangladesh's over-reliance on fast fashion buyers who prioritized profit margins over ethical sourcing. The absence of buyer accountability meant that factories bore the financial losses, while workers—already living on meager wages—absorbed the brunt of the fallout.

B. Labor Disruption and Human Costs

The Asian Development Bank (2021) estimated that 2.3 million workers were temporarily unemployed during factory closures. Layoffs and delayed wage payments left thousands of families in uncertainty. Women—comprising nearly 80% of the workforce disproportionately affected. Many were forced to return to rural villages, often without wages or severance, exposing the fragility of labor protections.
The crisis translated into very human struggles. Workers reported skipping meals, withdrawing children from school, and borrowing at high interest rates from informal lenders just to survive. Protests in Dhaka and Gazipur over unpaid wages underscored the desperation and mistrust between workers and employers.

C. Gendered Vulnerabilities: Women at the Margins

The pandemic deepened long-standing gender inequalities. Research by [15] found that many women not only lost their jobs but also faced heightened risks of food insecurity and gender-based violence. The closure of on-site childcare facilities further burdened female workers, forcing many to quit jobs altogether. Despite being the backbone of the sector's recovery once factories reopened, women's needs were largely absent in policy discourse.
This highlights a paradox: the industry thrives on women's labor yet consistently undervalues their welfare, reinforcing cycles of vulnerability.

D. Health and Safety: Compliance under Strain

When production resumed in mid-2020, factories were required to follow stringent health protocols, including PPE distribution, ventilation, and distancing. Larger export-oriented units managed to implement these measures, but SMEs—lacking financial and technical capacity—struggled. Reports by the [14] indicated widespread non-compliance, exposing workers to infection risks while undermining productivity.
For many workers, safety measures meant little when faced with the impossible choice between health risks and hunger. As one worker quoted: "We wear masks inside the factory, but at home we cannot eat them.*"* Such voices humanize the precarious balance between survival and compliance.

E. Institutional and Policy Response: Relief with Gaps

The Government of Bangladesh rolled out a USD 588 million-stimulus package to support wage payments, while NGOs such as BRAC and ActionAid provided food and emergency aid. Yet, implementation flaws were stark. The Centre for Policy Dialogue (2021) found that many workers did not receive timely payments due to bureaucratic delays and lack of transparency. Political influence in fund distribution further deepened inequities. While these interventions prevented total collapse; they were reactive rather than transformative. Workers' lived experiences suggest that social protection measures were patchy, uneven, and insufficient to address structural weaknesses.

F. Resilience and Pathways of Recovery

By FY 2022–23, Bangladesh's RMG exports rebounded to USD 47billion, signaling resilience and reestablishing buyer confidence (USDA, 2023). Notably, the country emerged as a global leader in sustainable production, with 200+ LEED-certified green factories enhancing its international image. However, wage stagnation, inflation-driven erosion of real income, and automation-induced job insecurity continue to threaten long-term recovery. The recovery story, therefore, is not one of triumph alone.

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VI. DISCUSSION AND IMPLICATIONS

Descriptive analysis of the COVID-19 period in the RMG sector shows systemic flaws that magnified under crisis conditions. The study's findings challenge the narrative of quick recovery and instead point to ongoing vulnerability:

- Labor protections were superficial and failed under stress.
- Gender-sensitive policy was largely absent despite women carrying the burden of recovery.
- Global buyers' exploitative behavior went unchecked.
- Emergency responses lacked coordination, equity, and follow-up.

These patterns suggest the need for not just economic recovery but social justice embedded in labor systems. Rebuilding trust among workers, restoring transparency, and centering voices of women in policy-making are essential steps forward.

Based on the observed realities in the RMG sector, this study offers the following actionable and context-sensitive reflections:

Mandate Nationwide Digital Wage Systems

Transitioning to digital wage payments ensures timely salary disbursements, enhances financial traceability, and helps workers access government or NGO support during crises. It also reduces wage theft and informal deductions, particularly for female workers who often face financial exclusion.

Expand Compliance Support for SMEs

Recognize that small and medium garment enterprises (SMEs) lack the financial cushion to implement post-pandemic safety, wage, and compliance reforms. Offer targeted grants or subsidized technical assistance that enable SMEs to uphold labor standards without sacrificing viability.

Develop a Multi-Stakeholder Crisis Preparedness Framework

Institutionalize an emergency response system involving the government, employers' associations, international buyers, and labor unions. Such a platform should focus on disaster relief logistics, worker income stabilization, and post-crisis recovery planning—ensuring that future shocks do not lead to humanitarian fallout.

VIII. CONCLUSION

The COVID-19 pandemic was more than an economic crisis for Bangladesh's Ready-Made Garment (RMG) sector—it was a human crisis. Behind the staggering statistics of canceled orders, factory closures, and export losses were millions of workers, predominantly women, whose lives upended overnight. Families faced impossible choices: skip meals, pull children out of school, or borrow at crushing interest rates just to survive. The resilience of the industry, while commendable, cannot overshadow the lingering scars of those who bore the brunt of the upheaval—workers left without wages, safety nets, or a voice in their own recovery.

The pandemic exposed what many already knew: the RMG sector's foundation is fragile. It thrives on the labor of women yet neglects their well-being; it depends on global buyers who prioritize profits over people; and it operates within systems where protections for workers vanish when crises hit. The rebound in exports and the rise of green factories are steps forward, but true progress must measured in more than dollars and certifications. It must measured in fair wages, safe workplaces, and the dignity of workers who power this industry.

This is not just a call for reform-It is a call for justice. Digital wage systems, stronger safeguards for SMEs, and inclusive crisis frameworks are not mere policy suggestions; they are lifelines for those who stitch the clothes we wear. The lesson of COVID-19 is clear: resilience cannot be built on the backs of the vulnerable. As Bangladesh's RMG sector looks to the future, its greatest challenge is not recovering from the pandemic, but reimagining an industry where growth and humanity go hand in hand.

The path ahead demands courage, collaboration, and above all, a commitment to valuing people as much as productivity. The workers have carried the sector this far; now it is time for the sector to carry them forward.

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Social Media Engagement and the Rise of Virtual Influencers: A Study focuses on customers' perception, relatability, and brand affiliation.

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Abstract - **This research paper examines how consumers perceive virtual influencers and to what extent these perceptions influence customers' perceptions, brand recognition, and relatability, ultimately leading to increased engagement. As hyper-realistic and computer-generated roles emerge as the newest trends in social media branding, the psychological and emotional effects they have on consumers' perceptions and relatability continue to be a subject of limited research. This study identifies the characteristics of virtual influencers, including relatability, credibility, emotional resonance, and brand value compatibility, to evaluate their impact on shaping consumers' engagement with social media advertising. This study will employe a quantitative research approach, a structured questionnaire, to collect primary data regarding customers' engagement with virtual influencers on three parameters. We expect this study to find a correlation between social media engagement and customers' perceptions, relatability, and brand loyalty. Although virtual influencers can optimize brand narratives, they often lack the emotional intensity necessary to establish trust and foster long-term consumer engagement. However, when these virtual images align with brand values and exhibit perceived authenticity, they can also foster positive consumer-brand relationships through familiarity, credibility, and the element of relatability. Furthermore, apart from addressing gaps in existing research, such as considering relativity as an emergent dimension, this research also responds to the call of advertisers to consider these factors simultaneously while formulating AI-based marketing strategies. Additionally, further research can be conducted into additional influences and evolving technologies that continue to reshape how people engage with brands online.**

Keywords: **Virtual-Influencers, Consumer-perception, Brand-affiliation, Relatability, Engagement**

I. INTRODUCTION

Social media has changed not just where people find brands, but also who or what can influence them. In recent years, digital studios and companies have created virtual influencers carefully designed, computer-generated characters that feature on platforms alongside real creators. These avatars offer creative control, round-the-clock availability, and the ability to scale campaigns. However, they also raise important questions about authenticity, emotional connection, and consumer trust. Early successes in marketing demonstrate real potential, but research on how everyday users perceive and interact with these virtual figures remains limited.

This paper brings together current research to explore how three related factors, relatability, credibility, and alignment with brand values, influence social media engagement with virtual influencers. Instead of presenting new survey findings, the study reviews and combines recent empirical evidence from SSRN-hosted working papers and other scholarly research to provide a clearer picture of existing knowledge and discussions. By examining this new technology in a less-explored regional context, the paper aims to clarify when virtual influencers enhance consumer-brand relationships and where they do not. The rest of the paper explains the method used for the literature review, presents combined findings, discusses their implications for marketers and regulators, and suggests areas for future research.

II. BACKGROUND / PROBLEM

The fast and rapid growth of social media has seen to transform the consumer brand relationships, and creating a marketplace where consumers engagement which is built on relatability and trust. The shifting environment of virtual influencers AI driven and computer-generated characters has emerged as a new marketing tools. Unlike any other in person influencers these digital platforms are raising questions about the authenticity, credibility and emotional connections. Likewise, for other brands they are offering a consistency and creative storytelling at scale, but their artificial nature is imposing a risk of alienating audiences who value the authenticity of influencers and brands. Whereas the global campaigns are already deploying virtual influencers and empirical research on their impact remains relatively limited, mainly in the emerging markets like Bangladesh. Overall, understanding how consumers perceive these digital figures is very crucial for businesses seeking to foster the brand loyalty and maximize engagement in the digital economy.

III. GAP & OBJECTIVES

The research gaps that have been identified was that in previous studies on marketing influencers have widely focused on human influencers, which have seen to leave a gap into understanding how consumers are engaging with virtually imposters. Whereas some other are acknowledging their potential and very little is known

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about whether the virtual influences are able to and can establish trust, emotional resonance and long lasting brand relationships. The study addresses that gap by investigating the three key dimensions which are relatability, credibility, and brand alignment as their role in shaping consumers engagement. The objective is to evaluate whether these factors can actually generate the meaningful consumers brand connections and identify how businesses can leverage the virtual influencers in their digital marketing strategy.

IV. METHOD

This study employed a secondary research design that was reliant on published numbers and analysis from peer-reviewed journals, working papers, and research reports found in SSRN, Research gate and Google Scholar. Rather than relying on a survey or direct data collection, the study integrated empirical evidence from recent studies on virtual influencers, consumer attitudes, and social media activity. Source selection was informed by three criteria: [1] relatability, with a preference for those published since 2022, [2] Relevance, with attention to consumer–brand relationships and virtual influencer marketing, and [3] Credibility, with a preference for scholarly or peer-reviewed sources. Approximately ten to twelve research papers were studied, covering topics focused on relatability, credibility, authenticity, and brand affiliation. A thematic analysis approach was employed to identify trends across the literature review, research methodology, key findings, and gaps, examining the influence of virtual influencers on consumers' interactions. By basing the investigation on secondary data, the research will ensure a broad perspective from numerous contexts, while acknowledging that the extent and limitations of the available literature shape its findings.

V. RESULTS / FINDINGS

The literature review analysis revealed consistent factors regarding consumer perceptions and interactions with virtual influencers. Across the multiple studies, relatability was consistently the most pronounced factor in driving consumer interactions. Audiences were more likely to follow, share or interact with a virtual influencer when those digital personas exhibited human-like characteristics such as humor, similar lifestyle, or emotional expression. A few studies have also identified brand alignment as a salient factor: when the virtual influencer is able to align its projected values with the brand's identity, consumer interactions show increased levels of engagement, such as sharing and following, as well as improved identification with the brand. While credibility was discussed as an essential factor, it proved to be less impactful than relatability and value alignment. Scholars noted that audiences typically express skepticism regarding the authenticity of virtual influencers, which could impact the trust-building process between audiences and virtual influencers. The scholars reported that younger consumers, particularly those who engage more with platforms like Instagram and TikTok, have a much more favorable attitude towards engaging with virtual personas than those in older generations. Ultimately, readers of these studies can understand that while virtual influencers cannot replace human authenticity, they can still be valuable if designed with relatable characteristics and aligned intrinsically with brands through established narratives.

VI. DISCUSSION, IMPLICATIONS & ORIGINALITY

The findings shed light on the evolving discussions around authenticity in digital marketing. The finding that relatability and brand affiliation take precedence over credibility suggests that the importance of personal connection and value alignment is more significant than credibility when engaging and connecting with virtual influencers. This challenges traditional influencer marketing models that describe trust as the primary determinant of engagement. In practice, the findings emphasize the need to create virtual influencers rooted in cultural relevance and aligned with consumer lifestyles. For policymakers, the increasingly overlapping boundaries between artificial entities and real persons raises questions regarding transparency, advertising regulation, and consumer protection. From an originality standpoint, the study offers a configuring exploration of an emerging market context Bangladesh where little attention has been given to understanding consumer interaction with virtual influencers. By examining relatability as a separate dimension of engagement, this study adds theoretical insights to the influencer marketing literature and implications for businesses experimenting with AI fueled branding strategies.

VII. LIMITATIONS & FUTURE WORK

There are certain limitations as well based on the Social Media Engagement and the Rise of Virtual Influencers. First of all, the research findings are based largely on secondary literature and recent publications. That is, they reflect the perspectives and examples and the data identified in the texts, rather than direct, first-hand evidence. As such, some subtle variations of consumer behavior, particularly in culturally / regionally distinct situations, may have been overlooked. Second, a lot of the literature we reviewed focused on younger, urban, digital native populations, which limits the extent to which we can draw conclusions for older consumer groups or rural, non-digital consumers. Finally, all of the referenced literature relied on cross-sectional studies, and as a result, we have a limited understanding of how consumer associations with virtual influencers may develop over time. For these reasons, future research should venture into cross-cultural contexts, conduct many longitudinal studies, and consider how experience with technology,

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like more lifelike AI avatars, may adjust consumer trust, relatability, and engagement in the future.

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Biodiversity and Business: Strategic Planning for Nature-Positive Growth in Bangladesh's Industrial Expansion

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Abstract- **Over the last two decades, Bangladesh has seen fast industrial development which gives a rationale for the rise in GDP. This expansion has frequently come with biodiversity harm, such as the loss of forest cover, greater wetland loss, and invitation for more species to become at-risk. The targets of the nation are the sustainable development therefore to include sustainability of biodiversity in industrial planning is necessary. The quest for "nature-positive growth" underscores the necessity of conserving and regenerating biodiversity while striving for economic growth—area in which Bangladesh is beginning to indicate the first signs of progress through green investments and eco-certifications. The paper explores the relationship between industrial growth and biodiversity restoration based on secondary data for the period 2000–2023, in terms of industrial GDP, wetland loss, species vulnerability, forest cover, eco-certified plants, green FDI and government conservation expenditure using trend analysis technique.**

Keywords- **Biodiversity, Eco-Certification, Green Foreign Direct Investment, Industrial Expansion, Nature-Positive Growth, Sustainable Development**

I. INTRODUCTION

Bangladesh has experienced rapid industrialization since 2000, changing the structure of its economy with industrial GDP growing from USD 12.5 billion in 2000 to USD 198.9 billion in 2023. This rapid expansion, however, has not been without significant environmental consequences, impacting the country's biodiversity in particular. The very idea of nature-positive growth is a shifting of goal posts from a situation where economic growth and environment protection are not alternatives, but two wheels of the same cycle that should be driven to achieve sustainability [1].

The moment is now to make industrial planning take into account biodiversity. Bangladesh's natural resources including one of the world's largest mangrove forests (Sundarbans) and significant wetland systems harbor unique biodiversity that is coming under pressure due to industrial growth. The conventional industrial mode of development has favoured short-term economic benefits at the expense of long-term environmental protection, which has manifested itself in habitat destruction, species extinction and ecosystem degradation.

Nature-positive growth is introduced as a strategic approach to end and reverse biodiversity loss and remain competitive in economic terms. This approach acknowledges that healthy ecosystems deliver valuable, life support services upon which industry relies such as water filtration, climate regulation and raw materials. For Bangladesh, embracing nature-positive solutions is not just an environmental obligation, but also an economic imperative if our industries are to become more sustainable in the long term [2].

New initiatives such as "green" finance, eco-certification schemes, carbon pricing schemes, sustainable ecosystem/green hedging financial instruments, and environmental regulations have opened up possibilities for businesses to pursue both profit and conservation imperatives. The increased importance of 'green' foreign direct investment (FDI) and the increasing number of eco-certified firms suggest that stakeholders are increasingly willing to accept that environmental governance can improve business value and performance.

II. METHODOLOGY

A full trend analysis methodological approach is used in this study for industrial growth and biodiversity preservation in Bangladesh for the years 2000 to 2023. This approach combines analysis of secondary quantitative data with qualitative review of policy trends and business practices.

A. Data Collection

The secondary data have been gathered from different sources such as Bangladesh Bureau of Statistics (BBS), Ministry of Environment, Forest and Climate Change, Bangladesh bank, World bank, IUCN and so on. Chosen indicators for analysis are:

Industrial GDP (USD billion)
Forest cover percentage
Wetland area loss (percentage)
Number of threatened and vulnerable species
Eco-certified business count
Green FDI inflows (USD million)

- Government conservation expenditure (USD million)
- Protected area coverage (km²)
- Biodiversity restoration project count

Analytical Framework

The Trend Analysis Approach The trend analysis approach consists of several analytical elements. A trend analysis was made for all indicators during the 23-year period. Correlations were then sought to establish relations between economic and environmental variables to identify

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trade-offs and synergies. Dynamic comparison was used to compare the growth rate of various indicators and achieve a dynamic balance between industrial growth and environment protection.

C. Data Processing

Data normalization method was used to make them comparable among various measurement scales. If data were lacking, interpolation was applied when possible, data quality was checked by referring to other sources of information. Non-parametric statistics were performed on the data using statistical software to identify meaningful patterns and correlations.

III. RESULTS

A. Industrial Growth Trajectory

The industrial sector of Bangladesh witnessed tremendous growth during the study time. Meanwhile, the industrial GDP also spread wings steadily, with an average annual growth rate of 8.7%. The ready-made garments, pharmaceuticals, leather, and technology industries were the driving force behind the nation's growth.

The industrial development provided large employment supporting to national economy growth. Nonetheless, this development was mainly characterized as traditional development for production efficiency, rather than environmental quality.

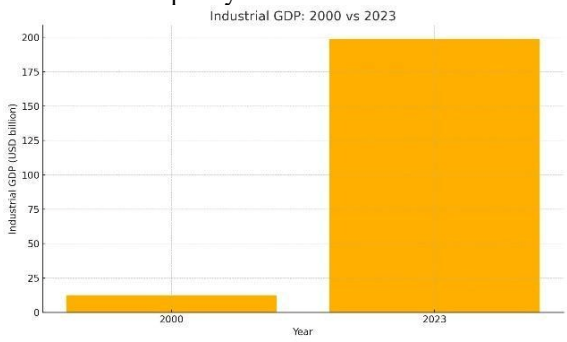


Figure 1. Industrial GDP growth from USD 12.5 billion in 2000 to USD 198.9 billion in 2023.

B. Biodiversity Loss Indicators

The environmental externalities of rapid industrialization were manifest in various indicators of biodiversity. Forest cover decreased by 42 % over the study period equivalent to a loss of ca. 2.1 million ha of forested area. Most of this deforestation was caused by industrial land use change, urban expansion and agricultural intensification.

Wetland loss was even greater at 40.7 per cent of wetlands disappearing over the period from 2000 to 2023. These habitats, which support essential services such as flood defense, water purify cation and biodiversity habitat were under threat from industrial development, expansion of aquaculture and infrastructure.

The number of threatened and vulnerable boreal species skyrocketed from 210 to 530, a sign of major ecological stress. This increase is related to an enhanced monitoring and general decline of species, independent of taxonomic groups.

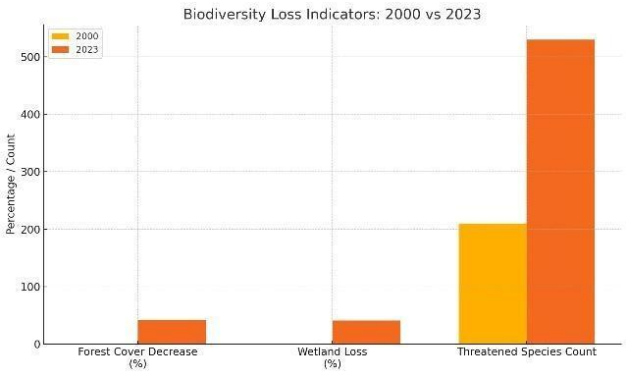


Figure 2. Percentage loss of forest cover and wetlands, and increase in threatened species, 2000–2023.

C. Positive Conservation Developments

Although alarming trends of biodiversity loss were noted, some good news were also reported in the analysis. The number of eco-certified businesses grew from 12 to 560, a 46-fold increase that demonstrates increasing business interest in environmental standards. These certifications spanned different industries such as textiles, leather, pharmaceuticals and food processing.

What is exciting is that green FDI saw an impressive rise to the tune of USD 310 million in 2018 from just USD 5.5 million a year ago, signifying international investors' growing confidence in Bangladesh's green development potential. This capital helped finance renewable energy developments, the implementation of clean technology and sustainable industrial processes.

Expenditure by government on conservation increased dramatically (from ±USD 5m to ±USD 240m) in line with increased policy commitment to the conservation of biodiversity. This money was used for the management of protected areas, species conservation projects and ecosystem restoration.

The area of protected areas widened by 6600 km², protecting a total of the region of 25,000 km². This growth included the formation of additional national parks, wildlife sanctuary and community conservation area.

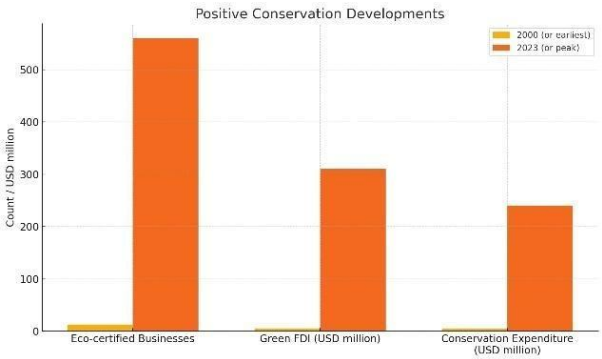


Figure 3. Rise in eco-certified firms, green FDI inflows, and government conservation spending over the study period.

D. Restoration and Conservation Initiatives

The number of biodiversity restoration projects rose to 345 by 2023. Such projects included those focused-on

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forest restoration, wetland restoration, species reintroduction and community-based conservation programmes. The projects also highlighted new methods of reconciling conservation goals with local economic concerns.

Community involvement in conservation operations has increased drastically, with more than 15,000 local community members participating in differentconservation activities. This involvement constituted sustainable livelihoods projects, environmental education activities and CBNRM.

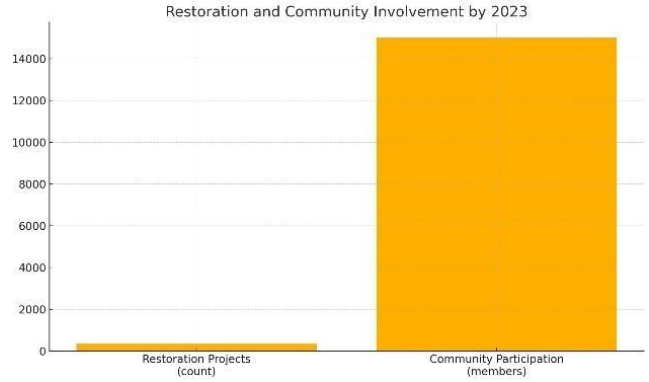


Figure 4. Total restoration projects (345) and community participants (~15,000) by 2023.

IV. DISCUSSION

A. Dual Nature of Development Trends

This duality is confounded and the complexity between the two divergent images of development in Bangladesh come to the fore in these findings. And though industrial expansion continues to drive the pressures on biodiversity—such as habitat conversion and the extraction of resources—a concurrent increase in conservation actions reflects what many believe to be a growing turning point toward nature-positive approaches to development [3].

The large growth rate is a clear sign an unambiguous that environmental compliance has come to be seen as a competitive rather than a regulatory burden. Firms engaged in ecocertification report increased market access, enhanced brand image and cost saving benefits from resource efficiency.

B. Green Finance and Investment Patterns

Increase of green FDI it indicates the global perception of the country regarding industrial growth in a sustainable manner. These investments have promoted the transfer of technology and the development of skills and adoption of best practices in the environmental field. The link between green investment increase and eco-certification uptake implies that economic incentives do work to improve environmental performance.

Growth in government conservation expenditures reflects policy awareness that the conservation of biodiversity necessitates significant public outlays. Yet the amount of money spent on conservation overall is small relative to what industrial developers invest, suggesting room for improvement in resource allocation for environmental protection [4].

C. Policy Implications

The results indicate that nature-positive growth can be stimulated by combined policy measures and that in practice nature-positive growth is often driven by a combination of economic incentives and regulatory frameworks. Successful initiatives were based predominantly on partnerships between government, the private sector and civil society institutions.

Drawing support from the tax policy to the businesses that are eco-certified, the rapid environmental protection examination and approval system and preferential credit to the green investments, they have been used to promote business voluntary environmental performance improvement above the minimal required by regulations [5].

D. Challenges and Barriers

There are now still a number of hurdles to overcome if we are going to secure genuinely nature-positive growth. With minimal technical capability for EIA and monitoring, the effectiveness of the conservation effort becomes restricted. Lack of coordination among various government departments in charge of industrial promotion and environment protection leads to policy incoherence.

SMEs in particular have a hard time to access eco-certification, because of high costs related to compliance and lack of technical knowledge. Specifically, tackling these obstacles would necessitate the design of specialised assistance schemes and procedures for minimising red tape for SMEs [6].

V. CONCLUSION

Indeed, Bangladesh's example shows that nature-positive growth is possible through a systematic incorporation of nature into industrial planning. Eco-certifications and green investments and restoration projects have also been growing at the same time, which suggests an increasing convergence of economic and environmental interests in this region [7].

Nevertheless, the ongoing squeeze on biodiversity from industrial expansion highlights the urgency for more rapid deployment of nature-positive approaches. At this rate, it looks like we can say we're moving, but in order to be able to counteract continued losses of biodiversity we need to be moving much, much faster. [8]

Strategic policy backing, the strengthening of corporate accountability, and continued investment in green innovation will be paramount to support the consolidation and scaling-up of nature-positive growth pathways. Comprehensive environmental accounting systems, strengthened regulatory environment and enhanced international collaboration would facilitate this transition. [9]

The next areas where research should be turned include producing sectorial guidance on nature-positive industrial

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development, evaluating the cost effectiveness of various policy instruments, and measuring the economic return of investing in biodiversity conservation. Monitoring over the long-term of both economic and environmental variables will be critical for devising adaptive management strategies which address this highly complex development challenge. The Bangladesh example offers useful lessons for other developing nations that are challenged to reconcile industrial growth and protection of biodiversity. The feasibility of nature-positive solutions that have been demonstrated gives hope that strategic development and stakeholder cooperation could reach common goals of sustainable development [10]

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Navigating Privacy Concerns: A Literature Review on Data Transparency and Customer Trust in Digital Marketing

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Abstract - **As digital marketing continues to evolve into a data-intensive field, consumer concerns about privacy have grown more visible. This review of existing literature examines how openness in data practices shapes the trust relationship between brands and their customers in online settings. The evidence consistently indicates that when companies explain their data policies clearly and follow ethical standards, perceptions of intrusiveness decline and consumer confidence strengthens. Straightforward communication on privacy matters improves user understanding and reduces doubt. Trust is also influenced by individual factors such as digital literacy and personal sensitivity to privacy, particularly in AI-enabled and self-service marketing contexts. Technological tools such as blockchain show promise in promoting accountability and decentralized data security. However, challenges remain in aligning regulatory frameworks, ensuring technical clarity, and navigating cultural differences in expectations of trust. This review provides both a conceptual foundation for future research and practical insights for creating trust-focused digital marketing strategies.**

Keywords - **Data Transparency, Consumer Trust, Digital Marketing, Privacy Concerns**

I. INTRODUCTION

The rapid expansion of digital marketing has fundamentally reshaped how companies connect with consumers. While this shift has enabled greater personalization and efficiency, it has also sparked significant debate around issues of privacy, transparency, and consumer trust. In today's digital economy, personal data functions as a vital resource, making the ways in which it is gathered, processed, and shared central to the credibility of brand–consumer relationships [1].

Existing research highlights that consumer trust in digital environments depends heavily on how clearly organizations communicate their data policies. When firms openly explain how information will be collected, stored, and applied, consumer skepticism decreases and trust is strengthened [2], [3]. In contrast, intrusive marketing tactics, vague consent mechanisms, and weak regulatory enforcement have been identified as key drivers of distrust [4]–[6].

This paper presents a systematic literature review (SLR) that investigates how data transparency shapes consumer trust in digital marketing. The analysis brings together insights across five major themes: global trends in transparency and trust, key enablers of customer trust, barriers arising from privacy concerns, regional and sectoral evidence, and the role of emerging technologies such as blockchain and AI.

II. METHODOLOGY

This study employed a literature review approach to ensure a rigorous and transparent synthesis of prior research. Relevant publications were retrieved from major academic databases, including Scopus, Web of Science, ScienceDirect, Google Scholar, and ResearchGate. The search was limited to the period 2016–2025 to capture both foundational and recent contributions. Studies included explicitly examined the relationship between privacy, transparency, and consumer trust in digital marketing. From an initial pool of over 60 papers, 17 were retained after full-text screening. These studies were then categorized thematically into five groups: (A) global patterns, (B) enablers of trust, (C) barriers to trust, (D) regional and sector-specific evidence, and (E) technology-driven innovations.

III. LITERATURE REVIEW

A. Global Trends in Transparency and Trust

Privacy and transparency are now seen as key strategic levers in digital marketing. Martin et al. [1] showed that strong privacy practices not only lower consumer worries but also enhance organizational performance. Luo [2] further confirmed that across industries, transparent privacy policies directly foster consumer trust. Magrizos et al. [3] demonstrated that presenting privacy information in simplified and visual formats reduces feelings of intrusiveness and boosts brand credibility. Taken together, these studies emphasize that transparency goes beyond regulatory compliance, it represents a competitive advantage and a crucial trust-building factor.

B. Key Enablers of Customer Trust

Several drivers play a central role in building consumer trust. Sansome et al. [7] observed that while consumers often demand transparency, their engagement with brand policies depends on individual motivations and digital literacy. In the fintech sector, Aldboush and Ferdous [8] and Devlin [18] highlighted that ethical handling of data strengthens consumer confidence. Within AI-driven marketing, responsible innovation, adherence to ethical

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standards, and secure personalization practices can improve consumer trust when paired with transparency [9]–[11], [19], [20]. These findings indicate that ethics, openness, and organizational accountability must work together to sustain long-term consumer trust.

C. Barriers and Privacy Concerns

Despite the presence of enablers, significant challenges remain. Yadav et al. [4] revealed that consumer trust deteriorates when marketing practices appear intrusive. Islam [5] found that unclear or ambiguous data usage deepens skepticism, particularly in AI-supported marketing. Insufficient transparency in corporate product presentations contributes to heightened perceptions of risk [6], [21]. Collectively, these studies illustrate the gap between consumer expectations of openness and the realities of business practices.

D. Regional and Sectoral Evidence

Trust-related perceptions vary across regions and industries. Rowi et al. [12] reported that in Southeast Asia, transparent marketing practices improved customer engagement and loyalty in e-commerce platforms. In the European context, Jiménez-Zarco et al. [13] demonstrated that combining co-creation with transparent communication strengthened brand trust. However, Portes et al. [14] cautioned that achieving global uniformity in transparency standards may be unrealistic, given differences in cultural values and regulatory environments. These results suggest that trust-building approaches must adapt to local contexts.

E. Technology and Innovation in Transparency

Technological advances are increasingly shaping the way transparency is delivered. Blockchain has been identified as a promising solution for protecting privacy, ensuring accountability, and decentralizing data control [22]. Qaisar and Fatimi [15] showed that blockchain adoption enhances consumer confidence in digital marketing. Hammadi et al. [16] reported that blockchain-enabled systems improved trust in e-commerce platforms, while Eido and Zeebaree [17] confirmed that decentralized models contribute to stronger perceptions of security and transparency. At the same time, AI-driven personalization presents both risks and opportunities: though it raises ethical concerns, trust can be reinforced when AI tools are implemented responsibly with fairness and accountability [9]–[11].

IV. RESULTS

The review highlights strong and consistent evidence that transparency in data practices enhances consumer trust in digital marketing.

A. Global Trends in Transparency and Trust

Research confirms that transparent privacy measures reduce consumer doubts while also improving firm outcomes [1]–[3].

B. Key Enablers of Customer Trust

The main drivers of trust include clear communication [7], adherence to ethical data practices [8], and responsible use of AI technologies [9]–[11].

C. Barriers and Privacy Concerns

Consumer skepticism remains high when companies use intrusive data collection techniques [4], rely on unclear consent processes [5], or fail to provide transparent corporate messaging [6].

D. Regional and Sectoral Evidence

In Southeast Asia, transparency has been linked to stronger engagement and loyalty [12], while in Europe, combining co-creation with openness improves consumer trust [13]. However, cross-national studies warn that global uniformity in transparency standards is difficult to achieve due to cultural and regulatory variations [14].

E. Technology and Innovation in Transparency

Innovations such as blockchain [15]–[17], [22] and ethically guided AI systems [9]–[11], [19], [20] are emerging as effective tools for strengthening accountability and trust in digital ecosystems.

V. DISCUSSIONS AND RECOMMENDATIONS

The evidence suggests that transparency functions both as a mechanism for building trust and as a strategic resource for organizations. In emerging markets, consumers often interpret transparency as a sign of accountability and ethical responsibility [12]. In contrast, in more developed economies, transparency is typically associated with compliance to regulatory requirements [13]. This contrast highlights the need to recognize the context-specific role of transparency in shaping consumer trust. They also support the resource-based view (RBV) by showing that strong data protection capabilities can serve as valuable strategic assets [1], [9].

For practitioners, three actionable recommendations emerge. First, simplify privacy communication by presenting policies in accessible and visual formats, enabling consumers to engage meaningfully with information. Second, design AI-driven personalization tools with embedded accountability, ensuring that innovation enhances trust rather than undermines it. Finally, leverage blockchain solutions to decentralize data management and reinforce accountability, particularly in sectors where consumer skepticism remains high. Collectively, these strategies position transparency as a foundation for long-term consumer trust and loyalty in digital markets.

VI. LIMITATIONS

This study has a few boundaries that should be acknowledged. First, the review only covers studies published between 2016 and 2025. As a result, some earlier influential work and the very latest publications beyond

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this time frame might not be reflected here. Second, only English-language articles were included, which means important contributions from other languages may have been overlooked. Third, because this is a literature review, the discussion is based on the findings of past studies rather than on fresh empirical data. Finally, the coverage of regions is uneven. Research from Europe and Asia is relatively well represented, while studies from Africa, Latin America, and the Middle East remain limited. These gaps point to the need for broader, more diverse, and longer-term studies in the future to build a fuller understanding of how transparency and trust work across different cultural and market settings.

VII. CONCLUSION

This review establishes that data transparency is fundamental to building consumer trust in digital marketing. Evidence shows that openness in communication, adherence to ethical standards, and the application of advanced tools such as blockchain and AI can significantly reduce consumer skepticism and strengthen trust. At the same time, obstacles remain which are unclear data practices, intrusive collection methods, and varying cultural expectations continue to challenge uniform trust-building approaches. The findings highlight that transparency is not a one-size-fits-all concept. In Europe, it is largely shaped by regulatory compliance, whereas in Asia, it is perceived more as a signal of accountability and brand responsibility. Although blockchain offers potential for decentralized solutions, its global adoption remains inconsistent. For practitioners, adopting transparency-by-design, improving digital literacy among consumers, and embedding ethical AI practices are essential steps toward long-term trust. For researchers, there is a need to broaden investigation into underrepresented regions and to examine the lasting impacts of transparency initiatives. Thus, transparency should be viewed not only as an ethical obligation but also as a source of competitive advantage. By aligning privacy practices with consumer expectations, firms can reduce risks while fostering durable trust and loyalty in the digital marketplace.

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Sustainopreneurship for Climate Action: A Conceptual Framework from Literature

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Abstract - **Climate change raises environmental risks and social inequality, and the role of entrepreneurs in bringing climate solutions to market is still not well studied. This paper builds a conceptual framework from the literature to explain how sustainopreneurs support climate action. The study uses a systematic review of peer-reviewed papers and selected proceedings, a thematic evidence map, and an abductive synthesis to identify key constructs and links. The analysis points to five linked mechanisms: problem sensing, mission orientation, effectuation-based venturing, community anchoring, and institutional interfacing. These mechanisms guide ventures toward mitigation through clean technologies and circular practices, toward adaptation and resilience through reliable and affordable services, and toward climate justice through access and inclusion. Outcomes differ with policy settings, capability levels, and market awareness, while helpful levers include training and digitization, recognition and finance, and public-private partnerships. The paper contributes an integrative framework and testable propositions with practical guidance for policy, education, and ecosystem design.**
Keywords– **Sustainopreneurship, Sustainable Entrepreneurship, Climate Change, Climate Action, Sustainability**

I. INTRODUCTION

Climate change increases environmental risks and widens social inequality, which directs research and practice to entrepreneurship that provides solutions with environmental and social value. Sustainopreneurship, which is entrepreneurship aimed at sustainability, presents "business with a cause" to achieve triple bottom line results (economic, environmental, and social) rather than profit only [1], [2]. A mission-driven intent sets sustainopreneurs apart from typical founders, and it fits effectuation logic that uses available means, accepts affordable loss, leverages contingencies, and builds partnerships to create opportunities under uncertainty [2]. Despite growth in the field, reviews report conceptual fragmentation and limited empirical depth [3], [4]. At the same time, policy debates often focus on invention and give less attention to the entrepreneurial commercialization that enables adoption at scale [2]. These gaps motivate an integrated account that links
sustainopreneurship mechanisms to concrete pathways for climate action.

Although case evidence has grown across green technology ventures, grassroots water and waste services, and circular economy initiatives, a consolidated explanation of how sustainopreneurs turn sensed problems into mitigation, adaptation and resilience, and climate justice outcomes is still limited. Common barriers include fragmented or weak policy support, price and scale disadvantages relative to conventional offerings, and low public awareness, especially in developing economies [5]. Grassroots enterprises often face capability gaps in registration, bookkeeping, and marketing, which weaken viability even when social need is high. Targeted training and digitization are suggested as immediate ways to professionalize such firms while keeping services affordable for low-income users [6]. The literature therefore needs a mechanism-focused synthesis that specifies the conditions under which mission orientation and effectuation lead to climate outcomes, and the institutional and community interfaces through which this occurs.

This study has three objectives. First, it consolidates definitions and theoretical foundations of sustainopreneurship, with emphasis on mission orientation, triple bottom line value, and effectuation [1], [2]. Second, it synthesizes climate-relevant evidence across green technology, grassroots and frugal innovation, and local service delivery to inductively derive pathways that link venture processes and stakeholder engagement to climate outcomes. Third, it proposes a conceptual framework and a research agenda that identify key barriers and enablers, including policy design, financing architectures, skill development (including digitization), and networked partnerships, which matter most for scaling sustainopreneurship for climate action [3], [5], [6], [4].

The scope is literature based and thematically limited to sustainopreneurship for climate action. Priority is given to peer-reviewed studies and selected conference proceedings that analyze ventures producing environmental outcomes directly linked to mitigation, such as clean energy and waste or resource efficiency, or to adaptation, resilience, and justice, such as affordable water access and services for vulnerable groups.

The remainder of the paper reviews definitions and theories, synthesizes prior studies by theme to derive propositions, presents the conceptual framework with implications for research, education, and policy, and ends with limitations and directions for future research.

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II. LITERATURE REVIEW

Sustainopreneurship is usually defined as entrepreneurship that aims at sustainability and joins economic viability with environmental care and social value, known as the triple bottom line [2], [7]. Conceptually, it stands out because it is driven by a cause and treats social and ecological problems as the space for entrepreneurial opportunity [7]. Within this view, effectuation is a common theory, since sustainopreneurs start from available means, accept affordable loss, use contingencies, and build partnerships to create solutions when the future is uncertain [2]. Reviews show growing attention, but they point to conceptual spread and call for frameworks that link these logics to climate action results [3], [4].

Studies on sustainopreneurship and climate action group into several themes. First, work on green technology ventures stresses mitigation. Ahamat [2] shows that green technology entrepreneurs use effectuation and mission focus to design and bring to market products that lower environmental harm [2]. By treating sustainability as a core value offer and not a limit, these ventures avoid tradeoffs and seek gains in both ecological performance and competitiveness [2]. The reported mechanisms are mainly market facing, for example new offerings in energy, transport, or pollution control. Yet many enablers sit outside markets, such as access to networks, collaborative partnerships, and legitimacy for "green" value propositions, which the study notes are important for the move from prototype to adoption.

A second line studies grassroots and bottom of the pyramid enterprise, where climate action often appears as adaptation and resilience. Nthuni, Mugo, and Owako [6] analyze small water providers in informal settlements and show that these micro-operators improve access and affordability for low-income residents, which is a resilience outcome in places where climate variation and weak infrastructure worsen water insecurity [6]. Although they create social value, these ventures are commercially fragile because business capabilities such as registration, finance, and record keeping are weak, and digitization is limited. Suggested fixes include formalization, targeted training in marketing and financial management, and digitizing billing and operations to improve viability while keeping prices affordable [6]. This stream shows that community anchoring, and the right capabilities are needed for climate relevant services to grow and endure.

A related line maps barriers and enablers in policy and market settings. Perera and Abeysekera [5], using multiple cases from Sri Lanka, identify repeated obstacles, including unsupportive or fragmented policy, price and scale disadvantages against conventional rivals, and low public awareness of sustainability [5]. They call for recognition and tailored support tools, such as legal forms, financing vehicles, and information platforms, to lower transaction costs and signal legitimacy. In parallel, work on identity and capability suggests that environmental values and sustainability education help move founders from "entrepreneur" to "sustainopreneur," with implications for workforce development and curricula [7]. Taken together, these strands indicate that climate focused ventures depend as much on institutions and capability support as on the business model.

At the field level, state of the art reviews helps place these themes in context. Aghelie, Sorooshian, and Azizan [3] describe the domain as nascent, with a strong conceptual focus and relatively few empirical studies, especially those that link mechanisms to measured environmental outcomes [3]. Terán-Yépez et al. [4] provide a bibliometric map that shows growth and fragmentation and calls for clearer definitions and integrative models [4]. Taken together, these reviews point to a methodological opportunity for systematic synthesis that keeps focus on climate relevant outcomes, such as mitigation, adaptation and resilience, and justice, while tracing the processes and contexts that shape them.

Across themes, the contributions to climate action can be grouped into three pathways. Mitigation appears when sustainopreneurs bring to market cleaner technologies or circular practices that cut emissions and waste [2]. Adaptation and resilience are observed when ventures secure reliable access to essential services, such as water, under environmental stress, often through locally adapted low-cost delivery models [6]. Climate justice and inclusion appear when affordability and participation for low income or marginalized users are central to the offer, which helps share the benefits of climate action more fairly [6], [5]. The literature also notes that these pathways are conditional, because mission and effectuation create opportunities, but producing climate outcomes depends on institutional support such as policy, finance, and legal forms, on community engagement, and on basic management capabilities [3], [5].

In sum, the literature shows that sustainopreneurship for climate action is diverse yet convergent, since cause driven entrepreneurs use effectual processes to build green technologies and community anchored services, while institutional gaps and capability deficits are common bottlenecks, and outcomes cluster around mitigation, adaptation and resilience, and inclusion. These patterns motivate a conceptual framework that explains how problem sensing and mission alignment move through venture processes and stakeholder interfaces to climate relevant outcomes, which supports testable propositions and policy design.

III. METHODOLOGY

This study uses a structured literature review to examine how sustainopreneurship supports climate

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action. Major databases, including Scopus, Web of Science, Google Scholar, IEEE Xplore, SpringerLink, ScienceDirect, JSTOR, ProQuest, SAGE Journals, SSRN, and EconLit were searched. Items published mainly in the last 10–15 years were focused, while keeping earlier
foundational works when needed. Searches combined terms such as sustainopreneurship, sustainable entrepreneurship, environmental entrepreneurship, effectuation, green technology, circular economy, waste, water, climate action, mitigation, adaptation, resilience, and climate justice.

Inclusion criteria required a clear link between entrepreneurial activity and climate outcomes. Eligible items reported at least one climate-relevant dimension, such as mitigation, adaptation and resilience, or justice and inclusion, and were published in reputable peer-reviewed outlets or recognized proceedings. We excluded items on corporate CSR without an entrepreneurial venture, purely policy commentary without an entrepreneurial lens, studies not connected to climate relevance, and materials outside the time window unless foundational.

Screening was two stages. We reviewed titles and abstracts for relevance, then read full texts that passed the first stage. For each study we recorded context, method, intervention type, climate outcome, and noted barriers and enablers.

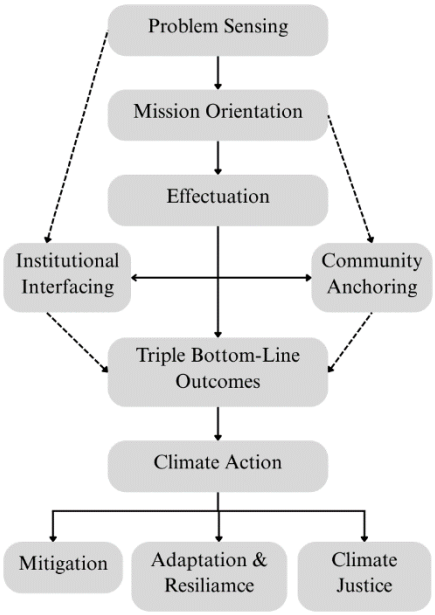
The review is qualitative. A meta-analysis was not suitable because measures and outcomes varied widely. We applied thematic coding aligned to the conceptual framework: problem sensing, mission orientation, effectuation-based processes, community anchoring, institutional interfacing, and climate outcomes. An audit trail documented search strings, screening choices, and code updates.

IV. CONCEPTUAL FRAMEWORK

This paper views sustainopreneurship as entrepreneurship that aims to solve sustainability problems and that is guided by a cause or mission, which sets it apart from general venturing [2], [7]. The framework starts with problem sensing. Local environmental and social pressures are read as entrepreneurial opportunities. Mission alignment then directs this sensing into effectuation-based venture processes that use available means, accept affordable loss, make use of contingencies, and build partnerships. Prior studies link these steps to sustainopreneurial practice [2].

Two contextual forces shape whether these processes create impact. The first is the institutional setting. Policies, finance, legitimacy, and culture can enable or constrain action. Evidence from Sri Lanka points to competition with non-sustainable firms, weak policy support, high prices, and attitudinal barriers. Suggested responses include tailored funding and legal recognition [5]. The second is community anchoring and capabilities. Research on water providers serving low-income settlements in Kisumu shows commercial fragility due to limited business skills and strategy. Recommended remedies include registration, training in marketing, finance, and record keeping, and the digitization of operations [6].

Fig. 1. Conceptual Framework



When effectuation is supported by conducive institutions and strong community anchoring, ventures produce triple bottom line outcomes that combine economic, environmental, and social value [2]. These outcomes connect to climate action through three routes. The first is mitigation through cleaner production and green technologies. The second is adaptation and resilience through more reliable and accessible services, such as water. The third is climate justice and inclusion by keeping services affordable and participatory for low-income users. Over time, these outcomes feed back into problem sensing and can also prompt institutional adjustments that recognize the role of entrepreneurs in commercialization, which policy debates often overlook [2].

V. DISCUSSION

This discussion explains how sustainopreneurs turn climate problems into mitigation, adaptation and resilience, and justice outcomes, which aligns with the conceptual framework. It does not repeat study details. It focuses on the main mechanisms, which are problem sensing, mission orientation, effectuation, community anchoring, and institutional interfacing, and on the conditions that shape their results. The synthesis draws on cases in green technology, water and waste, and grassroots settings, and it reflects the current state of the field [3], [4].

A. Problem sensing and mission orientation

Studies across settings show that sustainopreneurs first notice local environmental and social pressures, such as gaps in energy or water, and interpret them as

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opportunities for action [2]. A mission that centers on "business with a cause" guides which problems they address and shapes later choices about sustainability goals [7]. In climate work, a clear mission keeps mitigation or resilience as a design rule and lowers the risk of drifting toward purely commercial aims as the venture grows [1], [2].

B. *Effectuation under uncertainty*

Climate challenges are complex, and contexts often change. For this reason, sustainopreneurs commonly use effectuation, which starts from what they have, sets an affordable loss, uses contingencies, and builds partnerships [2]. Effectuation supports the mission. The overall goal, such as expanding clean water access, stays fixed, while the path is adjusted through co-creation with stakeholders, pilots, and pivots. This pattern appears in green technology commercialization and in service delivery, where quick learning and recombining resources are necessary [1], [2].

C. *Community anchoring for adoption, resilience, and justice*

Community anchoring is the joint work of defining needs, designing solutions, and building local capability. It is often needed for lasting climate results. In Kisumu, small water providers improved access and affordability for low-income residents, which supported adaptation and equity. At the same time, many providers were commercially fragile because registration, record keeping, and marketing skills were weak, so formalization, training, and digitization were recommended [6]. Across studies, anchoring raises adoption, lowers transaction costs, and directs benefits toward vulnerable groups, which supports climate justice.

D. Institutional interfacing and scaling:

Links to policy, finance, and legitimacy decide whether innovations scale. Common barriers are unsupportive or fragmented policy, higher relative prices than conventional options, and low public awareness [5]. Helpful measures include recognition and legal forms for hybrid ventures, targeted finance, and information platforms that lower adoption frictions [5]. Prior work also notes that policy often focuses on invention and pays less attention to the entrepreneurial task of commercialization. Active institutional interfacing, such as public-private partnerships, standards, and procurement, helps turn prototypes into broad climate impact [2].

E. *How mechanisms work together to produce climate outcomes:*

These mechanisms form an iterative path. Problem sensing, guided by mission, starts effectual processes that gather means and partners. Community anchoring improves the fit between solutions and context and helps share benefits fairly. Institutional interfacing removes system barriers and embeds solutions in wider structures. The outcomes then fall into three climate action routes. The first is mitigation through cleaner technologies and circular practices [2]. The second is adaptation and resilience through reliable and affordable service delivery under environmental stress [6]. The third is justice through affordability, participation, and access for low-income groups [6], [5]. The evidence map by sector, context, and outcome shows that these routes appear often, while the strength of each mechanism varies by setting.

F. *Boundary conditions and contextual variation:*

Three conditions appear often. The first is policy. Supportive rules and incentives help scaling, while policy gaps require entrepreneurs to build coalitions and engage in advocacy [5]. The second is capability. Where managerial and digital capabilities are limited, ventures need support through training and digitization to keep services affordable and effective [6]. The third is market awareness. Low awareness of sustainability lowers willingness to pay and slows adoption, but mission-consistent communication and work with trusted partners can help [5]. These factors change how strongly the links in the framework operate, so the same design can lead to different climate outcomes across contexts.

G. *Implications:*

For research, the framework points to tests of mechanisms. One question is whether community anchoring moderates the link between effectuation and outcomes when policy is weak. Another is whether enabling legal forms mediate the path from mission to scale. For practice and policy, the review suggests levers such as recognition regimes, blended finance, skills and digitization programs, and evidence platforms that reduce frictions at each stage. Overall, the literature supports sustainopreneurship as a process that depends on context. Mission-driven effectuation that is anchored in communities and linked to institutions is more likely to achieve climate action at scale.

TABLE I
CONNECTING SUSTAINOPRENEURSHIP TO CLIMATE ACTION

Proposition	Statement
P1: problem sensing → opportunity	Strong sustainability problem-sensing capabilities increase the identification and pursuit of high-impact mitigation or adaptation opportunities by sustainopreneurs.
P2: mission orientation → outcomes	A clear sustainability mission is positively associated with climate outcomes (mitigation and justice), by steering strategic choices toward environmental and social goals alongside economic aims.
P3: effectuation → innovation/resilience	Under high uncertainty, effectuation (means-driven experiments, affordable loss, partnership building) yields more innovative and resilient climate solutions than predominantly predictive planning.
P4: community anchoring × outcomes	Ventures with deeper community anchoring achieve greater improvements in adaptation/resilience and equitable access than otherwise similar ventures lacking such anchoring.

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P5: institutional interfacing → scale	Active interfacing with policy and finance (e.g., recognition, procurement, public–private partnerships) accelerates scaling and amplifies mitigation impact.
P6: context moderation	Supportive policy, higher capabilities, and greater market awareness *amplify*, while policy voids and capability deficits *attenuate*, the positive effects of p1–p5 on climate outcomes.

VI. CONCLUSION

This review brings together the literature on sustainopreneurship to show how mission-driven entrepreneurs turn observed sustainability problems into climate outcomes. Across green technology and community service settings, four linked mechanisms appear often: problem sensing, mission orientation, effectuation-based venture creation, and the pair of community anchoring and institutional interfacing. Community anchoring helps local fit and fairness, while institutional interfacing supports scale through policy, finance, and legitimacy [2], [6], [5]. Together these mechanisms lead to three groups of outcomes: mitigation, adaptation and resilience, and climate justice [2], [6], [5]. The strength of these links depends on context, in particular policy settings, capability endowments, and market awareness, which explains differences across places [3], [4].

This paper adds a conceptual framework that links these mechanisms into a clear path from problem sensing and mission alignment to climate outcomes and it brings attention to the often-overlooked role of entrepreneurs in commercializing climate solutions [2]. By organizing the evidence by theme and setting out propositions, the framework advances work at the intersection of entrepreneurship and climate action. It connects effectuation to climate performance, positions community anchoring as a driver of resilience and justice, and points to the moments where institutional engagement matters for scale. For policy and education, the synthesis highlights practical levers such as recognition regimes, blended finance, training and digitization, and ecosystem links that can lower known frictions and raise the chance that sustainopreneurial solutions reach real climate impact [6], [5]. In short, sustainopreneurship appears as a process that depends on context, in which mission-driven effectuation that is locally anchored and connected to institutions is more likely to deliver climate action at scale [1], [7].

Further Research

Future research should test the framework with clear measures for problem sensing, mission orientation, effectuation, community anchoring, and institutional interfacing [3]. Scholars should run comparative studies across policy settings and income levels to estimate how context changes the size of effects [5]. Longitudinal and mixed methods can link effectual behaviors to mitigation, adaptation and resilience, and justice results over time [2]. Quasi-experimental designs that use policy changes or staged program rollouts can support stronger causal claims [5].

Studies should also test which capability supports, such as training and digitization, most improve viability in grassroots service models [6]. Finally, updated reviews should refresh the evidence map and report shared metrics so results can cumulate across sectors and regions [3], [4].

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Bridging The Divide: Addressing The Skills Gap in Bangladesh's Ready-Made Garment (RMG)

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Abstract - **Bangladesh's knitwear sub-sector under the ready-made garments (RMG) industry has expanded rapidly, yet factories report persistent mismatches between job requirements and available skills. Using a structured survey and focused discussions with local and foreign mid- and high-level managers in knitwear factories, we map educational backgrounds, assess the adequacy of qualifications, and document training needs. General and commerce degrees dominate managerial pipelines, while technically trained managers are scarcer at senior levels. Managers consistently rate communication, leadership/time management, industrial rules & regulations, health & safety, and quality management as highly important, alongside core technical competencies. The evidence points to a dual-track response: targeted upskilling in supervisory soft skills and compliance, and pipeline development for technical and IT competencies within mid-level roles. We conclude with actionable recommendations for factory HR units, industry associations, and skills-development programs to align training portfolios with evolving buyer expectations and process automation.**

Keywords - **Bangladesh; knitwear; managers; RMG; skills gap; training; upskilling**

I. INTRODUCTION

Bangladesh is the world's second-largest exporter of ready-made garments and a global hub for knitwear production. In 2024, apparel exports totaled about US$38.5 billion, with knitwear contributing roughly US$20.5 billion and woven US$18.0 billion [1], [2]. Long-run series reported by the industry show sustained growth and a high share of RMG in total export earnings [3], while central-bank reviews document recent quarterly dynamics and risks [4]. Against this backdrop, the knitwear sub-sector faces tightening buyer requirements, diffusion of automation, and the need to upgrade workforce capabilities as Bangladesh advances toward Least Developed Countries (LDCs) graduation and higher value-added production [5], [6].

Particularly, executive leadership gap in RMG sector in Bangladesh is a perceived and real problem with

significant impact on industry performance. Currently, in shortage of local professionals this gap is being partly filled with 200,000 foreign workers who reportedly remit approximately $5 billion annually only from the RMG sector.

Researchers observed empirical evidence of linkages of skill enhancement and career progress of students or trainees with establishment of educational infrastructures and conducting academic programs [7], [8], [9]. Therefore, it is crucial to explore the causes and types of skills mismatches of graduate produced by the educational institutions of Bangladesh to take the role of professionals in the RMG sector.

The main aim of this study is to determine the types of skills needed for the mid and high-level managers of RMG sector of Bangladesh. Within the wide range of the RMG sector this research particularly focused on the Knit-ware sector. Particularly, this research focused on understanding the capacity/skills of current mid-and-high-level managers; gaps in capacity compared to their foreign counterparts; and policy options to reduce the gaps.

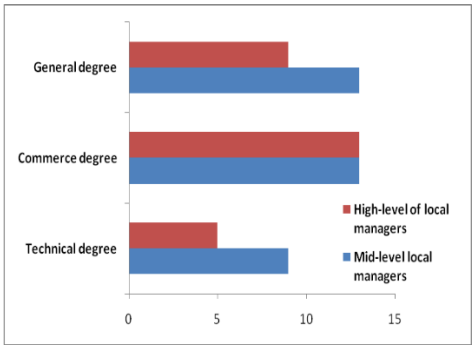
II. METHODOLOGY

A structured survey was administered among 50 mid- and high-level managers in 20 knitwear factories across Dhaka, Narayanganj, Savar, and Gazipur. The instrument captured: (i) educational background; (ii) perceived importance of qualifications and workplace skills; (iii) adequacy of current expertise; (iv) key deficiencies; and (v) training needs. In selecting participants and factories, a purposive sampling technique was adopted to capture prominent industries with long business experience with exporting and having mid-level and high-level foreign managers working records.

Responses were recorded using categorical and 0–10 rating scales. Descriptive statistics were computed and visualized in Figs. 1–7. To complement survey data, focused group discussions (FGDs) and in-depth interviews (IDIs) were conducted with industry owners and stakeholders from BGMEA, BKMEA, and training providers. Secondary sources, including policy documents and industry reports, were used for triangulation. No personally identifiable information was collected.

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III. RESULTS



. Fig1: Distribution of high-level and mid-level local managers by degree type.

Educational pathways and pipeline risk. Fig. 1 shows that mid-level managers predominantly hold general degrees, while high-level managers are more likely to have commerce backgrounds. Technical degrees are scarce at senior levels, creating a structural bottleneck for leadership succession in an increasingly automated industry. This imbalance suggests that without targeted interventions, factories may continue to depend on foreign professionals for technical oversight, leading to higher operational costs and remittance outflows.

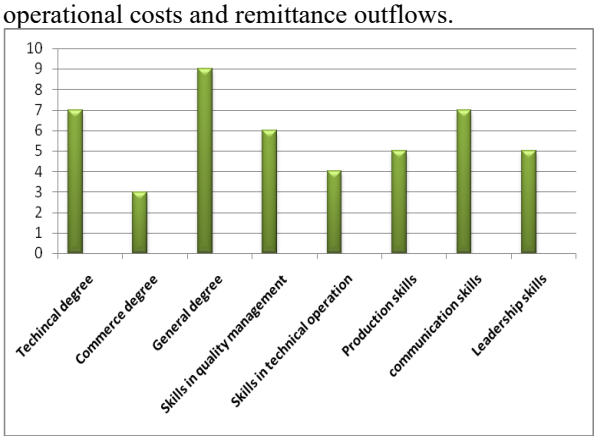


Fig. 2: Importance of educational qualifications and managerial skills in the knitwear sector.

On a 0–10 scale (Fig. 2), respondents rated communication, leadership/time management, and knowledge of industrial rules and regulations as highly important, alongside technical operation and quality management. These priorities reflect the dual challenge of maintaining compliance with global buyer standards while ensuring production efficiency. The emphasis on soft skills indicates that technical expertise alone is insufficient for managerial effectiveness in a compliance-driven environment. At the same time, it also highlights the importance of mixing existing education systems into multi-disciplinary and inter-disciplinary manners, i.e. introducing soft skills, basic computing and software skills, and ethical skills etc. irrespective of disciplines. Lifelong learning opportunities should be created by continuous online and offline medium so that mid-high-level managers can keep them updated by acquiring required skills to fulfill market demand.

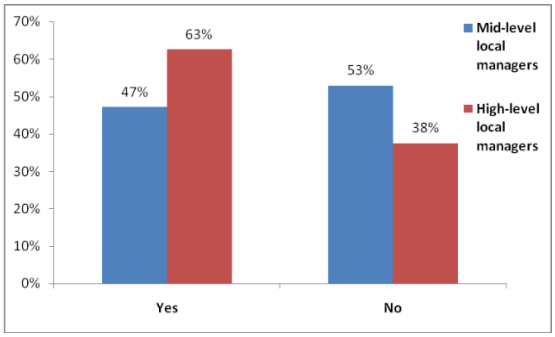


Fig. 3: Comparison of qualification adequacy between mid-level and high-level managers'

As shown in Fig. 3, 63% of high-level managers believe their qualifications are adequate, compared to only 47% of mid-level managers. This disparity highlights a vulnerability at the supervisory tier, where day-to-day operational decisions are made. Inadequate skills at this level can cascade into production inefficiencies, compliance failures, and reputational risks for exporters. At the same time, it also highlighted the importance of continuous learning and upskilling related skills, which cannot be achieved relying only on existing traditional education systems in Bangladesh. This issue was also evident during the FGD with some foreign managers where we have found that they are very highly skilled and earning much higher compared to their Bangladeshi counterparts though they have lower formal education.

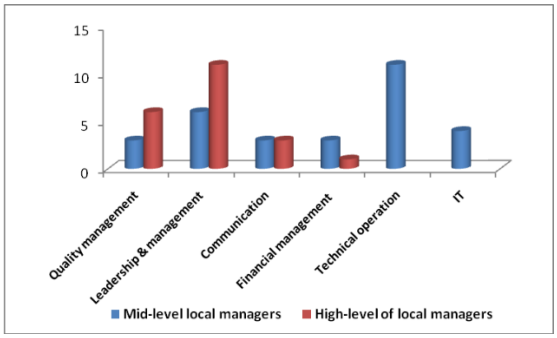


Fig. 4: Distribution of mid-level and high-level managers by key skill categories.

Fig. 4 indicates that high-level managers cluster around leadership and compliance, while mid-level managers dominate technical and IT functions. This segmentation creates a progression barrier: mid-level managers lack exposure to strategic decision-making, while senior managers lack technical operation fluency and IT skills. Bridging this gap requires blended training pathways that combine technical and managerial competencies. It also highlights important facts that both groups of managers significantly lacked communication skills.

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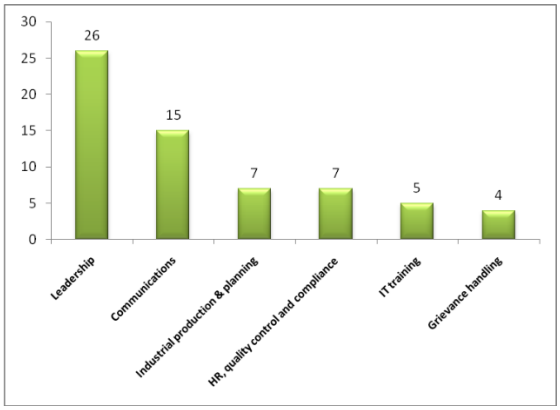


Fig. 5: Reported frequency of training needs across different managerial and operational areas.

Fig. 5 highlights leadership as the single largest training need, followed by communication. Industrial production & planning and HR/quality/compliance follow, with IT training and grievance handling requested by smaller yet non-trivial shares. This pattern reflects the dual challenge facing the knitwear sector: maintaining operational efficiency while meeting compliance and buyer-driven standards. The strong emphasis on leadership and communication suggests that factories recognize the strategic importance of supervisory soft skills in managing large workforces and ensuring adherence to global compliance norms. During the FGD many factory owners also highlighted that superiority in leadership and communication skills is the two major causes for which sometimes they prefer to hire foreign managers instead of relying on local managers.

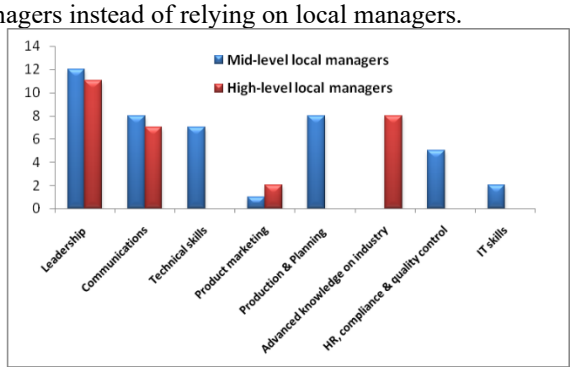


Fig. 6: Importance of workplace skills and knowledge areas as perceived by respondents.

In consistent with the findings of figure 5 while asked both high level and mid-level manager group identified that leadership is the single most important workplace skill followed by communication skills.

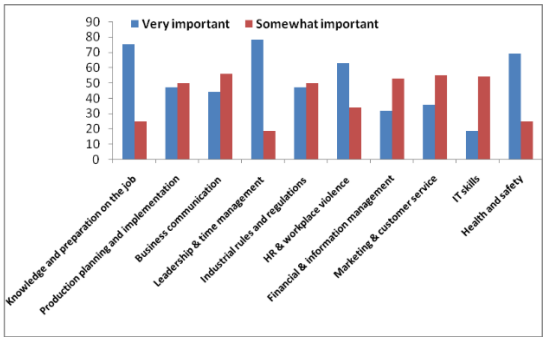


Fig. 7: Perceived importance of workplace skills and knowledge areas among respondents.

Finally, analysis for perceived importance of workplace skills and knowledge areas shows significant difference between two groups. Fig.7 shows that respondents rate knowledge/preparation on the job, industrial rules & regulations, financial & information management, health & safety, and communication as 'very important' at high rates, while some domains are more commonly deemed 'somewhat important.' These findings underscore the compliance-centric nature of the sector, where failure to meet buyer standards can result in order cancellations and reputational risks. The prioritization of health and safety also reflects lessons from past industrial accidents, reinforcing the need for continuous compliance training.

IV. DISCUSSION

The evidence above points to a structural skills gap with two facets. First, leadership, communication, and compliance competencies are strategic bottlenecks, particularly for supervisors and line managers. Second, technical operation and IT capabilities remain concentrated among mid-level roles, posing a pipeline risk for progression to higher-level positions. This segmentation creates a "dual-track" workforce: senior managers lack technical fluency, while mid-level managers lack exposure to strategic decision-making. Without bridging this gap, factories risk stagnation in leadership development and slower adoption of automation technologies.

These findings are consistent with national and international assessments that call for market-responsive training, stronger industry–training-provider linkages, and

certified short courses tailored to factory needs [5]–[9]. The relatively low demand for IT training, despite its critical role in Industry 4.0, suggests a lag in recognizing digital transformation imperatives. A just-transition lens is warranted as automation diffuses across processes, shifting task content and raising the premium on transferable skills [8]. Addressing these gaps is not merely a training issue but a competitiveness imperative. Factories that fail to invest in leadership and compliance risk losing access to premium buyers, while those that neglect technical and IT upskilling may fall behind in productivity and cost efficiency.

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So, for ensuring sustainability of Knitwear sector based on the survey data and FGD findings few feasible and actionable recommendations that can be suggested includes: (i) deploy modular training on supervisory soft skills paired with compliance refreshers on industrial rules and health & safety; (ii) design role-progression pathways blending on-the-job projects with short courses in quality management, data-driven production planning, and IT for manufacturing; (iii) partner with sector platforms (e.g., CEBAI, SEIP, TVET providers) to co-develop curricula and certify completion; and (iv) use routine skills audits to align factory training calendars with evolving buyer requirements [10], [11], [12], [13].

V. CONCLUSION

Bangladesh's knitwear sub-sector has achieved remarkable export growth, yet upgrading to higher-value, more automated production will depend on a workforce that couples supervisory soft skills and regulatory competence with strong technical and IT foundations. The findings of this study reveal that leadership, communication, and compliance skills are strategic bottlenecks, while technical and IT expertise remains concentrated at mid-level roles, creating a progression barrier for future leadership.

Closing these gaps is not only a training priority but a competitiveness imperative. As global buyers increasingly demand compliance, sustainability, and digital integration, factories that fail to invest in skill development risk losing market share and profitability. Conversely, firms that adopt structured upskilling programs can reduce reliance on foreign managers, lower remittance outflows, and strengthen resilience against automation-driven disruptions.

Coordinated action by factories, industry associations, and training programs—supported by policy frameworks such as NSDP and SEIP—can align curricula with market needs, foster industry–academia partnerships, and institutionalize certified short courses. These measures will help safeguard competitiveness in the post-LDC era and position Bangladesh as a leader in sustainable and technologically advanced apparel manufacturing [1], [2], [5], [6].

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Resilience Modeling of Supply Chain Partners Using Bayesian Networks

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Abstract— **Supply chains are increasingly exposed to disruptions caused by natural disasters, technical failures, and human errors, amplified by globalization and system complexity. These vulnerabilities have underscored the need for resilient supply chain (SC) designs that can withstand disruptions, sustain performance, and recover efficiently. Although prior research has largely examined supply chain resilience (SCR) qualitatively, quantitative models that integrate both proactive and reactive decision-making remain limited. In particular, the causal interdependencies among suppliers, buyers, and transportation nodes are often overlooked. This paper addresses this gap by introducing a Bayesian Network (BN) framework for resilience modeling of supply chain partners. The proposed approach captures conditional dependencies between disruptions and SC entities, enabling decision-makers to evaluate resilience under varying scenarios. By quantifying robustness, recovery capability, and the impact of mitigation strategies, the BN model provides actionable insights for enhancing SCR through data-driven probability assessments.**
Keywords— **Supply chain resilience, Bayesian network, risk analysis**

I. INTRODUCTION

The advent of globalization in the 21st century has brought significant opportunities for supply chain (SC) companies. These include reducing overhead costs, enhancing customer service, optimizing inventory management, and increasing operational efficiency. However, despite these benefits, global supply chains have become increasingly vulnerable to disruptions due to their growing complexity and heightened exposure to external risks. These risks encompass geographic factors such as political instability, economic challenges like price volatility, and natural disasters.

For instance, the 2011 floods in Thailand disrupted global supply chains on an unprecedented scale, impacting nearly 10,000 factories, including major corporations like Honda, Canon, Sony, and Goodyear.

These companies were forced to cut production and suffered substantial revenue losses [1]. Beyond the direct effects on domestic manufacturing, the floods also severely affected overseas manufacturers, who faced raw material shortages due to disrupted transportation and infrastructure systems. Transportation is particularly critical for industries heavily reliant on large supplier networks, such as automotive, electronics, and aviation.

Similarly, the 2011 earthquake and tsunami in Japan caused widespread disruptions across global supply chains, including in the automotive and retail sectors in the UK [2]–[4]. According to [5], Nissan was forced to halt production at its Sunderland plant in the UK for three days due to a shortage of engine parts supplied by a Japanese partner located in the earthquake-affected region. Multi-tier supply chains, such as those in the automotive and aviation industries, are particularly vulnerable to such disruptions. For example, an automaker may have multiple plants worldwide and rely on over 10 tiers of suppliers, involving approximately 1,500 companies per tier spread across more than 5,000 locations globally [1].

Designing resilient supply chains that can recover from disruptions quickly and cost-effectively presents a formidable managerial challenge. The examples of supply chain disruptions discussed above underscore the critical need for resilience. A reliable and resilient supply chain minimizes business operation discontinuity and mitigates the risk of losing market share during disruptions. Moreover, the interdependencies between suppliers and manufacturers highlight the necessity of adopting a holistic approach to supply chain resilience. Disruptions that impact a supplier often propagate downstream, affecting manufacturers and other entities. A central challenge in building resilient supply chains lies in understanding the effects of various proactive and reactive mitigation strategies and efficiently allocating resources both before and after disruptions occur. To minimize the likelihood and impact of disruptions, it is essential to quantify supply chain resilience and evaluate how different mitigation strategies influence overall robustness. This paper seeks to address this challenge by developing Bayesian Network (BN) models capable of quantifying and enhancing the resilience of two-echelon supply chains comprising buyer and supplier entities.

These models evaluate the reliability and resilience of supply chains under both single and multiple correlated disruptions, providing decision-makers with valuable insights into designing and managing resilient supply chains.

II. LITERATURE REVIEW

Different definitions have been proposed by scholars to define Supply Chain Resiliency (SCR). For example, Poins and Koronis defined SCR as the ability to return to its original status under emergency risk environments [6]. Hosseini et al. presented a definition of SCR based on the notion of resilience capacity, defining it as the capability of the SC to utilize absorptive capacity to

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withstand the turbulence of disruption and minimize the consequences by utilizing adaptive and restorative capacity with minimal restoration cost [7]. A comprehensive review of SCR definitions can be found in [7]. Although there is no unique definition for SCR, some commonalities can be observed, such as absorptive capability prior to disruption and restoration capability afterward.

There is growing interest in the literature on SCR, but most existing works examine SCR from a qualitative perspective. For example, many research efforts have identified and discussed enablers of SCR such as information sharing between SC entities, collaboration, excess backup inventory, SC visibility, connectivity, and robustness. Recently, more focus has been placed on the quantitative aspects of SCR. For example, in [8], BN was used to evaluate and select resilient suppliers. Similarly, [9] utilized BN to analyze the resilience capacity of inland waterway ports under different disruption scenarios. In [9], a mixed integer programming model was developed to find optimal demand allocation in the presence of disruption risk. Although resilience was not directly measured, the model incorporated drivers of SCR like backup suppliers and multiple sourcing. A BN-based framework to measure the resilience of a sulfuric acid manufacturer was proposed in [9]. Structural equation modeling was used in [8] to examine dependencies between SC capabilities, risk, and resilience, revealing that tighter integration and greater flexibility enhance resilience. Barriers to SCR were measured using Grey clustering and VIKOR in [9]. A graph-based model developed in [9] measured structural redundancy in terms of disrupted manufacturing plants and lost material capacity.

The SCR of a manufacturer was assessed using control theory in [9], which employed the integral of time absolute error to quantify inventory and shipment rate losses. The interface between SCR and sustainability was explored through discrete-event simulation in [10], focusing on the ripple effects of disruptions. A redundancy network optimization model proposed in [10] integrated sustainable resource use and SCR. Control theory methods were also applied for structural-operational design. An adaptive framework to enhance SC decision-making efficiency, consistency, resiliency, and sustainability was proposed in [11]. The role of ICT in building resilience across six industries was examined in [11]. Lastly, [12] proposed a data-driven decision support system using simulation and machine learning for resilient supplier selection, leveraging smart manufacturing data to predict supplier disruption proneness and SC impact.

III. THEORY OF BAYESIAN NETWORK (BN)

BN is a directed acyclic network topology that consists of set of arcs and nodes, in which each node represents a variable (attribute in this study) and each arc represents the dependency between two variables. Without loss of generality, let's denote a directed acyclic graph by G, where V and E represent set of nodes and arcs respectively. An arc from node X to Y encodes an assumption that there is an influential dependence or a direct causal of X on Y; the node X is called to be parent of Y, and node Y is called to be child of X. Each node has an associated probability table, called conditional probability table (CPT). The CPT of a node Z is the probability distribution of Z given the set of parents of Z. For a node Z without any parents, the CPT can be simply the prior probability distribution of Z.

Let's assume that a BN contains *n* variables . The chain rules of joint probability distribution can be represented as follows:

$$P(X_1, X_2, \dots, X_n) = P(X_1|X_2, X_3, \dots, X_n)P(X_2|X_3, \dots, X_n) \dots P(X_{n-1}) \quad (1)$$

The Eq. (1) can be rewritten as shown in Eq. (2).

$$P(X_1, X_2, \dots, X_n) = \prod_{i=1}^{n} P(X_i|X_{i+1}, \dots, X_n) \quad (2)$$

Eq. (2) can be further simplified by knowing the parents of each node. For example, if we know that and are the parents of , then the joint probability distribution of , can be substituted with . Now, let's assume that denote the parents of node , the full joint probability distribution of BN can be represented as:

$$P(X_1, X_2, \dots, X_n) = \prod_{i=1}^{n} P(X_i|Parents\ (X_i)) \quad (3)$$

Let's consider the BN model illustrated in Fig. 1 with 5 nodes. The full joint probability distribution of this BN is as follows:

$$P(X_1, X_2, X_3, X_4, X_5) = P(X_1)P(X_2|X_1)P(X_3)P(X_4|X_2, X_3)P(X_5|X_4) \quad (4)$$

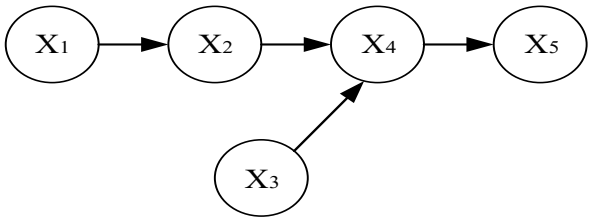


Fig 1. An illustrative example of BN model with 5 nodes.

Marginalization technique can be used to extract the probability of each individual node. For example, the probability of node can be calculated as follows:

$$P(X_2) = \sum_{X_1, X_3, X_4, X_5} P(X_1)P(X_2|X_1)P(X_3)P(X_4|X_2, X_3)P(\quad (5)$$

The global joint probability given in Eq. (5) can be simplified by marginalizing local CPT as below:

$$P(X_2) = \left(\sum_{X_1} P(X_1)P(X_2|X_1)\left(\sum_{X_4}\left(\sum_{X_3} P(X_4|X_2, X_3)P(X_3)\left(\sum_{X_5} P(X_5|X_4)\right)\right)\right)\right)$$

To demonstrate the application of BN, let's consider a simple BN with three nodes: distributor, manufacturer

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1 and manufacturer 2 nodes (parent nodes). As shown in Fig. 2, the distributor node is conditioned on manufacturer 1 and manufacturer 2 nodes whereas each node has two states of operational or disrupted, meaning that the functionality (operational/disrupted states) of distributor depends on functionality of its manufacturers.

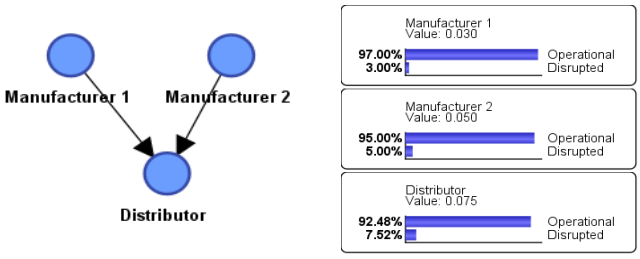


Fig 2. A simple BN with two nodes of manufacturers and a single distributor node and their corresponding distribution probability.

As shown in Fig. 2, the prior disruption probability of manufacturer 1 and manufacturer 2 is 3% and 5% respectively, meaning that there is 3% and 5% chance that manufacturers 1 and 2 fail to supply the finished products to the distributor. The conditional probability table (CPT) of distributor given disruption and operational probabilities of each supplier are represented in Fig. 3. For example, the probability that distributor is being disrupted is 0.75 given that manufacturer 1 and manufacturer 2 are disrupted and operational respectively. The posterior distribution probability of distributor node is calculated based on the conditional probability table (CPT) of distributor and prior probability of two manufacturers as shown in Eq. (7).

TABLE 1. CONDITIONAL PROBABILITY TABLE (CPT) OF DISTRIBUTOR NODE.

Mfg. 1	Operational		Disrupted	
Mfg. 2	Operational	Disrupted	Operational	Disrupted
Distributor Operational	0.98	0.3	0.25	0.01
Distributor Disrupted	0.02	0.7	0.75	0.99

IV. PROPOSED ROBUSTNESS AND RESILIENCE METRICS

In this section, we propose metrics for measuring the robustness and resilience of suppliers and manufacturers with respect to contingency and mitigation strategies. In the supply network, the causal relationship is interpreted as: disruption at x is a direct cause for disruption at y. We assume that the company downstream the supply network will not cause a disruption upstream. This is consistent with typical supply networks, where materials flow from upstream to downstream. It is also assumed that there are no return flows and recycle is not allowed as cycles are not permissible in BNs.

3.1. Metric for measuring robustness of supplier

Robustness of a supplier is defined as the capability of that supplier to withstand against any type of disruption (e.g., local and global disruptions) by pre-positioning sufficient inventory prior disruption occurs. Local disruptions are specific ones that are restricted to each individual supplier. For example, earthquake and fire are considered to be two local disruptions for suppliers who are located in California as those disruptive events are among most natural disasters in California, but hurricane
is considered to be the main natural disaster for the suppliers who are in the south coast of US like New Orleans, LA. The global disruptions are those types of disruptions that globally impact all suppliers regardless of their location and operations such as economic collapse, inflation rate, etc. [12]. Both types of disruptions are considered in the robustness and resilience modeling of suppliers. A different version of this paper is presented at the IMHRC conference [13].

To measure the robustness of supplier, let us define the notations below:

i	Set of suppliers,
j	Set of manufacturers,
g	Set of global disruptive events,
l	Set of local disruptive events,
	Pre-positioned capacity of supplier i
	Quantity of products ordered to supplier i by manufacturer j
	Binary variable which takes value of 1 if local disruption type l occurs on supplier i, and 0 otherwise
	Binary variable which takes value of 1 if local disruption type l occurs on manufacturer j, and 0 otherwise
	Binary variable which takes value of 1 if global disruption type g occurs, and 0 otherwise
	Restoration capacity of supplier i which will be implemented aftermath of disruption
	Restoration capacity of manufacturer j which will be implemented aftermath of disruption
	Demand required by manufacturer j

Let denote the robustness of supplier i and assume that supplier i can be disrupted due to any local and global disruptive event. The can be calculated as follows:

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$$R(s_i) = \sum_{\omega_{il},\beta_g \in \{0,1\}} P(Z_i > w_{i1} + w_{i2} + \cdots w_{iJ} | \omega_{il}, \beta_g, \forall l \in L_i, \forall g) \times P(\omega_{il} = \psi_{il}, \forall l \in L_i) \times P(\beta_g = \psi_g, \forall g) \quad (8)$$

where, $\psi_{il} = \begin{cases} 1, & \text{if local disruptive event type } l \text{ occurs on supplier } i \\ 0, & \text{otherwise} \end{cases}$

$\psi_g = \begin{cases} 1, & \text{if global disruptive event type } g \text{ occurs} \\ 0, & \text{otherwise} \end{cases}$

and is the set of local disruptions impacting supplier *i*. Let's consider the BN illustrated in Fig. 3(a), in which two suppliers are impacted by both local and global disruptions. In this figure, both suppliers are impacted by global disruption type 1 ($g1$), supplier 1 is impacted by two local disruptions and where the occurrence of is conditioned on the occurrence of . Finally, the second supplier is conditioned on its local disruption and global disruption as well. Let's assume that supplier 1 (must meet the orders that receive from three manufacturers, and represent the quantity of orders that are placed to supplier 1 by manufacturers 1, 2 and 3 respectively. The robustness of the supplier 1, can is calculated by Equation (9):

$$(s_1) = \sum_{\omega_{11},\omega_{13},\beta_1 \in \{0,1\}} P(Z_1 > w_{11} + w_{12} + w_{13} | \beta_1 = \psi_1, \omega_{11} = \psi_{11}, \omega_{13} = \psi_{13}) \times P(\beta_1 = \psi_1, \omega_{11} = \psi_{11}, \omega_{13} = \psi_{13})$$

V. SIMULATION RESULTS

In this section, we show how the proposed metrics, discussed in Section IV, can be applied to a two-echelon SC with a set of suppliers and a single manufacturer. To demonstrate the applicability of proposed metrics, let's consider the BN depicted in Fig. 3(b) with three types of nodes; set of suppliers, set of disruptions (global and local), and a single manufacturer. In this figure, the first supplier (is impacted by two local disruptions (hurricane and labor strike) and a global disruption (economic collapse). The second supplier (is conditioned by two local disruptions (earthquake, tsunami) and a global disruption. It is notable that the occurrence of tsunami depends on the occurrence of earthquake. The disruption of Mfg. 1 depends on its local disruption (fire), global disruption (economic collapse), and disruption of suppliers 1 and 2 (.

It should be highlighted that the distribution probability of suppliers and manufacturer is calculated using CPT in a similar way that is demonstrated by Equation (1). For example, supplier 1 is conditioned on three nodes (two local disruptions (hurricane and labor strike) and a global disruption (economic collapse). The CPT of supplier 1 requires entries (three disruption nodes and supplier 1 node). The number of CPT entries could exponentially increase when the number of local and global disruption increases. As such, it is difficult if it is not possible to model the CPT for suppliers and manufacturer with many parent nodes. Instead, we used noisyOR approach that can be used instead of CPT.

The BN capture causal relationships between disruptive events and supply chain (SC) entities, offering a robust method for managing risks under uncertainty. Using conditional probabilities, the model evaluates supplier robustness based on their ability to meet manufacturer demand through normal capacity or pre-positioned inventory (mitigation strategy) under local and global disruptions. Resilience further accounts for restoration capacity (contingency strategy) beyond static buffers. The framework also models interdependencies among disruptive events. Through BN inference, supplier performance is simulated under scenarios such as demand surges, helping SC managers quantify vulnerabilities, anticipate disruption impacts, and strengthen resilience strategies.

Disruption and demand fluctuation modeling

This sub-section aims to analyze the impact of different disruption scenarios on the probability of suppliers to meet the demand of manufacturers. Here, three scenarios are defined. Scenario 1, where the probability of disruption associated with supplier 2 being occurred is changed from 3% in the baseline model (Fig. 3.b) to 65.79%. Under this scenario, the probability that supplier 2 meets the demand of manufacturers 2 and 3 reduces from 96.12% in baseline model to 33.90%. In scenario 2, we are interested to see how the distribution probability of variables should change if supplier 1 aims to fully meet the demand of all manufacturers. As such, we set the probability of "satisfied" state of "satisfied node to 100%, assuming that supplier 1 satisfies the demand of manufacturers by 100% and propagate the impact of this observation by updating the marginal distribution probability of all other unobserved variables. Finally, scenario 3 refers to the case which estimates the likelihood that suppliers 1 and 2 can meet the demand with respect to potential functions on demand variable. In this scenario, we make an observation by assuming that the mean of demand of manufacturer 2 is increased from 38.07 in baseline model (Fig. 4) to 55 (Fig. 5). Under this scenario, the probability of satisfying demand by suppliers 1 and 2 reduce from 93.04% and 96.12% (Fig. 4) to 90.31% and 94.96% (Fig. 5), respectively.

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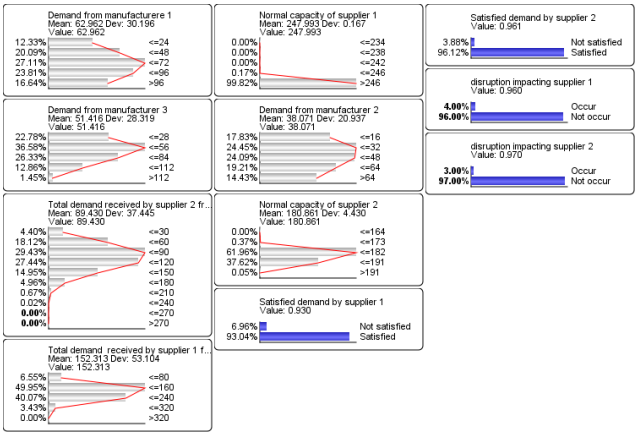


Fig 4. The distribution probability of BN variables shown in Fig. 3(b).

VI. CONCLUSIONS

This paper introduces Bayesian Network (BN)-based metrics to measure the robustness and resilience of suppliers and manufacturers. BNs capture causal relationships between disruptive events and supply chain (SC) entities, making them effective for modeling risks under uncertainty. Supplier robustness is defined by the ability to meet manufacturer demand using normal operational capacity or pre-positioned inventory (mitigation strategy) under local and global disruptions. Resilience extends beyond inventory by incorporating restoration capacity (contingency strategy). The model also captures interdependencies among disruptive events. Using BN inference, we simulate supplier performance under scenarios such as demand surges to evaluate the ability to sustain service levels. The proposed framework enables SC managers to quantify vulnerabilities, assess disruption impacts, and design effective mitigation and contingency strategies.

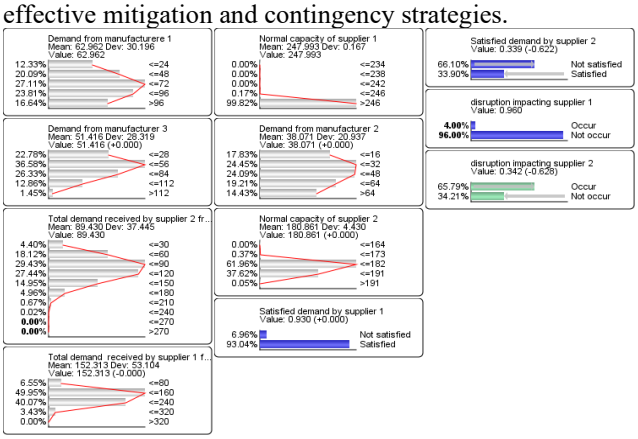


Fig 5. The distribution probability of BN in Fig. 3(b) under scenario 1.

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Transforming Private Universities in Bangladesh into Research Driven Institutions: Barriers, Opportunities, and Strategic Pathways

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Abstract- **Academic research is crucial for creating knowledge, driving innovation, and supporting national growth. This study investigates the barriers, opportunities, and strategies for supporting sustainable research in private universities. It uses a mixed-methods approach that includes interviews with university leaders, faculty, staff, and policy experts, along with a survey of academic staff from various institutions.**

The findings show several significant challenges: low funding, no clear research policies in institutions, high teaching loads, and little professional development. There is also a weak connection to national priorities, along with a lack of infrastructure and incentives. However, there are emerging opportunities. More early-career faculty and students are showing interest in research. Digital platforms, global collaboration, and visionary leadership can help integrate research into university missions. The study suggests that increasing investment in faculty development, creating strong institutional frameworks, and enhancing industry-academia partnerships can help transform private universities into important contributors to Bangladesh's knowledge-driven future.

Keywords- **Faculty development, research barriers and opportunities, sustainable academic research.**

I.INTRODUCTION

Academic research is the foundation of higher education. It drives knowledge creation, technological progress, and socio-economic development. Around the world, universities are seen as centers of innovation and contributors to national growth. In Bangladesh, private universities have quickly increased access to higher education since they started in the early 1990s. However, their ability to produce impactful and lasting research is still limited compared to public universities.

Several challenges hold back research productivity in private universities. These include inadequate funding, limited research facilities, heavy teaching and administrative loads, and a lack of clear research policies. Additionally, weak connections with national research priorities and industry make it harder for them to create knowledge that supports development goals.

Despite these challenges, there are opportunities. Growing research interest among early-career faculty and students, the availability of digital tools, the possibility of global

collaboration, and strong leadership can help improve research capacity.

Around the world, academic research is acknowledged as a foundational pillar of university performance. Research does not only make innovation but also raise institutional reputation, draw global collaborations, and contribute directly to community development [1]. The combination of research with teaching ensures that curricula remain vibrant and reflective of emerging knowledge frontiers [2]. For developing countries like Bangladesh, strengthening research within universities is necessary to deal with local challenges—from public health and education to environmental sustainability and business-industrial development.

After the Private University Act rolled out in 1992, Bangladesh has witnessed a rapid proliferation of private universities. As of 2025, there are over 110 private universities, educating more than 60% of the country's tertiary-level students. Despite this growth, critics say these institutions are prioritizing enrollment-driven revenue models over research investments [3]. Several studies have pointed to poor research infrastructure, the absence of an institutional research plan, and regulators who look the other way [4]. A broader review of literature across South Asia and Sub-Saharan Africa reveals a general limitation on sustainable academic research in the private higher education sector. These include inadequate research funds, poor or no policy frameworks, low faculty inspiration due to lack of incentives, and minimal collaboration between academic circles and industry [5]. In many cases, research activities are performed as isolated initiatives by individuals rather than as part of an articulate institutional plan.

Despite these challenges, emerging literature also highlights opportunities for transformation. The digital age has made it unthinkingly easy to team up for low-cost research collaboration and data collection [6]. The international financial support organization and intellectual society are increasingly investing in South-South and North-South research with joint ventures. In addition, new generations of faculty, many of whom studied abroad or
were exposed to global research customs, are showing strong interest in
integrating research into their academic identity. These improvements propose that with appropriate strategic support, private universities in Bangladesh could represent their position in national development through research.

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This paper looks at the barriers, opportunities, and strategies for turning private universities in Bangladesh into research-focused institutions. It uses a mixed-methods approach that combines qualitative and quantitative analysis.

II. METHODOLOGY

To explore the barriers, opportunities, and pathways for sustainable academic research in private universities in Bangladesh, this study uses a mixed-methods research design. This method combines qualitative insights and quantitative evidence, which improves the validity and applicability of the findings.

A. Research Design

The study combines qualitative data collected through semi-structured interviews with university administrators, senior faculty members, and policymakers, along with quantitative data gathered through structured surveys administered to academic staff in selected private universities. This design allows for data triangulation and offers a multi-dimensional view of the institutional, structural, and policy-related challenges and opportunities.

B. Sampling Strategy

A purposive sampling method selected participants from ten private universities in Bangladesh. Institutions were chosen based on: age (established versus newer universities), Research activity (based on UGC annual reports [7] and institutional websites) and willingness to participate in the study. The participants included 15 administrators and policy experts (e.g., vice-chancellors, deans, directors of research), 25 faculty members from various disciplines for qualitative interviews, and 100 survey respondents (academic staff from diverse departments)

C. Data Collection Tools

Data was collected through interview guide covered topics such as institutional research strategy, challenges faced, leadership engagement, funding mechanisms, and collaboration initiatives. Survey Questionnaire included Likert-scale items on research infrastructure, teaching workload, funding access, training/professional development, attitudes toward research and incentives and barriers. The survey was given both online and in person.

D. Data Analysis

Qualitative data was analyzed using thematic analysis, which allows patterns and insights to emerge from interview transcripts. Codes were created both deductively (from literature) and inductively (from data). Quantitative data were analyzed using descriptive statistics, correlation analysis, and inferential techniques to validate and complement the qualitative findings. SPSS software processed statistical data.

E. Limitations

The study offers valuable insights, including its limitations, such as, non-random sampling, which may affect applicability, self-reported data, which may present
response bias, focus on urban institutions, potentially excluding rural perspectives. Despite these limitations, the study provides a strong foundation for understanding the complex dynamics of research sustainability in the private university sector of Bangladesh.

III. RESULTS

This section shares the findings from interviews and surveys. The information is organized around the main themes of barriers, opportunities, and strategic pathways for research development in private universities.

TABLE I
KEY BARRIERS TO RESEARCH IN PRIVATE UNIVERSITIES

S. L	Barrier	Frequency (%)	Interpretation
1	Inadequate funding	78	Major constraint across most institutions.
2	Lack of institutional policies	65	Weak research governance.
3	Heavy teaching workload	72	Limits faculty time for research.
4	Limited professional development	58	Insufficient training and mentorship.
5	Weak alignment with national priorities	60	Research often disconnected from policy goals.

Source: Survey instrument
Notes: Data has been compiled by the researcher

Distribution of research interest among faculty

The distribution of research interests shows clear generational differences. Early career faculties are more engaged in research, with most reporting high or moderate interest. In contrast, senior faculties show lower levels of research involvement. This trend highlights the need for specific initiatives to build capacity and support the research potential of younger academics.

The qualitative interviews supported these findings. For example, one faculty member noted, "*Our teaching load is so heavy that pursuing meaningful research becomes almost impossible*." Similarly, policy experts highlighted the absence of clear institutional frameworks to guide research agendas.

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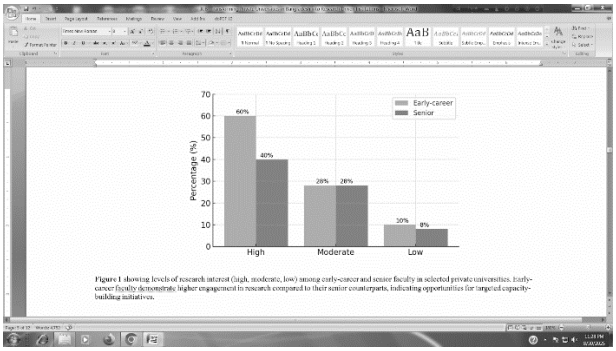


Fig. 1. Distribution of Research Interest among Faculty

Figure 1 Showing levels of research interest (high, moderate, low) among early-career and senior faculty in selected private universities. Early career faculty show more engagement in research than their senior counterparts. This indicates opportunities for targeted capacity-building efforts.

TABLE II
EMERGING OPPORTUNITIES FOR RESEARCH DEVELOPMENT IN PRIVATE UNIVERSITIES

S.L	Opportunity	Frequency (%)	Interpretation
1	Growing interest among early-career faculty	70	Younger academics show higher motivation for research.
2	Student engagement in research	55	Increasing participation in research projects.
3	Digital platforms and resources	62	Online tools enabling access to research materials and collaboration.
4	International collaborations	48	Partnerships with foreign universities and organizations are expanding.
5	Visionary institutional leadership	40	Some leaders actively integrating research into missions

Source: Survey instrument
Notes: Data has been compiled by the researcher

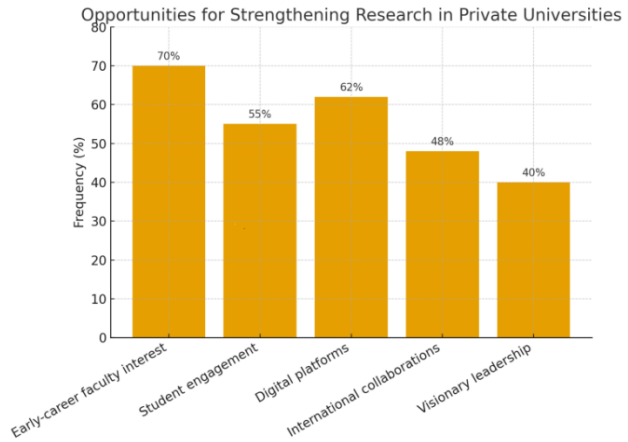


Fig.2. Opportunities for Strengthening Research in Private Universities

A simple clustered chart can show how often each opportunity occurs. This adds to the barriers figure and provides a clear comparison of constraints and possibilities.

This figure shows the relative frequency of emerging opportunities in private universities.

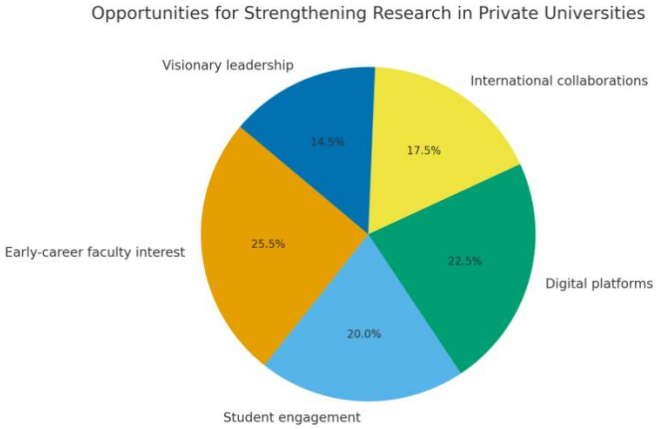


Fig. 3. Opportunities for strengthening research in private universities

A simple clustered bar or pie chart can show how often each opportunity occurs.

TABLE III
CORRELATIONS BETWEEN INSTITUTIONAL VARIABLES AND RESEARCH OUTCOMES

Variable Pair	Correlation Coefficient (r)	Interpretation
Research infrastructure ↔ Faculty output	0.72*	Very highly positive
Leadership support ↔ Faculty motivation	0.65*	Highly positive
Teaching load ↔ Research productivity	–0.81*	Very highly negative
Access to professional development ↔ Research confidence	0.58*	Highly positive

*Indicate significance at 1% level
Source: Survey instrument
Notes: Data has been compiled by the researcher

These correlations strongly support the qualitative findings. For instance, the very high negative relationship between teaching load and productivity (r = –0.81) shows how excessive teaching responsibilities hurt research activity. Similarly, leadership support has a positive link with faculty motivation (r = 0.65), confirming that strong leadership is an important factor.

The findings suggest that, although structural challenges like underfunding, poor infrastructure, and high workloads are common, there is significant potential within the academic community. With focused policy support and strong leadership, private universities in

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Bangladesh can become research-driven institutions, making valuable contributions to national innovation and development goals.

IV. DISCUSSION

The findings of this study highlight a contradiction in Bangladesh's private higher education sector. While private universities have rapidly increased and now makeup the majority of university enrollment, their role in national research output remains limited. The following discussion places these findings within a broader context and examines ways to promote sustainable academic research in line with national and global priorities.

A. Interpreting Barriers in the Institutional Context

This study identifies systemic barriers similar to those reported in other parts of the Global South. Limited institutional research funding, heavy teaching loads and the absence of formal research strategies reflect earlier findings [5], [3] in Bangladesh. These challenges indicate a continuation of teaching-focused models in private higher education, where research is undervalued in terms of both resources and institutional culture.
The strong negative relationship between teaching loads and research productivity ($r = –0.81$) supports the idea that institutional priorities need to shift to prioritize research. Without implementing balanced workloads, private universities will struggle to fully contribute to the knowledge economy.

B. Aligning with Global and National Research Trends

Around the world, research focused on sustainability is increasingly important across various fields such as science, technology, social sciences, business, and humanities [8]. Bangladesh's National Research and Innovation Strategy also call for more involvement from private institutions in tackling local development challenges, including climate adaptation, urbanization, education reform, and industry innovation.

Even with supportive policies, a misalignment between institutional strategies and national research priorities limits private universities' participation. Few institutions currently have systems in place to connect national goals with practical research agendas. Bridging this gap is crucial for making meaningful contributions to sustainable research.

C. The Role of Visionary Leadership and Institutional Culture

Qualitative interviews and correlation data show the significant impact of effective leadership. Institutions led by research-focused administrators had higher faculty engagement, better use of funds, and more visibility in partnerships. These findings are consistent with Maringe and Sing [6], who emphasizes the role of leadership in fostering a research culture through policies, incentives, and capacity-building initiatives.
In Bangladesh, where institutional autonomy varies and external accountability is low, leadership plays a key role in prioritizing research. Promoting visionary leadership at all levels—departmental, faculty, and administrative—is essential for driving lasting institutional change.

D. Opportunities as Levers of Strategic Change

Despite many barriers, clear opportunities for change exist. Young faculty interest in research, access to digital platforms, and potential for international partnerships is "low-cost, high impact" chances that institutional leaders can exploit.

Moreover, collaboration between industry and academia is still underused but holds promise. With Bangladesh's expanding IT, textile, and agribusiness sectors, private universities can serve as research partners for sustainable industry innovation.

This discussion highlights that nurturing sustainable academic research in private universities calls for systemic change, strategic vision, and a robust culture of inquiry. By aligning institutional priorities with national goals, encouraging faculty involvement, and taking advantage of digital and international opportunities, the existing research gap can be closed. To help Bangladesh transition to a knowledge-based economy, private universities should change from being primarily teaching institutions into vibrant research driven institutions that meaningfully contribute to sustainable development.

V. RECOMMENDATIONS

To transform private universities in Bangladesh into lively research-driven institutions, a multi-layered approach involving institutional, regulatory, and collaborative strategies is needed. Based on the findings and analysis, the following recommendations are proposed:

A. Institutional-Level Recommendations

i. Develop and Implement Research Strategies

Each private university should create a clear institutional research strategy, outlining its research priorities, funding distribution, faculty engagement plans, and connection to national development goals. To establish research and innovation, strengthen current ones to oversee and support research activities.

ii) Reduce Teaching Loads for Active Research Faculty

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Policies should be introduced for balancing teaching and research that allocate qualified or research-focused faculty to have lighter course loads or less administrative duty. Research should include expectations in faculty evaluation and promotion processes.

iii) Strengthen Research Infrastructure

University should invest in necessary research infrastructure like access to journals, data analysis software, research labs, and collaborative platforms. Also encourage the use of digital tools, such as online databases, e-learning platforms, and cloud-based research tools.

iv) Establish Internal Research Funding Mechanisms

Universities should introduce competitive internal research grants, especially aimed at junior faculty and interdisciplinary projects. A specific portion of minimum percentage of the university's operational budget (e.g., 2–5%) should be reserved for faculty-led research and innovation.

v) Build a Research Culture

University should organize regular seminars, conferences, and research workshops to promote academic inquiry. Senior researchers should engage mentorship programs that connect with early-career academics.

B. National and Policy-Level Recommendations

i) Incentivize Private Sector Participation in National Research Programs

The University Grants Commission (UGC) and Ministry of Education should provide private universities to access public research funding, especially for projects related to Sustainable Development Goals (SDGs).

ii) Enhance Regulatory Support

The Private University Act should include required research performance indicators and incentives. Require universities to publish annual research reports and contribute to national research databases.

iii) Foster Capacity Building through Training Programs

Nationwide professional development programs (in partnership with public universities or international organization) should be focused on research methods, grant writing, publication ethics, and data management.

C. Collaboration and Industry Engagement

i) Strengthen Industry-Academia Partnerships

Universities should encourage collaborative research projects with the textile, technology, agriculture, and

pharmaceutical sectors, focusing on sustainable innovation. Dedicated university-industry liaison offices should be facilitating joint ventures, consultancy services, and internships.

ii. Promote International Research Collaboration

Universities should develop memorandum of understandings (MoUs) with foreign universities and research centers for joint publications, faculty exchanges, and virtual symposiums. Use global platforms to secure funding and expand academic networks.

These recommendations, if implemented thoughtfully, can transform private universities in Bangladesh from teaching-focused institutions to centers of research and innovation. By embedding research into their core missions, investing in capacity, and engaging with industry and global partners, these universities can make meaningful contributions to national development and global sustainability goals.

VI. CONCLUSION

This study has investigated the main hurdles, new chances, and ways to turn private universities in Bangladesh into sustainable research centers. The findings reveal serious structural issues, such as underfunding, poor institutional planning, and heavy teaching workload that have often pushed research to the background in the private sector. Still, the study points out strong reasons for change, such as growing research interest among young faculty, the rise of digital tools, and the potential for collaboration across sectors and internationally.

As Bangladesh shifts towards a knowledge-based economy, private universities need to change from just teaching to becoming centers for research and innovation. This change is essential for maintaining institutional credibility and competing globally. It also aligns with national development goals and the UN Sustainable Development Agenda.

This study reveals that transforming private universities in Bangladesh into sustainable academic research-driven institutions is possible, but it needs strategic investments, supportive policies, visionary leadership, and a long-term commitment to creating knowledge. If these steps are met, private universities in Bangladesh can play a significant role in the future of research and development.

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A Decade of Incentives: Cash Incentive Economic Impact on Bangladesh

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Abstract- **This study investigates the economic impact of Bangladesh's cash incentive programs between 2014 and 2024, focusing on their role in promoting exports and formal remittance inflows. Special emphasis is given to the 2% remittance incentive introduced in 2019 and the broader evolution of incentive policies as Bangladesh prepares for graduation from Least Developed Country (LDC) status in 2026. A mixed-methods approach is employed, combining a review of policy documents with a period-based comparative analysis of official economic data from the World Bank and Bangladesh Bank. The findings indicate that the 2% remittance incentive had a significant positive impact on remittance inflows, with an average growth rate of 16.41% during 2019–2021. While export growth was strongest during periods of incentive expansion, key economic ratios, such as export-to-GDP and remittance-to-GDP, generally declined over the decade. This suggests that while these sectors grew in absolute terms, they did not keep pace with overall GDP growth. The analysis concludes that while cash incentives have played a positive role, a strategic and well-planned transition to targeted, WTO-compliant support mechanisms is essential to ensure long-term competitiveness post-LDC graduation.**
Keywords- **Cash Incentives, Economic Policy, Export Performance, LDC Graduation, Remittance, Bangladesh.**

I. INTRODUCTION

1.1 Background and Context

Bangladesh has long utilized cash incentive programs as a central policy instrument to stimulate economic growth, boost exports, and encourage remittance inflows through formal banking channels. These incentives, which originated with a focus on a limited number of sectors, evolved significantly over the decade from 2014 to 2024, expanding to encompass 43 distinct products and sectors by 2024. The government's approach has been dynamic, adapting to changing economic conditions, shifting global market demands, and the nation's overall development trajectory. This period represents a critical juncture in Bangladesh's economic history, marked by major policy shifts, external shocks such as the COVID-19 pandemic, and the momentous preparation for its graduation from Least Developed Country (LDC) status in 2026.

As a policy tool, cash incentives are designed to make Bangladeshi exports more price-competitive in international markets and to provide a financial advantage that encourages workers abroad to use official banking channels for remitting money home, thereby bolstering foreign exchange reserves. An early example of this approach was the 5% cash incentive provided to export-oriented Ready-Made Garment (RMG) factories since 2008, which was instrumental in helping the sector become more competitive in emerging markets such as Russia, India, and China. As the economy grew, these policies expanded, but their long-term efficacy and sustainability have come under increasing scrutiny. The central question is whether these programs have succeeded in fostering genuine, self-sustaining economic competitiveness or if they have created a dependency on subsidies. This study examines the influence of these programs on key economic indicators, moving beyond simple growth figures to a more nuanced analysis of their relative importance in the broader economy over the last ten years.

1.2 Research Objectives

This study is designed to provide a comprehensive evaluation of Bangladesh's cash incentive framework. The primary objectives are to:

Document the evolution of cash incentive programs in Bangladesh from 2014 to 2024.

Analyze the impact of these programs on key macroeconomic indicators and ratios.

Evaluate the specific effectiveness of key measures, particularly the 2% remittance incentive introduced in 2019.

Assess the implications of the recent strategic policy shifts away from direct cash incentives in light of Bangladesh's impending LDC graduation.

Provide data-driven insights and policy recommendations for the future of economic support mechanisms as the nation enters a new economic phase.

II. LITERATURE REVIEW: INCENTIVE PROGRAMS TO ENHANCE EXPORT EARNINGS AND REMITTANCES

Foreign currency inflows act as a pivotal catalyst for any economy to flourish. The impacts of the financial inflows are positive and visible in the areas such as national development, poverty reduction, and economic stability. Two of the major sources of foreign currency inflows are exports and remittances, each of them has their own dynamics though. Exports are generally accepted to be a positive force for development not just they bring foreign currencies to a country, but its effects are multifaceted [17]. The proponents argue that the export increases competitiveness of local firms at international standards, enhance diversification and also it pushes for innovations and efficiencies [3]. From economists' point of view, exports are justified as it helps local firms to reach economies of scale [21]. However, evidence shows that firms, mainly small and medium sized, often lacks know-how of doing business globally, information about global

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markets, competencies to perform internationally and, last but not least, internal capabilities to understand and proceed for going global [18, 13, 2].

On the other hand, the discourse on remittances, which linked to migration, often take ambivalent stance [16]. The enduring fluidity of the polarizing argument encompasses between the implications of financial impacts and socio-economic repercussions resulted out of "brain drain"—an issue that raises concern of migration of skilled worker from developing countries to developed ones [23]. In light of socio-economic development, critics argue that the net benefit of remittances could be offset by the negative impacts of the brain drain. Apart from this issue, it is widely accepted that the remittance definitely plays a positive role for the development of an economy. To be specific, "Remittances can contribute significantly to local, regional and national economic development in migrant-sending countries and also play an instrumental role in reducing poverty as they flow mainly to poor and marginalized families" [24]. Particularly, it is more so for the developing nations where there are abundant human resources with high unemployment rate which defies the argument of "brain drain". In addition, in many cases, people migrate not for only economic reasons but for other forced situations such as civil unrest and political oppression. Whatever the reasons may be, proponents of migration suggest that often the migrants return to home country with new skills that may help their own economy to move forward at par with the concurrent global developing trends [15].

Globalization of firms definitely need resources, both human capital and financial. Actually, the performance of a firm depends on both internal and external factors and they are hardly alienated rather intertwined in a complex manner [22]. A synergy of the internal and external forces can enhance capacities of a firm for internationalization. There are different types of (both financial or non-financial) incentives are provided to firms and/or exporters and outgoing workers in order to enhance foreign currency inflows [7]. The financial incentives like cash incentives and tax exemptions are direct benefits that are provided to the foreign currency earners whereas, the non-financial benefits may take different forms starting from infrastructure development for export-oriented firms, curtail official bureaucracy, developing skilled workers for targeted sectors, enhance operational efficiency and guidance/advise/support to go global and also sustain in systematic fluctuating situation in the international market [28, 6]. Researchers and academicians have done extensive research and positive impacts of such interventions have unfolded out of their researches [27]. Munch & Schaur explored the impact of the service provided by the Danish Trade Council on startups. The parameter they studied are productivity, employment and value creation [22]. The results revealed that the firms that were provided support had higher chance to graduate as exporters than that of the controlled group. In similar vein, according to a study conducted by Atkin, Khandelwal, and Osman [1] found that the around 19% firms ended up as exporters among who were given an opportunity to be part of an international order. Lastly, a study showed that the chance of being an exporter is 2.5 times higher for the government incentive intervened firms compared to others [11].

With such background it is evident that there is growing effort from respective governments in enhancing foreign currency inflows from a range of sources, particularly for the developing nations [19, 15]. Incentive programs need substantial government budgets and they must be well justified. Thus, to optimize intervention in this paradigm, it is deemed important to understand the forces and dynamics of the foreign currency inflows [14, 8, 20]. As briefly mentioned above, the major forces are exports and remittances and, hence, their link to various government incentives needed to be explored in order to optimize strategies [13]. Many researchers have conducted such studies but, in many cases, it is reported that the results are ambiguous [10, 8].

Hence, it is of keen interest for many governments to know to what extent various export promotion incentives are effective. The government initiatives to enhance foreign currency inflows and their effectiveness for the Bangladeshi economy is still an under-researched area. Therefore, this study takes a modest attempt to explore government interventions and their effects in the Bangladeshi economy.

III. METHODOLOGY

3.1 Data Sources and Collection

The analysis presented in this report relies on a comprehensive review of secondary data from a variety of reputable sources. These include official policy documents, central bank circulars, and government announcements from the Government of Bangladesh (GOB) and the Bangladesh Bank (BB). Quantitative economic data was collected from reliable international and national sources, including the World Bank, the Bangladesh Bureau of Statistics (BBS), and the Export Promotion Bureau (EPB). These datasets provided the foundational time-series data for key indicators such as Gross Domestic Product (GDP), exports, imports, remittance inflows, and foreign exchange reserves for the period 2014 to 2023.

3.2 Analytical Framework

A mixed-methods approach was adopted to provide a thorough and multi-faceted evaluation. This framework combines a qualitative review of policy evolution with a robust quantitative analysis of economic performance.

The quantitative analysis employs two key methods:

Period-Based Comparative Analysis: The decade from 2014 to 2024 was divided into four distinct phases to assess the impact of major policy changes. These periods are:

Early Period (2014–2015): This phase serves as a baseline, representing the period before a significant expansion of the incentive framework.

Middle Period (2016–2018): This period is characterized by the initial expansion of cash incentives across a broader range of sectors.

Remittance Incentive Period (2019–2021): This phase is defined by the introduction of the landmark 2% remittance

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incentive and the economic disruptions caused by the global COVID-19 pandemic.

Recent Period (2022–2024): This final period reflects the strategic reduction of incentive rates and the government's formal preparations for LDC graduation.

Pre-Post Analysis: To specifically isolate the effect of the 2% remittance incentive, a comparative analysis was conducted on economic performance before and after its introduction in July 2019. This method allowed for a direct assessment of the policy's influence on remittance inflows and foreign exchange reserves.

In addition to analyzing absolute values, the study calculated and examined key economic ratios to provide a more comprehensive view of structural changes. These ratios, including Export-to-GDP and Remittance-to-GDP, assess the relative importance of these sectors to the national economy over time.

IV. RESULTS

4.1 Economic Performance Analysis (2014–2024)

An analysis of key economic indicators across the four defined policy phases provides a detailed picture of Bangladesh's economic journey over the last decade. The data reveals both the successes and limitations of the cash incentive programs.

Table 1: Key Economic Indicators by Policy Phase (2014–2024)

Period	Average GDP Growth Rate (%)	Average Export Growth Rate (%)	Average Remittance Growth Rate (%)	Average Forex Reserve Growth Rate (%)
Early Period (2014-2015)	6.31	4.64	7.75	12.11
Middle Period (2016-2018)	7.42	6.04	-0.37	4.37
Remittance Incentive Period (2019-2021)	6.18	-0.83	16.41	19.12
Recent Period (2022-2023)	6.44	6.73	3.72	-27.75

Source: World Bank, Bangladesh Bank, and author's calculations

GDP Growth and Overall Economic Trends

The data presented in Table 1 indicates that Bangladesh's GDP growth rate reached its peak during the Middle Period (2016–2018) with an average of 7.42%, a phase characterized by the expansion of cash incentives across multiple sectors. A slight dip to 6.18% occurred during the Remittance Incentive Period (2019–2021), which can be largely attributed to the profound global economic disruptions of the COVID-19 pandemic. Despite this external shock, the nation maintained a relatively robust growth rate compared to many other economies, suggesting a degree of economic resilience that may have been bolstered by the support programs. The subsequent recovery in the Recent Period (2022–2023) further highlights the economy's ability to adapt and sustain momentum, averaging 6.44% growth.

Export Performance

Export performance showed a similar pattern, with the strongest growth rates occurring in the Middle Period (6.04%) and the Recent Period (6.73%). The negative growth of -0.83% during the Remittance Incentive Period aligns with the timing of the global pandemic, which severely disrupted international trade and supply chains. When comparing the pre-incentive period (2014–2018) and the post-incentive period (2019–2023), export growth increased by 1.44 percentage points in the latter, a finding that suggests a positive correlation between the broader incentive framework and export performance. This strong recovery in the most recent years indicates that Bangladesh's export sectors, particularly the garment and textile industries which receive approximately 65% of the incentives, have demonstrated significant resilience, even amidst recent reductions in incentive rates.

Remittance Inflows

Remittance inflows exhibited a dramatic and direct response to the introduction of the 2% cash incentive in July 2019. Following a period of negative growth averaging -0.37% during the Middle Period (2016–2018), remittances surged to an average growth rate of 16.41% during the Remittance Incentive Period. The pre-post analysis confirms this, showing that remittance growth increased by a substantial 3.78 percentage points in the post-incentive period compared to the pre-incentive period. This clear causal link is a significant finding of this study. The effect of this policy is visually represented in the following figure.

Foreign Exchange Reserves

Foreign exchange reserves experienced their most rapid growth (19.12%) during the Remittance Incentive Period, a clear consequence of the increased formal remittance

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inflows. However, this positive trend was not sustained. The Recent Period (2022–2023) saw a significant decline in reserves, with an average growth rate of -27.75%. This sharp drop highlights the fact that while the remittance incentive was successful in boosting reserves in the short term, its positive impact was not sufficient to counteract broader macroeconomic pressures such as increased import costs and global economic instability.

4.2 Analysis of Key Economic Ratios

While absolute growth figures provide a useful measure of economic activity, analyzing key economic ratios offers a more profound understanding of the structural shifts and the relative health of different sectors.

Table 2: Trends in Key Economic Ratios by Policy Phase

Period	Average Export-to-GDP Ratio (%)	Average Remittance-to-GDP Ratio (%)	Average Debt-to-GDP Ratio (%)	Average Forex-to-GDP Ratio (%)
Early Period (2014-2015)	16.78	7.97	20.15	12.82
Middle Period (2016-2018)	15.52	6.03	18.88	13.01
Remittance Incentive Period (2019-2021)	11.89	6.82	19.15	11.75
Recent Period (2022-2023)	13.02	5.38	18.92	8.79

Source: World Bank, Bangladesh Bank, and author's calculations

Export-to-GDP Ratio

The data in Table 2 reveals a consistent downward trend in the Export-to-GDP ratio, which declined from an average of 16.78% in the Early Period to 11.89% in the Remittance Incentive Period. Although the ratio recovered slightly to 13.02% in the Recent Period, it remains significantly below the levels seen at the beginning of the decade. This trend is a critical finding because it indicates that while export values have grown in absolute terms, they have not kept pace with the overall growth of Bangladesh's economy. This demonstrates a structural shift where other sectors, possibly driven by domestic consumption or alternative forms of manufacturing, are growing at a faster rate. The cash incentive programs, while effective in boosting export volume, have not been potent enough to maintain the relative importance of exports to the national economy, suggesting limitations in their long-term ability to structurally reorient the economy towards a more export-centric model.

Remittance-to-GDP Ratio

The Remittance-to-GDP ratio exhibited a similar, though slightly different, pattern. It declined from 7.97% in the Early Period to 6.03% in the Middle Period, but experienced a partial recovery to 6.82% during the Remittance Incentive Period. This partial recovery confirms the short-term effectiveness of the 2% incentive in counteracting a pre-existing downward trend. However, the ratio subsequently declined again to 5.38% in the Recent Period, even with continued high absolute remittance inflows. This reinforces the conclusion that the incentive, while successful in capturing formal remittances, is not a complete solution for maintaining their relative importance in a rapidly diversifying and growing economy.

Forex-to-GDP Ratio

The Forex-to-GDP ratio remained stable or slightly increased in the early part of the decade but declined significantly in the Remittance Incentive Period and even more sharply in the Recent Period, plummeting to an average of 8.79%. This is a noteworthy finding because it presents a contradiction. The analysis of absolute values showed that foreign exchange reserves grew rapidly due to the remittance incentive, yet their importance relative to the overall size of the economy decreased. This reveals that the positive impact of the remittance incentive on reserves was ultimately overshadowed by other, more powerful macroeconomic forces. The report hints at this, noting factors like "increased import costs, global economic pressures, and currency fluctuations". The policy's success in one area (boosting remittances) was not enough to counter its failure in another (broader fiscal stability), highlighting its limitations as a singular tool for national economic management.

V. DISCUSSION

5.1 Efficacy of Cash Incentives and Economic Resilience

The data demonstrates that cash incentive programs, particularly the 2% remittance incentive, were not only effective in achieving their stated goals of increasing absolute remittance inflows and export volume but also served a crucial role in enhancing economic resilience. Despite the severe global disruptions caused by the COVID-

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19 pandemic, Bangladesh's GDP growth remained robust during the Remittance Incentive Period (2019-2021). The analysis shows that the 2% remittance incentive acted as a powerful counter-cyclical tool. By stimulating formal remittance channels, it provided a stable and growing source of foreign currency and liquidity that helped to buffer the national economy against the severe global trade shocks that were simultaneously impacting export performance. This suggests that the policy was not just about promoting growth but also about building a level of resilience in the face of an unprecedented external crisis.

5.2 Challenges and Limitations of the Incentive Framework

Despite their demonstrable successes, cash incentive programs are not without significant challenges and limitations. The original report notes several administrative hurdles, including bureaucratic complexity, delayed disbursements, and a lack of effective monitoring and evaluation mechanisms. The analysis of fraud data provides quantifiable evidence that these are not merely theoretical problems.

Table 3: Fraud/Incentive Percentage (2016–2021)

Year	Fraud / Incentive (%)
2016–2017	1.12
2017–2018	1.10
2018–2019	1.10
2019–2020	0.77
2020–2021	1.04

Source: Civil Audit Report 2017-18

The data in Table 3 shows a persistent, albeit small, fraud rate, which has remained consistently around 1% of total incentives disbursed. While this percentage may appear minor, when applied to billions of dollars in incentives, it represents a significant and ongoing financial loss. This consistency indicates a persistent systemic weakness in the monitoring and evaluation frameworks. A continued, consistent fraud rate justifies the need for the report's recommendations for streamlined administration and enhanced monitoring as a means to improve fiscal efficiency and program integrity, which will be critical in the post-LDC graduation era. Furthermore, the expanding scope of these programs has raised concerns about fiscal sustainability and the risk of creating a dependency among exporters, which could undermine long-term competitiveness and innovation.

5.3 Strategic Implications for Post-LDC Graduation

The analysis of the policy evolution from 2014 to 2024 demonstrates that Bangladesh is already in a period of strategic transition. As the country approaches LDC graduation in 2026, direct cash subsidies on export receipts will become non-compliant with World Trade Organization (WTO) rules. The government has already begun reducing incentive rates for many products and is planning alternative support mechanisms.

This move is not merely a legalistic reaction to an international trade rule; it signifies a fundamental shift in economic philosophy. The government's planned alternatives, which include an export promotion fund, low-interest loans, technical assistance for product development, and support for green energy units , are a more sophisticated and forward-looking approach. Instead of providing broad-based, short-term fiscal stimulus in the form of cash, these new policies are designed to directly address structural weaknesses in the economy. They focus on long-term development in areas such as technological innovation, sustainability, and human capital, which are the true drivers of competitiveness for a middle-income economy. The transition represents a move from providing a fishing pole to teaching a man to fish—a more sustainable strategy for a country aiming to become a middle-income economy.

VI. CONCLUSION

Cash incentive programs have played a significant and often positive role in shaping Bangladesh's economic landscape from 2014 to 2024. The analysis demonstrates their effectiveness in boosting absolute economic indicators, particularly in increasing formal remittance inflows following the introduction of the 2% incentive in July 2019. The policies also appear to have contributed to the economy's resilience in the face of external shocks, such as the COVID-19 pandemic.

However, the analysis of key economic ratios reveals that while these sectors grew in absolute terms, their relative importance to the national economy has generally declined over the decade. This indicates that the cash incentives, while successful on a micro-level, have not been a panacea for maintaining a more balanced, export-centric economic structure. The findings highlight the need for a strategic transition away from direct cash subsidies toward a more sustainable and effective framework for economic support.

Based on the evidence presented, the following policy recommendations are proposed:

Adopt a more targeted approach to incentives, focusing on sectors with high potential for growth, diversification, and value addition, rather than a blanket approach.

Simplify and streamline the administration of remaining incentives and new support mechanisms to reduce transaction costs for businesses and improve accessibility.

Strengthen monitoring and evaluation frameworks to assess the true impact of policies and enable evidence-based adjustments, thereby improving fiscal efficiency and reducing misuse.

Accelerate the development of WTO-compliant alternatives, such as the proposed export promotion fund, technical assistance programs, and infrastructure support to foster long-term competitiveness.

Maintain the successful remittance incentive given its demonstrable effectiveness, while also exploring complementary measures to further boost formal inflows.

Implement complementary reforms in areas such as trade facilitation, business environment, and innovation support

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to create a more conducive environment for export growth and economic development.

The success of Bangladesh's journey toward becoming a middle-income country will depend on its ability to navigate the challenges of LDC graduation by learning from the successes and limitations of the past decade. By adopting a strategic, forward-looking, and evidence-based approach to export promotion and economic support, Bangladesh can build a more diversified, resilient, and competitive economy for the future.

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Determinants of F-commerce Impulse Purchase in Bangladesh: Mediating Effect of Perceived Price Dispersion

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Abstract - **F-commerce has become an integral part of daily life in Bangladesh, providing a platform where customers and sellers interact in real time to buy and sell products. Here, businesses not only showcase their products but also interact with their customers in real time, breaking the barriers of time and place. To understand this growing platform's impact on F-commerce impulse purchase, we have designed this study. While prior studies have explored individual factors such as Facebook usage intensity, para social relationships, and others, the current study aims to fill that gap by examining the collective impact of multiple factors on impulse purchasing within F-commerce. The study investigates the collective impact of F-commerce through six predictor variables such as Facebook usage intensity, hedonic gratification, para social relationship, social interaction, social trust, and online vividness of product, alongside the mediating role of perceived price dispersion on impulse purchasing behavior. To collect data, the study uses a purposive sampling technique, which is appropriate as data were collected from 403 Bangladeshi users of F-commerce platform. The survey was conducted through a structured questionnaire and used structural equation modeling (SEM) approach to analyze data via SmartPLS 4.0. The results show that para social relationships, social interaction, and social trust have significant influence on impulse purchase, whereas Facebook usage intensity, hedonic gratification, online vividness of product, and perceived price dispersion do not. Moreover, perceived price dispersion does not mediate the hypothesized relationships. These results offer valuable implications for marketers, businesspeople, developers, as well as researchers in developing more effective strategies and creating new avenues for further research on this growing multipurpose platform.**

Keywords - **F-commerce, Impulse Purchase, Perceived Price Dispersion, Facebook, Hedonic Gratification.**

I. INTRODUCTION

F-commerce in Bangladesh has expanded with improved internet access, enabling real-time buyer–seller interaction and greater accountability than traditional e-commerce [1], [2]. Although early privacy and security concerns slowed adoption, mobile-friendliness and brand-page interactivity promoted acceptance and kept customers updated on product launches. This growth accelerated during the COVID-19 period amid movement restrictions and rising internet use [3]. Facebook now accounts for a large share of commercial activity: 66.7% of businesses reportedly use it, lowering entry barriers for youth entrepreneurship and empowering many women; around 30% of users shop there, valuing convenience and delivery, yet cumbersome returns, weak after-sales service, and concerns about product quality, payment security, and seller trust continue to impede loyalty [4], [5],[6]. As F-commerce becomes routine, usage intensity, vivid product presentations, para social ties, and hedonic gratification can amplify unplanned buying; brands deploy influencer-driven live streams, vlogs, and visually rich posts, while perceived price fairness and credible reviews help build trust and reduce uncertainty [2], [7], [8], [9].

Bangladesh's Facebook-based commerce is expanding quickly and operates year-round, including most weekends and holidays except major events like Eid. Yet trust challenges persist, and prior studies have focused more on general purchasing drivers than on impulse buying [6]. To address this gap, we examine how Facebook usage intensity, hedonic gratification, para social relationships, social interaction, social trust, and online vividness shape impulse purchasing, and test the mediating role of perceived price dispersion. Considering these factors together in the Bangladeshi context clarifies the mechanisms behind impulse buying and supports development of a more resilient F-commerce ecosystem.

Online shopping in Bangladesh is expanding as consumers increasingly research products online before visiting stores and use social platforms to track new items, features, trends, discounts, and prices [10], [11]. Although Facebook began as a communication tool, F-commerce now enables interactive buying and selling, and brands cultivate warm communities that encourage customer feedback [12]. A youth-heavy user base engages socially and commercially while algorithms surface interest-aligned content, enabling personalized ads that elicit positive emotions and, together with vivid product presentations, can trigger impulse purchases [13], [14], [15]. Therefore, this study examines how these dynamics shape F-commerce impulse purchasing and provides guidance for marketers designing strategies suited to local user behavior.

The objective behind this study is to provide understanding of different factors which influence F-commerce impulse purchase, as well as to determine the perceived price dispersion mediating effect on F-commerce impulse purchase.

F-commerce has become an integral part of the online shopping landscape. Previous studies have shown that usage intensity positively affects impulse buying behavior [2]. The interactive nature of the platform allows buyers and sellers to engage directly, which creates hedonic gratification and influences impulsive purchasing [8], [16]. The same study also found that the impulse purchase

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behavior can be influence by para social relationship, social interaction, social trust. Zafar et al. [8], also noted that online vividness has a significant influence on consumers' impulse buying behavior. In another study, Chen & Ku [7] examined the moderating effect of perceived price dispersion on impulse buying.

Although these studies have investigated individual variables, no research has collectively analyzed these key factors or examined their combined effect on impulse purchases within F-commerce. To address this gap, the present study considers six independent variables, namely Facebook usage intensity, hedonic gratification, para social relationships, social interaction, social trust, and online vividness of products, as well as one mediating variable, perceived price dispersion.

II. LITERATURE REVIEW AND DEVELOPMENT OF CONSTRUCTS

a. Theoretical Background

The present study adopts the Stimulus-Organism-Response (SOR) paradigm to identify the factors of f-commerce impulse purchase. The original framework introduced by Mehrabian and Russel (1974), Under this model it judges how consumer external stimuli can influence their internal evaluation and ultimate drive their response to it [2], [17], [18]. This is particularly suited for assessing customer behavior in an online commerce environment. In the stimulus (S) part they process those stimuli. In the organism (O) part they customer they decide behavioral action [19]. In the context of F-commerce, factors such as Facebook usage intensity, hedonic gratification, para social relationships, social interaction, social trust, online vividness of products, and perceived price dispersion are conceptualized as external stimuli. These variables impact users' internal evaluations and ultimately drive their impulse purchasing behavior. By utilizing the SOR paradigm, this research aims to clarify the pathways through which these determinants influence unplanned buying behavior in the dynamic environment of F-commerce [2], [20].

b. F-commerce Impulse Purchase (FIP)

Impulse purchase in F-commerce refers to unplanned, immediate buying on Facebook, driven by a sudden urge with little deliberation [21], [22]. Not every unplanned act is impulsive; for example, quickly buying a genuinely needed item forgotten from a list is not impulse buying [23]. In online settings, cues such as advertisements, promotions, scarcity, and social influence heighten the likelihood of impulse purchases [24]. Prior work distinguishes pure, reminder, suggestive, and planned-impulse forms [8]. The interactive, visually rich nature of Facebook commerce, reinforced by celebrities and influencers, further elevates these urges [2], [25]. In this study, FIP is treated as the dependent variable capturing spontaneous, unplanned purchasing on Facebook-based commerce.

c. Facebook Usage Intensity (FUI) and F-commerce Impulse Purchase (FIP)

Facebook usage intensity (FUI) captures how frequently and deeply users engage with browsing, posting, groups, and interactions, reflecting habitual and emotional attachment [2], [26], [27]. In F-commerce, higher FUI increases exposure to brand pages, shopping groups, discovery posts, and ads, amplifying marketing and peer cues that prompt unplanned purchases [2]. Frequent use also builds familiarity and comfort, making users more responsive to shopping stimuli; thus FUI is expected to raise the likelihood of impulse buying on Facebook [16], [28]. Based on these theoretical considerations and previous findings, the following hypothesis is formulated:

H1: Facebook Usage Intensity (FUI) has positive impact on F-commerce Impulse Purchase (FIP).

d. Hedonic Gratification (HG) and F-commerce Impulse Purchase (FIP)

Hedonic gratification (HG) is the pleasure, excitement, and enjoyment from browsing and interacting with Facebook shopping content. Positive affect shortens deliberation and heightens the urge to buy; vivid visuals, entertaining live streams, and playful interactions provide hedonic value that nudges spontaneous purchases [2], [14]. On Facebook, gamified promotions, personalized ads, and para social entertainment intensify HG, converting attention into unplanned buying [13], [15]. Consistent with prior work linking hedonic motives to online impulse purchasing, higher HG is expected to increase FIP in F-commerce [7], [8]. In light of these findings, the following hypothesis is proposed:

H2: Hedonic Gratification (HG) has positive impact on F-commerce Impulse Purchase (FIP).

e. Para Social Relationship (PR) and F-commerce Impulse Purchase (FIP)

Para Social relationship (PR) is the imagined bond with influencers or celebrities on Facebook [29], [30], [31]. In F-commerce, repeated exposure and interaction foster trust and identification with endorsers [8], [32]. Such ties heighten spontaneous buying, as followers respond more to emotional connection and perceived similarity than to expertise [33], [34], [35]. Endorsements, live sessions, and product demonstrations by digital celebrities further accelerate impulse purchases [36]. Accordingly, stronger PR is expected to increase FIP. Based on these considerations, the following hypothesis is proposed:

H3: Para Social Relationship (PR) has positive impact on F-commerce Impulse Purchase (FIP).

f. Social Interaction (SI) and F-commerce Impulse Purchase (FIP)

Social interaction (SI) refers to communicative processes on Facebook, including conversations, comments, group participation, opinion exchange, and live-stream engagement, through which users form ties with friends, peers, sellers, and communities, building trust and socioemotional support [37], [38]. These interactions create

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belonging and involvement that elevate spontaneous purchasing; peer advice, affirming feedback, and real-time recommendations raise perceived value and credibility, lower uncertainty, and stimulate unplanned buying in F-commerce environments [39], [40], [41]. Based on these considerations, the following hypothesis is proposed:

H4: Social Interaction (SI) has positive impact on F-commerce Impulse Purchase (FIP).

g. Social Trust (ST) and F-commerce Impulse Purchase (FIP)

Social trust (ST) is the expectation that others on the platform will act honestly, ethically, and reliably, creating confidence for interpersonal and transactional exchanges. In F-commerce this is critical because buyers often share personal information and purchase from unfamiliar sellers. ST develops through positive interactions, transparency, and perceived fairness, and is reinforced by trustworthy recommendations and group norms [42], [43], [44]. When ST is high, positive reviews, social proof, and supportive community feedback reduce perceived risk and encourage spontaneous purchases, while also fostering repeat interactions and loyalty [45], [46], [47]. Based on these considerations, the following hypothesis is proposed:

H5: Social Trust (ST) has positive impact on F-commerce Impulse Purchase (FIP).

h. Online Vividness of Products (OVP) and F-commerce Impulse Purchase (FIP)

Online vividness of products (OVP) is the richness and quality of digital product presentation, including clear images, engaging videos, detailed descriptions, and interactive media, which provide multiple sensory cues and help consumers visualize and evaluate items; on Facebook this includes high-resolution photos, live demonstrations, dynamic clips, and immersive multimedia [48], [49], [50]. Higher OVP captures attention and evokes emotion, fostering positive attitudes and quick, unplanned decisions; interactive features such as virtual try-ons, review videos, and testimonials enhance authenticity and desirability, reduce hesitation, and increase impulse purchasing in F-commerce [51], [52]. On the basis of the discussion, the following hypothesis is proposed:

H6: Online vividness of product (OVP) has positive impact on F-commerce impulse purchase (FIP).

i. Perceived Price Dispersion (PPD) and F-commerce Impulse Purchase (FIP)

Perceived price dispersion (PPD) is consumers' awareness that the same or similar products are offered at different prices by different sellers; in F-commerce, users often encounter and compare such differences across pages and groups [53]. PPD reflects both actual price gaps and subjective perceptions shaped by experience and platform information, guiding judgments of price fairness and competitiveness in multi-seller digital markets [7], [54]. PPD can influence impulse buying in two ways: wide gaps may prompt search and delay, whereas unusually attractive or limited-time prices relative to alternatives can trigger immediate, unplanned purchases; credible reviews and transparent seller information strengthen this effect by reducing uncertainty [9], [55]. Based on these considerations, the following hypothesis is proposed:

H7: Perceived Price Dispersion (PPD) has positive impact on F-commerce Impulse Purchase (FIP).

j. Mediating Effects of Perceived Price Dispersion (PPD)

In F-commerce, a mediating variable clarifies how or why an independent variable influences a dependent variable. Perceived price dispersion (PPD) can serve as a mediator by shaping the connection between predictors such as Facebook usage intensity, hedonic gratification, para social relationships, social interaction, social trust, and online vividness of products, and the outcome of impulse purchase behavior. When customers observe different prices for similar products across sellers, their perceptions of price fairness and value influence the impact these independent variables have on purchasing decisions [7].

PPD may either strengthen or weaken the effects of variables like social trust, social interaction, and product vividness by providing additional information that shapes consumer judgment. For instance, positive social interaction or vivid product displays may lead to impulse buying if the perceived price is considered fair or especially attractive in comparison to alternatives [9], [56]. On the other hand, even high levels of hedonic gratification or trust may not result in impulse buying if price dispersion causes doubt or uncertainty. Thus, PPD is expected to mediate the relationships between these independent variables and F-commerce impulse purchase, offering insight into the mechanisms driving unplanned buying behavior in digital commerce [57]. All the above research shows how Perceived Price Dispersion influences customer purchase along with elements of hedonic gratification, online vividness. here are designed hypothesis given below:

H8: Perceived Price Dispersion (PPD) mediates the relationship between Facebook Usage Intensity (FUI) and F-commerce Impulse Purchase (FIP).

H9: Perceived Price Dispersion (PPD) mediates the relationship between Hedonic Gratification (HG) and F-commerce Impulse Purchase (FIP).

H10: Perceived Price Dispersion (PPD) mediates the relationship Para Social Relationship (PR)and F-commerce Impulse Purchase (FIP).

H11: Perceived Price Dispersion (PPD) mediates the relationship Social Interaction (SI) and F-commerce Impulse Purchase (FIP).

H12: Perceived Price Dispersion (PPD) mediates the relationship Social Trust (ST) and F-Commerce Impulse Purchase (FIP).

H13: Perceived Price Dispersion (PPD) mediates the relationship Online Vividness of Product (OVP) and F-commerce Impulse Purchase (FIP).

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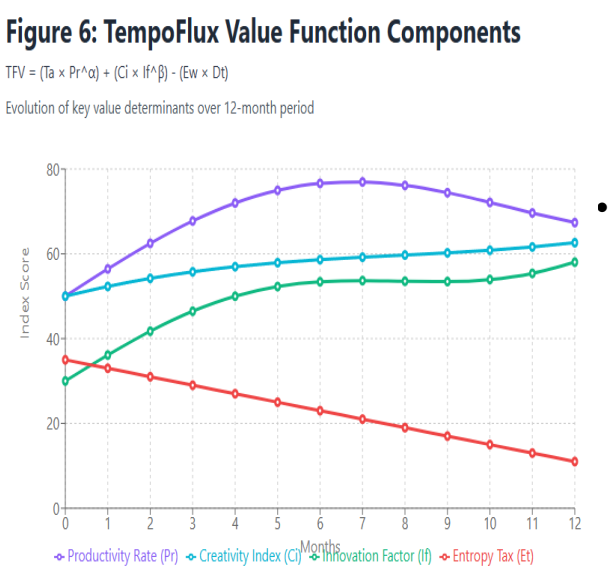


Fig. 1: Conceptual framework (source: Author's own work)

- RESEARCH METHODOLOGY

k. Data Sampling

The population comprised customers with experience shopping via Facebook-based commerce. Because the population size was unknown, we used purposive non-probability sampling to recruit respondents aligned with the study objectives. A structured, in-person questionnaire was administered. The final sample exceeds common benchmarks for SEM and is adequate for PLS analysis (Hair et al., 2017; Kline, 2023).

l. Measurement Instrument

All variables are measured with Likert scale type questions ranging from 1=strongly agree to 5- strongly disagree. In this study six independent variables have been taken, one mediating variable and one dependent variable. F-commerce usage intensity has 5 items adopted from the research paper [2]. Hedonic gratification has 5 items, which is adopted from several paper [8], [2]; [60]. Para Social relationship has 5 items adopted from [61]. Social interaction has 5 items adopted from [62]. Social trust has 5 items adopted from [8], [63]. Online vividness of product has 5 items adopted from Chen & Ku [7] and Wu et al. [64]. Price perceived Dispersion has 5 items adopted form Chen & Ku [7] and Wu et al. [64]. The dependent variable F-commerce impulse purchase was measured with 6 items these items were adopted from several previous research [2], [8], [39].

m. Data Analysis Technique

Data were analyzed using SPSS 25 for descriptive statistics and data preparation, and SmartPLS 4 to assess the measurement and structural models. The study employed PLS-SEM to test the hypothesized relationships and evaluate reliability and validity [58], and PLS-SEM is effective for applied multivariate analysis [65]. Analysis proceeded by first evaluating the measurement model, then the structural model to test hypothesized paths.

III. DATA ANALYSIS AND RESULTS

- *Respondent's Profile*

Among the 403 respondents, 72.2% were male and 27.8% female. The largest age group was 25–34 (51.1%), followed by 15–24 (31.3%), 35–44 (10.2%), 45–54 (5.2%), and 55+ (2.2%). Regarding education, 39.0% held a bachelor's degree and 30.5% a postgraduate degree, while 19.6% had HSC and 10.4% SSC. F-commerce experience was less than 1 year 22.1%, 1–2 years 21.3%, 3–4 years 24.1%, 5–6 years 16.6%, and more than 6 years 15.9%. Platform use frequency was very often for 36.0% of respondents, occasionally for 41.7%, and rarely for 22.3%. These demographic attributes suggested that sample is well-suited for accurately measuring the observed variables in the present study.

- *Measurement Model*

a. Convergent Validity

Convergent validity was assessed in Table 1 by examining item loading, Cronbach's Alpha (CA), Composite Reliability (CR), and Average Variance Extracted (AVE). Under the assessment of loading value ST1 value was less than 0.7 that's why the item ST1 is removed based on the standard criteria recommended by [66]. After the removal process, PLS algorithm generate AVE score higher than 0.50 for all the latent variables, which means the latent variables had sufficient convergent validity [66].The CR varied between 0.824 - 0.932, providing a positive reliability rate and the values are above the cut of value of 0 .70 [67], [68].Along with this CA value range between 0.822 - 0.888 which is higher than the standard value of 0.6 that proves the significant reliability of our measurement model.

TABLE 1
ITEM LOADING, CONVERGENT VALIDITY AND RELIABILITY

Constructs	Items	Loading	CA	CR	AVE
Facebook Usage Intensity (FUI)	FUI 1	0.722	0.866	0.879	0.653
	FUI 2	0.862			
	FUI 3	0.759			
	FUI 4	0.835			
	FUI 5	0.851			
Hedonic Gratification (HG)	HG 1	0.753	0.822	0.824	0.583
	HG 2	0.777			
	HG 3	0.781			
	HG 4	0.726			
	HG 5	0.780			
Para Social Relationship (PR)	PR 1	0.832	0.876	0.885	0.671
	PR 2	0.718			
	PR 3	0.845			
	PR 4	0.845			
	PR 5	0.847			

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Social Interaction (SI)	SI 1	0.826	0.888	0.889	0.690
	SI2	0.854			
	SI3	0.834			
	SI4	0.820			
	SI5	0.819			
Social Trust (ST)	ST 2	0.780	0.887	0.890	0.749
	ST 3	0.891			
	ST 4	0.906			
	ST 5	0.878			
Online Vividness of Products (OVP)	OVP1	0.787	0.878	0.879	0.673
	OVP2	0.800			
	OVP3	0.829			
	OVP4	0.852			
	OVP5	0.831			
Perceived Price Dispersion (PPD)	PPD1	0.837	0.874	0.878	0.666
	PPD2	0.808			
	PPD3	0.859			
	PPD4	0.749			
	PPD5	0.823			
F-Commerce Impulse Purchase (FIP)	FIP1	0.831	0.930	0.932	0.740
	FIP2	0.846			
	FIP3	0.902			
	FIP4	0.851			
	FIP5	0.868			
	FIP 6	0.861			

Source: Author's Own Work

b. Discriminant Validity

Following the assessment of convergent validity, which confirmed the internal consistency between items and their respective constructs, discriminant validity was evaluated to determine the extent the extent to which each construct is distinct from the others [69]. To examine the discriminant validity of the variables the study followed HTMT (Heterotrait-Monotrait) ratio [66]. The standard value for this examination has to be below 0.85 as recommended by [67], [68] and [70]. However, in some cases, the threshold value is suggested to be 0.90 [66], [71]. The variable's discriminant validity was quite satisfactory since the HTMT ratio of the variable (Table 2) topped the strict of cut-off below 0.85. This confirms that each construct is empirically distinct, and there no significant issues of multicollinearity or overlap among the variables.

TABLE 2
HETEROTRAIT-MONOTRAIT (HTMT) RATIO

	FIP	FUI	HG	OVP	PPD	PR	SI	ST
FIP								
FUI	0.561							
HG	0.454	0.763						
OVP	0.572	0.599	0.650					
PPD	0.313	0.454	0.525	0.642				
PR	0.641	0.720	0.676	0.573	0.313			
SI	0.633	0.663	0.669	0.668	0.460	0.737		
ST	0.764	0.691	0.554	0.725	0.337	0.713	0.691	

Structural Model

- Predictive Power of the Model

The benchmark value of R^2 is 0.75 indicates substantial, 0.50 indicates moderate, 0.25 indicates weak [66]. R^2 value for FIP is .539 indicating this independent variable explains 53.9% of the variance. Therefore, the R^2 for FIP reflects a moderate to substantial level of predictive accuracy. Another variable PPD R^2 value is .380, which also indicates moderate explanatory power.

- Result of Direct Path Analysis

The direct effects on FIP (Table 3) show that PR has a significant positive effect ($\beta = 0.179$, $p = 0.004$), SI has a significant positive effect ($\beta = 0.163$, $p = 0.013$), and ST is the strongest positive predictor ($\beta = 0.459$, $p < 0.001$). FUI ($\beta = 0.040$, $p = 0.549$), HG ($\beta = -0.069$, $p = 0.215$), OVP ($\beta = 0.045$, $p = 0.508$), and PPD ($\beta = 0.018$, $p = 0.704$) are not significant. These results confirm that PR, SI, and ST increase FIP, while FUI, HG, OVP, and PPD show no direct effect.

TABLE 3
RESULT OF DIRECT PATH ANALYSIS

H	Path	β	SD	T statistics	P values	Decision
H1	FUI → FIP	0.040	0.066	0.599	0.549	Rejected
H2	HG → FIP	-0.069	0.056	1.239	0.215	Rejected
H3	PR →FIP	0.179	0.062	2.889	0.004	Accepted
H4	SI→FIP	0.163	0.066	2.487	0.013	Accepted
H5	ST → FIP	0.459	0.062	7.414	0.000	Accepted
H6	OVP → FIP	0.045	0.068	0.661	0.508	Rejected
H7	PPD →FIP	0.018	0.047	0.380	0.704	Rejected

- Result of Indirect Path Analysis

The results of the indirect path analysis were examined to evaluate the mediating effects of PPD on the relationships between the independent variables and FIP. H8 (FUI → PPD → FIP, $\beta = 0.003$, $SD = 0.008$, $T = 0.350$ and $p = 0.726$) has no significant effect, H9 (HG →PPD → FIP, $\beta = 0.003$, $SD = 0.008$, $T = 0.336$ and $p = 0.737$) has no significant effect, H10 (PR → PPD → FIP, $\beta = -0.002$, $SD = 0.007$, $T= 0.334$ and $p = 0.738$) has no significant effect, H11 (SI → PPD → FIP, $\beta = 0.002$, $SD = 0.007$, $T = 0.328$ and $p = 0.743$) has no significant effect, H12 (ST → PPD → FIP, $\beta = - 0.004$, $SD = 0.010$, $T = 0.349$ and $p = 0.727$) has no significant effect, H13 (OVP → PPD → FIP, $\beta = 0.009$, $SD = 0.025$, $T=0.373$ and $p = 0.709$) has no significant effect. As all value hypothesis from H8 to H13 value is more than 0.05 that's why PPD has no significant effect on FUI, HG, PR, SI, ST, OVP.

TABLE 4

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RESULT OF INDIRECT PATH ANALYSIS

H	Path	β	SD	T statistics	P values	Decision
H8	FUI → PPD → FIP	0.003	0.008	0.350	0.726	Rejected
H9	HG →PPD → FIP	0.003	0.008	0.336	0.737	Rejected
H10	PR →PPD → FIP	-0.002	0.007	0.334	0.738	Rejected
H11	SI → PPD →FIP	0.002	0.007	0.328	0.743	Rejected
H12	ST → PPD → FIP	-0.004	0.010	0.349	0.727	Rejected
H13	OVP → PPD → FIP	0.009	0.025	0.373	0.709	Rejected

IV. DISCUSSION ON FINDINGS

H1 shows no significant effect of FUI on FIP (β = 0.040, p = 0.549). In Bangladesh, Facebook is primarily a social networking space for connection, self-presentation, and community rather than a dedicated shopping channel; high platform use does not translate into more impulse purchases [72]. This contrasts with prior evidence [2]. Practically, campaigns should be scheduled around shopping-relevant moments instead of relying on frequent exposure.

H2 indicates that HG does not significantly influence FIP (β = −0.069, p = 0.215). Given that many users seek entertainment and socializing on Facebook, heavy promotional content may interrupt enjoyment and dampen hedonic value, helping explain the divergence from earlier findings [8]. Marketers should carefully time and place promotions to avoid disrupting leisure use.

By contrast, H3–H5 are supported: PR (β = 0.179, p = 0.004), SI (β = 0.163, p = 0.013), and ST (β = 0.459, p < 0.001) significantly increase FIP. This aligns with research showing that influencer ties, peer interaction, and trust heighten spontaneous buying [8], [39], [63]. Emotionally resonant endorsements, community conversations, and transparent practices reduce perceived risk and encourage quick decisions. Firms should cultivate interactive brand communities, collaborate with credible endorsers, and strengthen after-sales service and transparency.

H6 and H7 are not supported: OVP (β = 0.045, p = 0.508) and PPD (β = 0.018, p = 0.704) show no direct effect on FIP, diverging from prior work [7], [39], [41], [73]. Attractive visuals alone may have limited influence, perhaps because high-quality imagery is easy to produce and less diagnostic, while limited price transparency reduces the salience of price comparisons. Overinvesting in visual stimuli or price cuts can be counterproductive and may even trigger mistrust. Emphasis should remain on PR, SI, and ST over OVP, PPD, FUI, and HG.

All indirect paths via PPD are non-significant (H8–H13, all p > 0.05), indicating no mediating effect of PPD on the relationships with FIP. In this context, impulse buying appears more emotion-driven and socially cued than price-comparison driven, consistent with the primacy of PR, SI, and ST over price-focused mechanisms. Strategically, price-based tactics (e.g., frequent discounts) should be de-emphasized in favor of building trustworthy relationships, credible endorsements, and active community engagement that can trigger spontaneous purchases without relying on perceived price gaps.

V. IMPLICATION AND CONCLUSION

Practical Implications

Given that PR, SI, and ST significantly increase FIP, while FUI, HG, OVP, and PPD do not and PPD shows no mediation, managers should prioritize community building and trust over purely visual or price-centric tactics. Partner with credible influencers to cultivate authentic para social bonds; use groups and live sessions for Q&A, demos, and peer endorsements; and standardize transparent policies on pricing, delivery, and returns to reduce risk perceptions. Emphasize verified pages, clear seller information, reliable cash-on-delivery or escrow options, order tracking, and responsive service. Highlight authentic user reviews and testimonials rather than heavy discounts or glossy creatives alone, and time campaigns to periods when users are more receptive to shopping. Train seller teams for fast, respectful messaging and track engagement and trust metrics, such as response time and repeat interactions, alongside sales. These steps align platform behavior with the social mechanisms that most effectively trigger impulse purchases in Bangladesh's F-commerce.

Policy Implications

Current study proves the presence of F-commerce impulse purchase presence in Bangladeshi customers. That's to ensure the business long term growth as well as to protect the customers. This study's findings provide some insights which will help the government of Bangladesh to take some practical initiative to make this platform more viable. Firstly, they should introduce formal training programs which will cover not only digital literacy training but also build trust, manage online customers. These programs will help the business to understand the need for a trustworthy and transparent relationship creating process. Secondly, the government should start consumer awareness campaigns on how to recognize trustworthy sellers, where to look for digital business identification numbers, especially for high value items sellers. Also, they should make a campaign about how a customer can seek legal help if they get scammed like not receiving product, receiving fake items. Thirdly, Government bodies can blacklist frequently reported scams sellers and public those reports to alert the citizen. Finally, they should create dedicated F-commerce community guidelines and ethical standards and promote these to make both sellers and buyer aware of it.

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- *Conclusion*

The study highlights that para social relation, social interaction and social trust impact on F-commerce impulse purchase in the context of Bangladesh. In this growing sector business can create strong connections by developing these variables. As well as marketers and developers must strategies based on local customer behavioral and cultural patterns.

On the policy front, they study highlight steps which will help both seller and buyer through training programs, customer awareness campaigns, and set up ethical guidelines for F-commerce base business. In conclusion, by implementing both Practical implications and Policy mentions in this study can contribute to building a long-term sustainable F-commerce ecosystem in Bangladesh.

VI. LIMITATIONS AND FUTURE RESEARCH DIRECTION

This study has several limitations: the sample is predominantly urban; although 403 responses were obtained, the size remains modest relative to the total F-commerce user base; the closed-ended questionnaire may have constrained respondents' views; the scope is limited to Facebook-based commerce (excluding platforms such as Instagram and conventional e-commerce); and the cross-sectional design captures behavior at a single point in time. Future research should broaden geographic coverage (including rural users), increase sample size, incorporate open-ended items or mixed-methods designs for richer insights, compare across multiple online platforms, employ longitudinal approaches, and analyze demographic subgroups to reveal heterogeneous effects.

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Assessing the Technological Factors behind Customer Repurchase Intention in E-commerce Industry of Bangladesh: Mediating Effect of Big Data Driven Marketing and IT Innovation Acceptance

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Abstract - **The rapid advancement of digital technology is reshaping the e-commerce landscape in Bangladesh by influencing customer behavior and repurchase intentions. This study examines the direct and indirect effects of technological factors such as Website Appearance (WA), System Quality (SQ), Customer Service through AI chatbots (CSAI), and Search Engine Optimization (SEO), along with the mediating roles of Big Data Driven Marketing (BDM) and IT Innovation Acceptance (IIA), on Customer Repurchase Intention (CRI). A structured questionnaire yielded 404 valid responses from e-commerce users. Data were analyzed using SmartPLS 4.0, beginning with evaluation of the measurement model for reliability and validity, followed by testing the structural model. Results indicate that WA, SQ, BDM, and IIA have significant positive effects on CRI, whereas CSAI has a negative impact. SEO is not directly significant but influences CRI indirectly through BDM and IIA. BDM does not mediate WA and CRI but mediates SQ, CSAI, and SEO. IIA mediates all technological factors and is the strongest predictor of CRI. The study provides actionable insights for e-commerce platforms in Bangladesh to enhance design, system reliability, personalization, and innovation adoption to strengthen customer loyalty and sustainable growth.**

Keywords - **Chatbot, Big Data, Technology, Customer Satisfaction and Customer Repurchase Intention.**

I. INTRODUCTION

The rapid growth of digital technology has transformed how people purchase products and services. Customers increasingly prefer online shopping because it is convenient, time saving, and allows them to compare products and prices before making decisions [1], [2]. The expansion of smartphones and internet access has accelerated e-commerce adoption across the world, including Bangladesh [3].

Technological features such as website design, system quality, search engine optimization, and the use of artificial intelligence in customer service are now critical in shaping customer experience and loyalty. Attractive website appearance builds trust, system quality ensures reliability and ease of navigation, and effective SEO improves visibility in competitive online markets [4], [5]. Similarly, artificial intelligence chatbots provide quick responses, although their effectiveness depends on user experience and cultural acceptance [6]. In addition, big data driven marketing and IT innovations such as secure payments and mobile applications are becoming key to personalization and customer retention [7], [8].

Although the e-commerce industry in Bangladesh has expanded rapidly, customer retention remains a major challenge as many customers purchase once but do not return, creating uncertainty for long term sustainability. Traditional marketing methods are not sufficient to address this issue because satisfaction and loyalty in online environments are shaped primarily by technological factors and user experience [9]. Customer retention is essential for sustainable business growth in digital commerce and identifying the technological factors that directly and indirectly affect repurchase intention will help e-commerce firms improve service quality, strengthen customer trust, and build long term relationships. A clearer understanding of these factors will also guide businesses in designing strategies that enhance customer satisfaction and ensure sustainability in a competitive digital marketplace.

Most previous studies have focused on individual factors such as website quality, mobile application features, or chatbot services [4]. Very few have explored how multiple technological factors interact to influence repurchase intention. In addition, there is limited evidence on how big data driven marketing and IT innovation acceptance mediate the relationship between technology adoption and customer retention in Bangladesh's e-commerce sector.

The primary objective of this study is to assess the influence of technological factors, namely website appearance, system quality, customer service through AI chatbots, and search engine optimization, on customer repurchase intention, while also examining the mediating roles of big data driven marketing and IT innovation acceptance in the e-commerce industry of Bangladesh.

II. LITERATURE REVIEW AND DEVELOPMENT OF CONSTRUSTS

- *Theoretical Review*

This study is guided by two well established theories that explain how technology and service quality influence customer behavior. The Technology Acceptance Model (TAM) proposed by Davis [10] emphasizes that adoption of

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technology depends on perceived usefulness and ease of use. In e-commerce, factors such as website appearance, system quality, and IT innovations shape customer acceptance and continued use, which can lead to repeated purchases. The Service Quality Theory (ServQual) developed by Zeithaml [11] highlights reliability, assurance, tangibility, empathy, and responsiveness as measures of service quality. These elements are closely linked to system performance and customer service through AI chatbots in digital platforms, where higher service quality builds trust and satisfaction that encourage repurchase. Together, TAM and ServQual provide a strong foundation for understanding how technological and service related factors influence customer loyalty in the e-commerce sector.

- *Customer Repurchase Intention (CRI)*

Customer repurchase intention is the decision to buy again from the same seller, shaped by prior experience and satisfaction, and reflects loyalty, reduced search effort, and long-term profitability [12], [13], [14]. In e-commerce, repurchase intention is influenced by system quality, which ensures smooth website performance and reliability, and by customer service tools such as AI chatbots that can enhance efficiency when they meet user expectations [15], [16]. SEO also supports retention by increasing visibility and strengthening customer awareness [17]. Since sustained loyalty is vital for business sustainability, identifying the technological drivers of repurchase intention is crucial for the growth of e-commerce in Bangladesh.

- *Website Appearance (WA) and Customer Repurchase Intention (CRI)*

Website appearance refers to the overall visual design and presentation of an online platform. In e-commerce, the website often creates the first impression and represents the brand's image. An attractive and user-friendly design enhances perceived trust, quality, and value in the minds of customers [18], [19], [20]. A positive website appearance strengthens customer satisfaction and loyalty, both rationally and emotionally, which in turn increases repurchase intention. Previous studies confirm that creative and appealing design features encourage repeat engagement and reduce customer switching [4], [21], [22], [23]. Therefore, the hypothesis can be formulated:

H1: Website Appearance (WA) has a positive impact on Customer Repurchase Intention (CRI).

- *System Quality (SQ) and Customer Repurchase Intention (CRI)*

System quality refers to the technical performance of an online platform, which determine how easily and effectively customers can complete transactions. In e-commerce, a system that is fast, safe, and user friendly provides a smooth shopping experience, builds trust, and enhances satisfaction. Prior studies show that strong system quality reduces complaints, increases customer engagement, and directly strengthens loyalty and repurchase intention [24], [25], [26], [27]. Therefore, the hypothesis can be formulated:

H2: System Quality (SQ) has a positive impact on Customer Repurchase Intention (CRI).

- *Customer Service through AI chatbot (CSAI) and Customer Repurchase Intention (CRI)*

Customer service through AI chatbots (CSAI) refers to the use of conversational agents that assist customers with product searches, recommendations, transactions, and payment-related inquiries in e-commerce. These tools provide instant responses and round-the-clock availability, enabling businesses to handle diverse customer needs efficiently [28]. Research shows that effective chatbot services improve customer trust, satisfaction, and loyalty, which are essential for repurchase intention [29], [30]. Chatbots that demonstrate accuracy, flexibility, and responsiveness enhance both rational and emotional satisfaction, further motivating customers to continue purchasing from the same platform [31]. Therefore, the hypothesis can be formulated:

H3: Customer service through AI chatbot (CSAI) has significant impact on Customer Repurchase Intention (CRI).

- *Search Engine Optimization (SEO) and Customer Repurchase Intention (CRI)*

Search engine optimization (SEO) is the process of increasing a website's visibility in search results, helping customers to locate relevant products and services. In e-commerce, it ensures that platforms appear in top search pages, which influences customer decision-making because buyers are more likely to click on the first displayed results [5]. Technical features such as keyword use, loading speed, and site optimization are also critical in shaping the customer experience and encouraging repeat purchases [32]. Recent studies confirm that effective SEO strategies improve engagement, extend browsing time, and increase the likelihood of repurchase in online markets [33], [34]. Therefore, the hypothesis can be formulated:

H4: Search Engine Optimization (SEO) has a positive impact on Customer Repurchase Intention (CRI).

- *Big Data Driven Marketing (BDM) and Customer Repurchase Intention (CRI)*

Big data driven marketing (BDM) refers to the use of customer data to deliver personalized offers and targeted messages. It enables businesses to understand customer behavior more accurately and suggest products that match individual needs [35]. In e-commerce, BDM helps firms move from traditional approaches to customer-centric strategies, improving satisfaction and retention [36]. With the support of digital platforms such as social media, data-driven campaigns strengthen relationships with customers and create competitive advantages [37]. Research also shows that BDM enhances customer relationship management and satisfaction, which directly increase loyalty and repurchase intention [38], [39]. By improving personalization and user experiences, BDM encourages customers to make repeat purchases, thereby sustaining long-term business growth [40]. Therefore, the hypothesis can be formulated:

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H5: Big Data Driven Marketing (BDDM) has a positive impact on Customer Repurchase Intention (CRI).

- *IT Innovation Acceptance (IIA) and Customer Repurchase Intention (CRI)*

IT innovation acceptance (IIA) refers to the readiness of customers to adopt new technological solutions that enhance convenience, security, and efficiency in online transactions. Innovations such as digital payment systems, mobile applications, and self-service technologies reduce perceived risk and increase trust, thereby improving satisfaction [41], [42]. Studies confirm that customer perceptions of value and originality in innovation significantly influence satisfaction, which then strengthens repurchase behavior [43], [44]. The adoption of IT innovations also supports competitive advantage by improving user experience and service quality [45], [46]. Evidence from recent research further shows that IT innovation acceptance positively affects customer loyalty, making it an important driver of repurchase intention in e-commerce [8]. Therefore, the hypothesis can be formulated:

H6: IT Innovation Acceptance (IIA) has a positive impact on Customer Repurchase Intention (CRI).

- *The Mediating effect of Big Data Driven Marketing*

The mediating effect of BDM suggests that it serves as an intermediary process through technological factors such as WA, SQ, CSAI, and SEO that influence CRI. Prior studies show that customers often respond more positively when firms use data to create personalized experiences [7], [8], [38]. BDM helps transform technological features into tailored offers and targeted communication, which enhance satisfaction and loyalty. Some research found that BDM can mediate the relationship between technological factors and consumer behavior [1]. Through the creation of virtual marketplaces and digital connections, technological development and especially the rise of BDM are completely changing the market. Thus, data driven marketing that makes offers more personalized and customized has a mediating effect on these factors [2]. Therefore, the hypothesis can be formulated:

H7: Big Data Driven Marketing (BDM) mediates the relationship between Website Appearance (WA) and Customer Repurchase Intention (CRI).

H8: Big Data Driven Marketing (BDM) mediates the relationship between System Quality (SQ) and Customer Repurchase Intention (CRI).

H9: Big Data Driven Marketing (BDM) mediates the relationship between Customer Service through AI chatbot (CSAI) and Customer Repurchase Intention (CRI).

H10: Big Data Driven Marketing (BDM) mediates the relationship between Search Engine Optimization (SEO) and Customer Repurchase Intention (CRI).

- *The Mediating effect of IT Innovation Acceptance*

IIA serves as a mediating factor by connecting technological features such as WA, SQ, CSAI, and SEO with CRI. Innovations such as mobile applications and secure payments not only provide functional benefits but also build trust and convenience, which lead to stronger loyalty [47]. Previous studies confirm that innovation adoption often acts as a pathway linking technology and customer retention [8], [42]. Studies show that when customers adopt new technologies, their satisfaction and loyalty increase, which strengthens repurchase behavior [47]. Innovation adoption is further supported by factors such as digital payment security and trust, which influence consumers' willingness to continue online purchasing [48]. Research also highlights that organizations that successfully introduce and integrate innovations achieve stronger customer interaction and improved service quality, both of which enhance loyalty [8]. Evidence from self service technologies similarly shows that innovation acceptance mediates service convenience and customer behavior [42]. Therefore, the hypothesis can be formulated:

H11: IT Innovation Acceptance (IIA) mediates the relationship between Website Appearance (WA) and Customer Repurchase Intention (CRI).

H12: IT Innovation Acceptance (IIA) mediates the relationship between System Quality (SQ) and Customer Repurchase Intention (CRI).

H13: IT Innovation Acceptance (IIA) mediates the relationship between Customer Service through AI chatbot (CSAI) and Customer Repurchase Intention (CRI).

H14: IT Innovation Acceptance (IIA) mediates the relationship between Search Engine Optimization (SEO) and Customer Repurchase Intention (CRI).

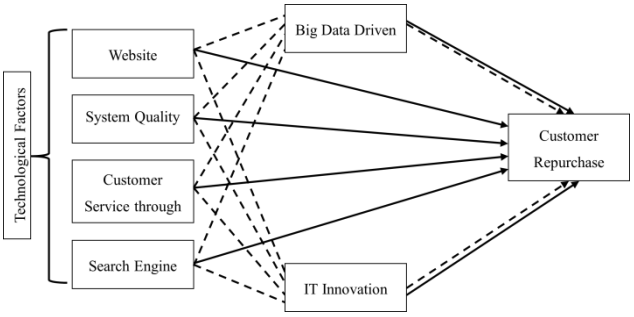


Fig. 1: Conceptual framework; Source: Author's own work

III. RESEARCH METHODOLGY

a. Data Sampling

The study targeted e-commerce customers in Bangladesh with prior online shopping experience. As the total population was unknown, a non-probability purposive sampling method was used to reach active users [49]. Questionnaires were distributed via WhatsApp, Facebook, Messenger, and email, yielding 404 valid responses from 550 distributed. The sample size was adequate for PLS-SEM, as it exceeded the recommended minimum of ten times the estimated parameters [50], and satisfied guidelines for complex models [51].

b. Measurement Instrument

A structured questionnaire was designed to measure the constructs of this study. The measurement items were

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adapted from validated scales and adjusted to the Bangladeshi context to ensure reliability and content validity [15]. Responses were recorded on a five-point Likert scale ranging from "strongly disagree" (1) to "strongly agree" (5), which is commonly used in social science and e-commerce research [52]. The instrument was pre-tested with 20 respondents, and minor wording changes were made to improve clarity.

c. Data Analysis Techniques

Data collected from 404 valid responses were first screened for completeness and accuracy. Descriptive statistics were generated using SPSS version 20 to summarize the demographic characteristics of respondents. To test the hypotheses, Partial Least Squares Structural Equation Modeling (PLS-SEM) was conducted with SmartPLS 4, which is suitable for complex models and predictive analysis with relatively small to medium samples [52]. The analysis followed a two-step approach, beginning with an evaluation of the measurement model to assess reliability and validity, and then testing the structural model to examine direct and mediating relationships among constructs [53], [54].

III. DATA ANALYSIS AND FINDINGS

- *Respondents' Profile*

The study surveyed 404 respondents. Most were aged 26–35 years (54.2%), and the majority were male (83.7%). In terms of e-commerce experience, 25.2% had more than six years and 22.8% had three to four years, indicating sufficient familiarity with online purchasing. A large proportion were job holders (66.1%), and more than half were graduates (56.2%). Regarding platform use, 47.3% reported using e-commerce sometimes and 23% very often, confirming that the sample was well suited for this study.

- *Measurement Model*

Convergent Validity

Convergent validity has been assessed through item loadings, Cronbach's Alpha (CA), Composite Reliability (CR), and Average Variance Extracted (AVE). All item loadings have exceeded the threshold of 0.70, CA values have been greater than 0.60, CR values have been higher than 0.70, and AVE values have been above 0.50. These results confirm that the constructs have been reliable and internally consistent [52], [53].

TABLE 1: ITEM LOADING, CONVERGENT VALIDITY AND RELIABILITY

Constructs	Items	Loading Value	CA	CR	AVE
Website Appearance (WA)	WA1	0.759	0.824	0.876	0.586
	WA2	0.778			
	WA3	0.756			
	WA4	0.772			
	WA5	0.763			
System Quality (SQ)	SQ1	0.719	0.815	0.871	0.575
	SQ2	0.766			
	SQ3	0.733			
	SQ4	0.775			
	SQ5	0.796			
Customer Service through AI chatbot (CSAI)	CASI1	0.855	0.918	0.938	0.753
	CASI2	0.877			
	CASI3	0.870			
	CASI4	0.866			
	CASI5	0.871			
Search Engine Optimization (SEO)	SEO1	0.824	0.849	0.893	0.625
	SEO2	0.776			
	SEO3	0.756			
	SEO4	0.825			
	SEO5	0.768			
Big Data Driven Marketing (BDM)	BDM1	0.822	0.880	0.913	0.676
	BDM2	0.824			
	BDM3	0.825			
	BDM4	0.856			
	BDM5	0.784			
IT Innovation Acceptance (IIA)	IIA1	0.814	0.843	0.888	0.613
	IIA2	0.777			
	IIA3	0.783			
	IIA4	0.779			
	IIA5	0.762			
Customer Repurchase Intention (CRI)	CRI1	0.754	0.886	0.913	0.637
	CRI2	0.826			
	CRI3	0.848			
	CRI4	0.812			
	CRI5	0.750			
	CRI6	0.795			

Source: Author's own work

Discriminant Validity:

Discriminant validity has been evaluated using the Heterotrait–Monotrait ratio (HTMT). Here, all HTMT ratios have been below the recommended threshold of 0.90, indicating that the constructs have been sufficiently distinct from one another [52], [53]. Thus, the conclusion can be made that the assessed variables had the sufficient validity and reliability towards further used for examining the structural model.

TABLE 2: HETEROTRAIT MONOTRAIT (HTMT) RATIO

	BDM	CRI	CSAI	IIA	SEO	SQ	WA
BDM							
CRI	0.750						
CSAI	0.708	0.500					
IIA	0.845	0.839	0.663				
SEO	0.888	0.717	0.652	0.815			
SQ	0.750	0.770	0.551	0.765	0.802		
WA	0.639	0.694	0.500	0.688	0.690	0.834	

Source: Author's own work

- *Structural Model*

The predictive power of the model has been assessed through the coefficient of determination (R^2). All R^2 values for BDM, IIA, and CRI have been between 0.50 and 0.75, indicating moderate predictive accuracy [52], [53]. Moreover, the direct effects of the technological factors on CRI have also been tested and shown in table 3. WA has shown a significant positive effect ($\beta = 0.138$, $p = 0.006$), and SQ has had a stronger significant positive effect ($\beta = 0.205$, $p = 0.000$). CSAI has demonstrated a negative but significant effect ($\beta = -0.086$, $p = 0.041$). SEO has not had a significant effect ($\beta = 0.017$, $p = 0.760$). BDM has shown

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a significant positive effect (β = 0.197, p = 0.002), and IIA has produced the strongest positive effect (β = 0.413, p = 0.000). These results confirm that WA, SQ, BDM, and IIA have significantly improved repurchase intention, CSAI has negatively influenced it, and SEO has not directly affected it.

TABLE 3: RESULTS OF DIRECT PATH ANALYSIS

H	Path	β	STDEV	*P* Values	Results
H1	WA → CRI	0.138	0.050	0.006	Accepted
H2	SQ → CRI	0.205	0.057	0.000	Accepted
H3	CSAI → CRI	-0.086	0.042	0.041	Accepted
H4	SEO → CRI	0.017	0.055	0.760	Rejected
H5	BDM → CRI	0.197	0.063	0.002	Accepted
H6	IIA → CRI	0.413	0.052	0.000	Accepted

Source: Author's own work

Table 4 shows that BDM has not mediated the relationship between WA and CRI (H7: β = 0.009, p = 0.407), but it has significantly mediated SQ and CRI (H8: β = 0.029, p = 0.046), CSAI and CRI (H9: β = 0.052, p = 0.008), and SEO and CRI (H10: β = 0.096, p = 0.003). IIA has mediated all four relationships: WA and CRI (H11: β = 0.058, p = 0.011), SQ and CRI (H12: β = 0.084, p = 0.001), CSAI and CRI (H13: β = 0.094, p = 0.000), and SEO and CRI (H14: β = 0.143, p = 0.000). These results indicate that BDM has acted as a partial mediator, while IIA has been a consistent and stronger mediator of CRI.

TABLE 4: RESULTS OF SPECIFIC INDIRECT EFFECT

H	Path	β	STDEV	*P* Values	Results
H7	WA → BDM → CRI	0.009	0.011	0.407	Rejected
H8	SQ → BDM → CRI	0.029	0.015	0.046	Accepted
H9	CSAI → BDM → CRI	0.052	0.020	0.008	Accepted
H10	SEO → BDM → CRI	0.096	0.033	0.003	Accepted
H11	WA → IIA → CRI	0.058	0.023	0.011	Accepted
H12	SQ → IIA → CRI	0.084	0.025	0.001	Accepted
H13	CASI → IIA → CRI	0.094	0.024	0.000	Accepted
H14	SEO → IIA → CRI	0.143	0.029	0.000	Accepted

Source: Author's own work

IV. DISCUSSION ON FINDINGS

The study has found that WA has had a significant positive effect on CRI. In Bangladesh, where customers rely heavily on visual impressions of digital platforms, an attractive design with clear layout, color, and navigation has enhanced trust and encouraged repeat purchases. These results are consistent with earlier studies that show how website aesthetics improve satisfaction and loyalty [4], [18], [19].

SQ has also shown a significant positive effect on CRI, highlighting that reliable, user friendly, and secure platforms are essential for Bangladeshi customers. A strong system has reduced complaints and increased trust, which is particularly important in a market where concerns about fraud and technical failures remain high. This finding is supported by previous studies confirming that system quality strengthens satisfaction and repurchase intention [25], [26], [27].

CSAI has demonstrated a negative but significant effect on CRI. Although chatbots have provided instant responses, many Bangladeshi customers have valued human like empathy and contextual understanding, which current chatbot systems often lack. This mismatch has lowered satisfaction, suggesting that automation must be combined with personalization to build loyalty. These findings are consistent with studies that show poorly designed chatbots can reduce trust [55], [56].

SEO has not shown a significant direct effect on CRI. While SEO improves visibility, Bangladeshi customers often depend more on social referrals, peer recommendations, and brand familiarity than on search rankings when deciding to repurchase. This result supports earlier research that visibility alone does not guarantee loyalty [57].

BDM has been confirmed as a partial mediator, significantly linking SQ, CSAI, and SEO with CRI but not WA. Personalization and targeted campaigns based on customer data have strengthened the influence of system performance, chatbot interactions, and search visibility on repurchase, while website design has affected CRI more directly through aesthetics and trust. In Bangladesh, social media platforms such as Facebook have provided essential data for BDM, enabling firms to customize offers and build stronger customer relationships that encourage loyalty and repeat purchases [38], [58].

IIA has emerged as a consistent and strong mediator, linking WA, SQ, CSAI, and SEO with CRI. Customer acceptance of innovations such as secure digital payments, mobile applications, and self service tools has improved trust, convenience, and satisfaction, which have led to stronger loyalty. Unlike BDM, which has mediated only part of the relationships, IIA has provided a consistent pathway by translating technological features into customer benefits. In Bangladesh, where mobile banking and fintech adoption have expanded quickly, IIA has been especially influential in shaping repurchase behavior and connecting technological advancement with loyalty [8], [47].

V. IMPLICATIONS AND CONCLUSION

- *Practical Implications*

The study has shown that WA and SQ have strengthened CRI, meaning firms should focus on attractive

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design and reliable systems to build trust. The negative effect of CSAI has indicated that chatbots need more personalized and human like features. SEO has not influenced CRI, suggesting that visibility must be supported with referrals and brand trust in Bangladesh. BDM has shown value in using social media data for targeted offers, while IIA has confirmed that mobile payments and apps are essential for customer retention.

- *Policy Implications*

The findings have offered guidance for policymakers in developing Bangladesh's e-commerce sector. WA and SQ have pointed to the need for digital standards that ensure usability and security. CSAI has shown that guidelines are required for improving AI-based services. SEO has suggested that policy should focus more on consumer protection and secure payments, while the mediating roles of BDM and IIA have confirmed the importance of promoting data-driven marketing and fintech adoption.

- *Conclusion*

This study has examined the effects of WA, SQ, CSAI, and SEO on CRI, with BDM and IIA as mediators in Bangladeshi e-commerce. WA and SQ have increased CRI, CSAI has had a negative effect, and SEO has not been significant. BDM has partly mediated the relationships, while IIA has consistently mediated all factors and emerged as the strongest driver of CRI. The findings have extended TAM and ServQual in this context and offered practical insights for firms and policymakers.

VI. LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This study has been limited to Bangladeshi e-commerce customers, which restricts the generalizability of the findings. A non-probability purposive sampling method has been used, which reduces representativeness, and the reliance on self-reported data may have introduced bias. The study has also applied a cross-sectional design, which does not capture changes in customer behavior over time or allow strong causal inferences. Future research may apply probability-based sampling across multiple countries, use longitudinal designs to observe behavioral changes, and include additional constructs such as culture, trust, or perceived risk to extend the model.

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Fintech, Climate Finance, and Behavioral Shifts: Evidence from Bangladesh's Digital Lending Landscape

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Abstract - **Mobile financial services, including bKash, Nagad have led to financial inclusion in Bangladesh are bound to play a more significant role in encouraging environmental sustainability. This study explains how digital finance can be used to attain climate objectives by incorporating eco-linked lending with sustainability awareness and green incentives. This paper reflects four hypotheses on voluntary dependability of green finance, sensitivity to incentives, ecological cognizance, and age gap using survey-based data on Bangladeshis, international case studies, and behavioral hypotheses. The findings suggest that younger users exhibit more positive attitudes towards sustainability, but users become more engaged when they see the environmental pay-off and consider trade-off in adopting more sustainable input and favorably influenced by green incentives. The results indicate that opportunities among fintechs is to incorporate (ESG) principles into the digital ecosystems of Bangladesh, reinforcing the fintechs as a climate resilience and inclusive green growth driver, despite the limitations.**
Keywords - **Sustainable Finance, Green Investment, Investor Behavior**

I. INTRODUCTION

With an increasing risk of economic loss, climate change is hitting the developing economies especially hard as poor people and weak infrastructures are the most vulnerable to its effects [1]. Bangladesh is one of the highly vulnerable countries to climate related disasters like rising sea level and extreme weather events and as such, it provides an excellent background to this discussion [2]. A response to this, green finance can facilitate a matching of capital flows with the achievement of low-carbon development and climate resilience, which presupposes financial products that are specifically geared toward environmentally sustainable developments [3]. In countries such as Bangladesh, digital money services, and in particular mobile money services (MFS) have not only fast-tracked financial inclusion but also created the basis of sustainable investing approaches [4].

Previous research demonstrates that consumers can have a varied rather high focus on long-run horizons and risk sensitivity; they are willing to take reduced returns to enjoy the environmental upside [5]. Also, behavioral research suggests that transparency tools such as carbon reporting and engagement tools eco-rewards and gamification, have positive effects on adoption of green finance but at least as high as those of financial incentives [6], [7]. However, most of these insights come from developed markets, leaving a knowledge gap in low-income, high-fintech contexts such as Bangladesh [8]. Bangladesh presents a compelling case since the MFS platforms such as bKash and Nagad have a large reach and they are accessible to and trusted by most individuals, including the unbanked citizens. [9]. However, there is little empirical data on whether and how these services can be used to provide green finance on a large scale. Although evidence is still limited and fragmented, global analogs such as M-KOPA's pay-as-you-go solar financing and Paytm's green purchase offerings show promising potential [10], [11].\This paper applies a survey (N ≈ 200) with a structured process to examine user attitudes and behavioral determinants of green finance adoption in Bangladesh so that it can fill this gap. We developed research questions and tested hypothesis using the following:

Research Question 1 (Trade-offs): What is the degree to which users are ready to make financial trade-offs (reductions in returns, longer horizons, and possible slightly higher risks) in green finance products to obtain sustainability benefits?

Hypothesis 1 (H1 -Trade-off): Investors will indicate readiness to make financial tradeoffs e.g. lower returns, longer time horizon, or an increased perception of risk, provided that the investment fits with their sustainability objectives.

Research Question 2 (Incentives): Do monetary and non-monetary reinforces (carbon accounting, tax breaks, gamification of eco-loyalty programs) make the user care about green financial products and engage in using them?*Hypothesis 2 (H2 -Incentives):* The availability of custom incentives, including special tax treatment on green savings, custom carbon emission reports that will relate to users spending, and gamification of the process linked to good green financial behavior, will greatly enhance the probability of the target using green financial products.

Research question 3 (Age): Are the younger generations more willing to use sustainable and digitally delivered financial services than older generations*Hypothesis 3 (H3 - Age):* The younger consumers, especially those below 35 years who are more digital-savvy and socially active, will be more drawn to see sustainable finance products availed through digital platforms.

Research Question 4 (Awareness):
Does higher environmental awareness and knowledge about green investing increase support for and interest in sustainable finance in Bangladesh?

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Hypothesis 4 (H4 - Awareness):
Greater environmental awareness and knowledge are positively associated with stronger support for green investment and higher likelihood of adoption.

II. METHODOLOGY

A. Research Design
This study uses a quantitative, cross-sectional, correlational design to find associations between user demographics, awareness, incentives, and willingness to adopt green finance through mobile financial services (MFS). A survey approach is used for measuring behavioral constructs at scale and applying statistical tests (descriptives, χ^2, t/ANOVA, correlations, regression).

B. Data Collection
A questionnaire in English was created in the professional form and distributed on Google Forms and on paper. Demographics (age, education, location), MFS usage (frequency, type), awareness (solar/wind, green investing, environmental occurrence), trade-offs (returns, risk, waiting time), incentives (tax benefits, carbon reports, eco-rewards), adoption intent, and policy support were included in the sections. Most other items were Likert or binary, otherwise, adapted from existing fintech/green finance studies and pilot-tested (n=20). Reliability was determined by using Cronbach alpha and construct validity by error free analysis. The acquisition of data took place in Dhaka (2025) with the informed consent of the participants.

C. Population and Sampling
The targeted population were adult users of MFS in Bangladesh; that is, potential retail investors. Convenience and snowball sampling returned 212 responses that were fully completed. Sample profile: 18–24 (54%), 25–34 (32%), 35+ (14%); majority undergraduate/graduate; 96% reported active MFS use. This is an exploratory look at segments that are digitally active, although not all-inclusive.

D. Data Analysis
Data were cleaned, coded (Likert=1–5; Yes=1, No=0, Maybe=0.5), and analyzed using SPSS, Excel, and R/Python scripts. Analyses included:
1. Descriptive statistics (frequencies, means, SDs).2. Reliability & validity checks (Cronbach's α, EFA).3. Bivariate tests: χ^2 for categorical variables; t-tests/ANOVA for group differences.4. Correlation analysis (Pearson/Spearman).5. Regression modeling: binary logistic regression predicting adoption intent from incentives, awareness, age, education, MFS use, and trade-off scores.

E. Ethical Considerations
The consent to participate in the survey was informed; the anonymity and confidentiality of the research were guaranteed. No identifying data were collected. The research was carried out in accordance with ethical principles of institutions; de-identified data are available on request with following approvals.

III. RESULTS

Hypothesis 1 (H1 -Trade-off): Willingness to Accept Trade-offs for Sustainability
A clear majority of respondents expressed willingness to make financial trade-offs for green finance products:
Lower returns: 90.1% accepted, 9.4% rejected
Longer investment horizons: 89.6% accepted, 9.4% rejected.*Higher risk:* 54.7% accepted, 43.9% rejected.
This indicates strong acceptance of return and time-horizon trade-offs, with risk emerging as the main barrier (≈45% resistant). Demographics (age, education) did not have a significant impact on any trade-off (all $p > 0.14$), pointing to widespread and cross-cutting receptivity.
Digital familiarity (MFS use): Frequent MFS users were more likely to accept longer wait times ($\chi^2 = 6.33$, $p = 0.042$). Additionally, respondents who had considered saving/investing via MFS were much more willing to take higher risk for green projects ($\chi^2 = 56.20$, $p < 0.001$).

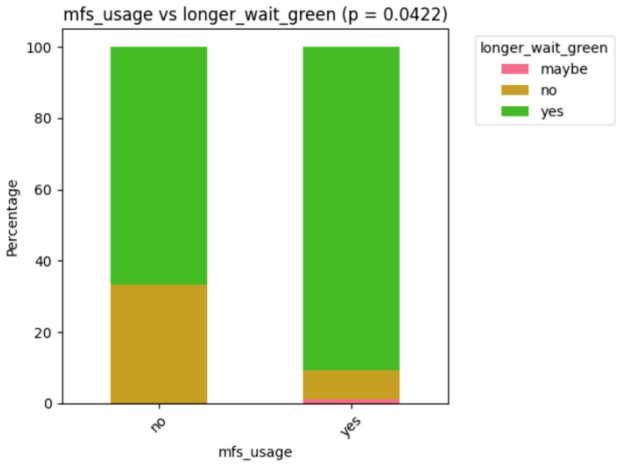


Fig. 1. MSF familiarity vs accepting longer waiting period

Beliefs and interest: Belief that green energy is better strongly predicted higher risk tolerance ($\chi^2 = 70.52$, $p < 0.001$).
Interest in investing in green projects was the strongest correlate of all trade-offs: lower returns ($\chi^2 = 93.34$, $p < 0.001$), higher risk ($\chi^2 = 47.81$, $p < 0.001$), and longer wait ($\chi^2 = 148.01$, $p < 0.001$).
Interpretation - Overall, H1 is supported. The majority tolerate reduced returns and long-term duration investments in time, and risk is the polarizing aspect. As seen in the trade-off willingness, the appeal is crosscutting across the demographics. Nonetheless, both digital financial familiarity (through MFS) and prior interest in investing have strong influences on willingness, indicating that specific nudges (e.g., education in the app or pre-commitment prodding) could be used to encourage taking up green finance products.

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Hypothesis 2 (H2 -Incentives): Incentives and Interest in Green Finance

Respondents overwhelmingly endorsed incentives as motivators:

Tax benefits: 96.2% said these would increase interest. Carbon footprint reports: 88.2% expressed interest. Gamified eco-rewards: 89.2% reported motivation. Additionally, 90.1% said they would invest in green products if tax benefits were offered. The average rating of carbon report usefulness was 3.65/5 (median = 4.0).

Inferential results:

Tax benefits: The carbon reports carbon-report rating between the "yes" and the "no" respondents was not statistically significant ($t = 2.19$, $p = 0.070$). This is because the number of those who answered no was just 7. *Carbon reports:* The reports were imbued with greater importance by those respondents who desired reports (mean = 3.80 vs 2.52, $p < 0.001$).

Eco-rewards: Had a very strong predictive effect of engagement ($F = 30.41$, $p < 0.001$); people motivated by the eco-rewards rated carbon reports higher. Correlations: Carbon report preference ↔ Eco-rewards: $r = 0.45$ (moderate, positive).Carbon report rating correlates with both carbon report preference ($r = 0.36$) and eco-rewards ($r = 0.36$)

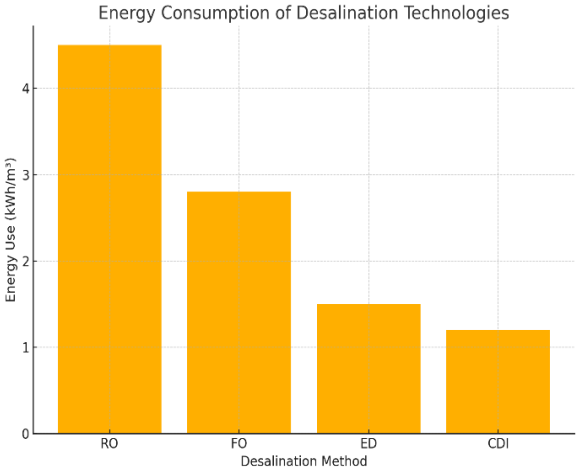


Fig. 2. Correlation Matrix of Incentive-Based Determinants in Green Finance Adoption

Interpretation - H2 is supported Incentives stimulate interest, but they are more or less strong. Carbon report footprint and gamified eco-rewards prove to be the strongest in terms of statistical and attitudinal robustness and they target similar user groups. Tax benefits, although very popular, demonstrate limited statistical variance in this survey (caused by ceiling effects) but are an excellent policy lever in stimulating adoption in practice. Within the product design footprint, carbon-impact reports coupled with eco-rewards should be the next level user-interface followed by straightforward tax-incentive communications. The fact impact reporting is complementary and gamified rewards is complementary, indicates that the two should be bundled together to have the optimum uptake.

Hypothesis 3 (H3 -Age factor): Younger people are more likely to root for green finance

At all age groups, the feeling on sustainability finance was highly favorable.

Carbon-report significance (1-5): 3,53 (18-24) to 4, 25 (55+).

National green investment (1-5): high at all ages (means 4.32-4

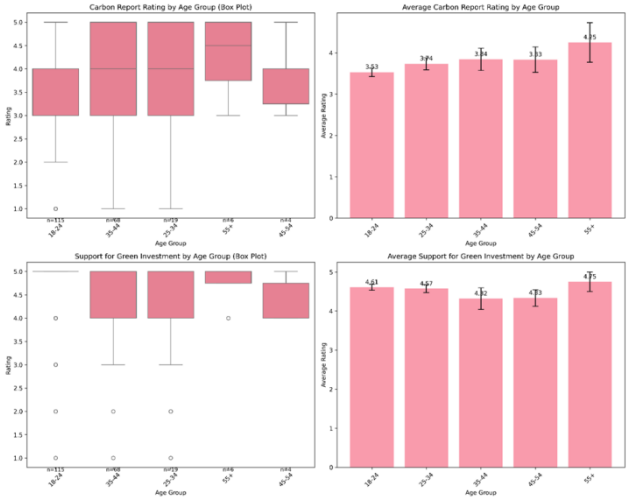


Fig. 3. Age-Stratified Analysis of Carbon Report Ratings and Green Investment Support

Inferential results

Between-group differences: ANOVAs did not show significant age differences on carbon-report importance ($F = 0.85$, $p = 0.494$) and green investment support ($F = 0.63$, $p = 0.639$).

Intra-group comparisons: In both measures, all the significant age groups were significantly above the neutral mark (3) ($p < 0.01$).

Carbon-report importance: Carbon-report importance correlated with green investment support ($r = 0.419$), which indicates that the importance attached to transparency is associated with more pro-investment attitudes.

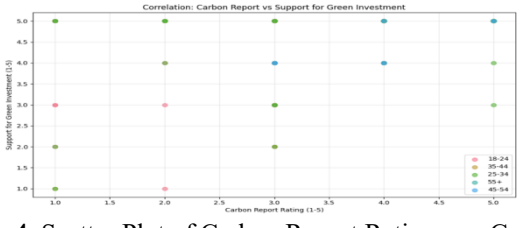


Fig. 4. Scatter Plot of Carbon Report Ratings vs. Green Investment Support by Age Group

Interpretation - H3 is rejected: younger respondents were not more favorable as compared to older groups. Rather, pro-sustainability feelings were quite consistent by age,

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suggesting that green finance is not a niche (appealing only to youth) but instead a mass-market opportunity. Carbon reporting goes a notch higher as a significant value attribute of the different demographics In the 45+ cohorts, small sample sizes in subgroups lead to the need to avoid excessive interpretation of observed differences.

Hypothesis 4 (H4 - Awareness): Awareness and Support for Green Investment

Awareness of renewables is near-universal among the tested group.
Heard of solar/wind: 99.5%.
Know about green investing: 59.9%.
Interested in green investing: 77.4%.
Environmental importance for investing (1–5): mean = 3.77 (SD = 1.13).
Support for promoting green investment (1–5): mean = 4.57 (SD = 0.85).
Correlations: Environmental importance ↔ Support for green investment: r = 0.368 (moderate positive). Environmental importance ↔ MFS saving consideration: r = 0.154 (weak).
Knowledge vs. Interest: Among those who know green investing: 83.5% were interested. Among those who do not: 68.2% were interested.

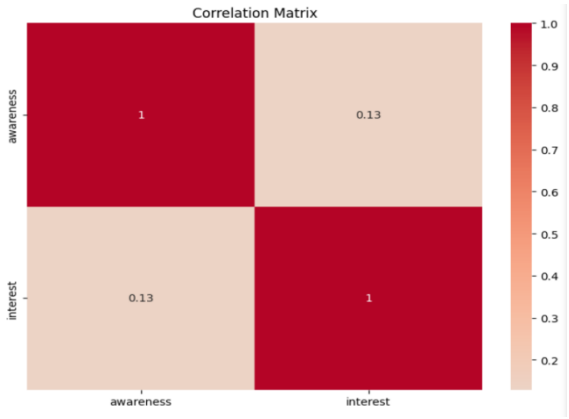


Fig. 5. Correlation Matrix of Awareness and Interest in Sustainable Products

Interpretation - H4 is supported and greater knowledge about green investing is associated with substantially greater self-reported interest (83.5% vs 68.2%). In addition, the moderate correlation between environmental importance and support at a policy level (r = 0.37) implies that greater environmental awareness and financial literacy may lead to a greater public support and demand for green product.

IV. DISCUSSION

This paper examined the Bangladesh consumer preparedness to adopt sustainable finance using digital transactional systems based on trade-offs, incentives, awareness, and age. The findings indicate the rather wide openness to the usage of the products on a cross-cutting basis with different products being adopted by people not based on their personae but the design and categorization of the products being used.

Incentives: Gamification and Transparency lead Engagement

Carbon-impact reports and eco-rewards were the strongest motivators on both statistical and substantive levels. The combination of the visibility of impact and the gamified engagement delivers trust and long-term interest. Tax incentives, which have universal appeal, were not nearly as variable in the survey data as were other policy levers, suggesting that tax advantages may be a more important policy lever than a fintech-differentiating factor.
Implication: Impact dashboards and reward mechanics deserve to be focused on as product design priorities, with governments helping to drive uptake further through the provision of some tax incentives.

Trade-offs: Eager to a Point

Most respondents would accept lower returns (90%), longer horizons (89.6%) in the case of green products, whereas fewer were adamant on the higher risk (54.7%). Intentions also influenced trading off by correlating substantially with pre-interest in green investment such that prior interest indicated willingness to compromise. Implication: Introduce tiered green funds- low-risk vehicles with moderate returns that can be used by the less enthusiastic user and riskier/high-impact funds that can be used by highly motivated adopters. Such segmentation gives a wider inclusion without cutting off the risk-sensitive groups.

Age: A Mass-Market Opportunity

As against the prevalent assumption, the support could not be more prevailing among younger users. Endorsement of sustainable finance was also extensive (≈ 4.3-4.7, using a 5-point scale), and consistent across groups. Implication Green finance is not a youth niche or a mainstream demand. Digital payment vehicles such as bKash and Nagad help ease the delivery channel to be available in every generation, so the focus should not be based on the idea of generation exclusivity, rather inclusivity.

Insights in Behavioral Finance

Nudges and framing: Current interest forecasts trade-off acceptance.
Salience: Carbon reports make intangible sustainability a reality.
Gamification: Eco -rewards remain motivated on a foundation of intrinsic motivation and social proof.
Risk sensitivity: It must be framed properly and have tips on the level of risk.

Practitioner Blueprint: Green Micro-Fund

The results indicate a product model that could work. A Green Micro-Fund in the mobile money apps, that have transparent carbon reporting and carbon e-rewards. Equipped with auto-investment through daily purchases,

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including behavioral nudges (users can round their bill to invest in sustainable energy). With progression of risk, starting with secure bonds, to more risk-laden climate funds.

Policy link: Push towards rebates of light taxes to support adoption.

Why this matters:

The robust environmental consciousness of the people of Bangladesh and the shift to digital rails means that sustainable fintech can take root firmly in the country. Gamifying transparency and inclusive design will enable the transition between expressing interest to actual participation by the providers and facile regulation to policymakers. Those combined position green finance as being mainstream, trusted and scalable, not just aspirational.

V. CONCLUSION

The study shows that mobile financial services like the ones used in Bangladesh (bKash and Nagad), have high potential to promote green finance. The user community is amenable to the diminution of returns and extension of horizon although the motivations of carbon reporting and eco-rewards go a long way in stimulating users to use the sites. Non-differently to age categories, interest in sustainable finance does not vary by age, making it a cross-mass-market rather than youth-oriented opportunity. By incorporating ESG principles, gamified rewards and clear impact reporting into fintech networks, Bangladesh can harness the opportunity of fintech as a lever in creating climate resilience and green inclusive growth.

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Unveiling the Key Drivers of Implementing ISSB's Sustainability and Climate Related Financial Disclosures IFRS S1 & S2

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Abstract: **Reporting sustainability and climate related information drives responsible business practices, boost corporate reputation and stakeholder trust. Consistent and comparable sustainability-related financial disclosures are necessary across industries and jurisdictions to furnish decision-useful information to capital markets and broader communities. The International Sustainability Standards Board (ISSB) issued two comprehensive standards IFRS S1, Disclosure of Sustainability-related Financial Information and IFRS S2 Climate Related Disclosures. The IFRS S1 Sustainability Disclosure Standard requires an entity to disclose information about its four core content areas named governance, strategy, risk management, and matrices & targets in relation to the entity's sustainability-related risks and opportunities. IFRS S2 focuses specifically on climate-related risks and opportunities requires an entity to disclose information about its governance, strategy, risk management and metrics & targets .This paper explores the key factors that drives the organization in Bangladesh to adopt IFRS S1 & S2 to unite the greater journey of Sustainability and climate resilience. The study relate the construct of Organizational readiness to change such as vision clarity, change appropriateness and change efficacy with the leadership support and top management support. Organizational context such as organizational history of change, organizational resources and flexibility impacts the adoption process. Climate awareness moderates the adoption of the IFRS S1 and S2.**

Keywords: **ISSB; Sustainability and Climate Disclosures; IFRS S1 & S2; Bangladesh**

I. INTRODUCTION

Economic expansion, even while improving living standards, leads to greenhouse gas emissions from waste disposal and fossil fuel combustion, causing climate change, biodiversity loss, and rising temperatures. Given the evident impact of human activities on climate change, there is a growing emphasis by governments and organizations on transitioning the global economy to achieve net-zero carbon emissions whilst the investment community has intensified demand on companies to delineate the unique risks and opportunities linked to their long-term operations and sustainability. Reporting sustainability and climate information ensures sustainable investments, enhancing corporate governance, attracts foreign direct investment consequently promoting environmental responsibility transparency and accountability. In the past two decades, there has been a notable proliferation of diverse reporting frameworks worldwide concerning sustainability issues, encompassing subjects such as climate change, emissions, pollution, water management, and the broader scope of social responsibility and governance.

With an agenda of ensuring consistent and comparable sustainability-related financial disclosures across industries and jurisdictions The United Nations Climate Change Conference (COP26) recommends the birth of the International Sustainability Standards Board (ISSB) that aims to develop a comprehensive global baseline of sustainability-related disclosure standards that provide investors and other capital market participants with information about companies' sustainability and climate related risks and opportunities to help them make informed decisions. ISSB issued two comprehensive standards IFRS S1 & S2, where IFRS S1 establishes the framework for sustainability-related financial disclosures, ensuring consistency across industries and jurisdictions and IFRS S2 focuses specifically on climate-related risks and opportunities, aligning with the Task Force on Climate-related Financial Disclosures [1,2]. IFRS S1 emphases on the disclosure of Sustainability-related Financial Information that discloses governance, strategy, risk management, and matrices & targets in relation to the entity's sustainability-related risks and opportunities whereas, IFRS S2 focuses specifically on climate-related risks and opportunities reports on the key area of Climate-related risks and opportunities, Greenhouse Gas (GHG) emissions reporting, Resilience analysis - Evaluation of business resilience in different climate scenarios and Transition plans that Outlines strategies to achieve net-zero emissions and other climate-related goals [3].

Regulators in various countries are currently debating the importance of the adoption and working to define their rules for mandatory ISSB filings; companies that choose to report voluntarily need to do so as a mandatory subsection of their general annual financial filings beginning in 2024. The global adoption of IFRS

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S1 and S2 has gained momentum, with major economies like the UK, Australia, Canada, and Singapore incorporating them into their financial reporting systems [2]. Bangladesh Bank and the Financial Reporting Council (FRC) have issued guidelines emphasizing the importance of sustainability disclosures for financial institutions. Aligning with global frameworks like the TCFD and the ISSB, Bangladesh is incorporating IFRS S1 and S2 into its financial sector regulations [4].

The question of whether to move toward mandatory adoption of the IFRS SDS is being debated from a variety of perspectives and considerations, including the value of adoption, the requirement, stakeholder demand, the availability of rules, and the readiness of preparers. With stakeholders acknowledging the importance of such reporting, the first step is to examine the key factors of adopting IFRS S1 and S2, observe the practical scenarios and look for any legislation governing that type of reporting.

Considering the diverse scenario of global adoption and the Bangladesh standpoint this study aims at discovering the key drivers of adopting ISSB's Sustainability and Climate related Financial Disclosures IFRS S1 & S2. Based on the organizational readiness to change theory and other organizational context this study builds a conceptual framework of the adoption of the ISSB's Sustainability and Climate related Financial Disclosures IFRS S1 & S2. This study has unique theoretical contribution that blends different factors form the organizational readiness to change theory with the different internal context that helps the organization to adopt the required standards. The study's findings help to provide the regulator and other stakeholders with a clear policy recommendation when assessing the businesses' readiness to adopt the requirements and to promote awareness and training campaigns, between organizational-level and observe the policy-level preparedness.

The rest of the paper is organized as follows: in part 2, reviews of pertinent literature are discussed; and also global scenario and the Bangladesh context is explained; Conceptual framework is clarified in section 3, and in section 4, methodology is described. A conclusion is provided in Section 5.

II. REVIEW OF THE RELATED LITERATURE

2.1 Overview of IFRS S1 and S2:

2.1.1 IFRS S1 Sustainability-related Financial Information

In order to help users decide whether to provide resources to an entity, the International Sustainability Standard Board (ISSB) released IFRS S1 (General Requirements for Disclosure of Sustainability-related Financial Information), which requires an entity to disclose information about its sustainability-related risks and opportunities (governance, strategy, risks management, as well as matrices & targets).

Governance: Disclosures on governance aim to understand a company's processes, controls, and procedures for monitoring and managing sustainability-related risks and opportunities. Companies must disclose information about their governance body(s), responsibilities, roles, policies, and how they determine staff availability and set targets. They also need to disclose management's role in these processes, whether delegated to proper authority, and whether controls are used to oversee sustainability-related risks and opportunities.

Strategy: The purpose of sustainability disclosures is to help users understand the impact of sustainability-related risks and opportunities on an entity's business model, value chain, and decision-making. This includes describing geographical areas, facilities, and assets, as well as highlighting progress against plans, trade-offs, and significant risks of material adjustments. Quantitative information can be provided in a single amount or range, and if not disclosed, the entity must explain the reason. This helps users understand the company's financial planning and sustainability-related risks and opportunities.

Risk management: Sustainability-related financial disclosures aim to provide users with insight into an entity's risk management processes, enabling them to identify, assess, prioritize, and monitor sustainability-related risks and opportunities.

Metrics and targets: An entity must disclose metrics related to business models, activities, and industry features, including measurement procedures and method limitations. It must also disclose specific qualitative and quantitative targets to monitor progress towards strategic goals and meet required law and regulation targets. Sustainability-related financial disclosures can be included in management commentary or other reports, using internal and external sources like risk management processes, industry experience, and external ratings.

2.1.2 IFRS S2 (Climate Related Disclosures)

IFRS S2 Climate Related Disclosures, issued by ISB, mandate entities to disclose governance, strategy, risk management, and metrics related to climate-related risks and opportunities.

Governance: IFRS S2 mandates entities to disclose governance information to investors, allowing them to understand the processes, controls, and procedures used to manage climate-related risks and opportunities. This includes information about governance bodies and management roles. Integrated governance disclosures avoid duplication for different sustainability-related risks and opportunities.

Strategy: IFRS S2 mandates entities to disclose their strategy for managing climate-related risks and opportunities, including changes to their business model, adaptation efforts, and funding plans. It also outlines the expected impacts on financial position,

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performance, and cash flows over short, medium, and long-term periods. The standard also sets criteria for quantitative and qualitative information requirements and permits only qualitative information. A climate-related scenario analysis is necessary to inform disclosures about climate change resilience, using relevant scenarios and assumptions such as climate-related policies, macroeconomic trends, local weather patterns, demographics, land usage, infrastructure, energy usage, and technology developments.

Risk Management: The standard mandates entities to disclose their risk management processes and policies, allowing investors to understand the methods used to identify, assess, prioritize, and monitor climate-related risks and opportunities.

Matrics and Targets: IFRS S2 mandates disclosure of cross-industry metric categories, industry-based metrics, and targets for mitigating climate risks or maximizing opportunities, specifying metrics for progress measurement.

2.2 Glimpses from the literature

The International Sustainability Standards Board (ISSB) released FRS S1 and IFRS S2 in June 2023, which set a global standard for financial disclosure pertaining to sustainability. General disclosure guidelines for sustainability-related risks and opportunities (including strategy, governance, risk management, and measurements & targets) are provided by IFRS S1. In accordance with the Task Force on Climate-related Financial Disclosures (TCFD) framework, IFRS S2 provides detailed guidelines on disclosures pertaining to climate change (IFRS Foundation, 2023). The following table summarizes some key papers related to IFRS S1 and S2 adoption..

#	Title	Authors & Year	Methodology	Key Findings	Research Gaps / Limitations
4	Sustainability Reporting Ecosystem & IFRS S1/S2	[5]	Literature review	Highlights integration of sustainability & financial reporting; identifies research opportunities.	Few empirical studies due to the newness of standards.
5	Importance of IFRS S1/S2 in Sustainable Business (US)	[6]	Mixed-methods	S1/S2 support sustainable business strategies and transparency.	US-centric; limited global applicability.
6	Analysis of Sustainability Report Standards & Adjustment of IFRS S1/S2	[7]	Comparative analytical review	Proposes adjustments needed for implementing S1/S2 in varied contexts.	Lacks empirical testing of proposed adjustments.
7	Companies' Readiness to Adopt IFRS S2 Climate-Related Disclosures	[8]	Empirical review (100 firms)	Firms aligned with TCFD are better prepared; average disclosure varies.	Focus on large global firms; draft S2 context.
8	Implementation of IFRS Sustainability Disclosure Standards into Integrated Reporting	[9]	Qualitative case study	Future-oriented firms embed S1/S2 into integrated reports, enhancing forward-looking transparency and engagement.	Limited to leading firms; not generalizable to smaller, less mature adopters.

2.3 Global Status of Adoption and the case of Bangladesh:

The global adoption of IFRS S1 and S2 has gained momentum, with major economies like the UK, Australia, Canada, and Singapore incorporating them into their financial reporting systems [10]. The Australian Accounting Standards Board (AASB) has aligned its sustainability reporting standards with IFRS S1 and S2, mandating compliance from 2025 for large corporations. The Singapore Exchange (SGX) is integrating IFRS S1 and S2 into its sustainability reporting framework, with mandatory climate disclosures expected by 2025. The UK government is working on embedding IFRS S2 within its corporate climate reporting regulations. Bangladesh has taken a proactive approach to sustainability reporting. Bangladesh Bank and the Financial Reporting Council (FRC) have issued guidelines emphasizing the importance of sustainability disclosures for financial institutions. Aligning with global frameworks like the TCFD and the ISSB, Bangladesh is incorporating IFRS S1 and S2 into its financial sector regulations [11].

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III. RESEARCH METHOD

The present study builds a conceptual framework of the adoption of the ISSB's Sustainability and Climate-related Financial Disclosures IFRS S1 & S2. The model paper seeks to build a theoretical framework that predicts relationships between concepts. A conceptual model describes an entity and identifies issues that should be considered in its study: it can describe an event, an object, or a process, and explain how it works by disclosing antecedents, outcomes, and contingencies related to the focal construct [12], [13]. This typically involves a form of theorizing that seeks to create a nomological network around the focal concept, employing a formal analytical approach to examine and detail the causal linkages and mechanisms at play [3]. A model paper identifies previously unexplored connections between constructs, introduces new constructs, or explains why elements of a process lead to a particular outcome [14], [15]. For example, Payne et al. [16] used resource-based theory to develop a conceptual model of the antecedents and outcomes of customer value propositions. This study build a conceptual model of IFRS S1 & S2 adoption based on the organizational readiness to change theory and other internal organization level context.

IV. CONCEPTUAL FRAMEWORK

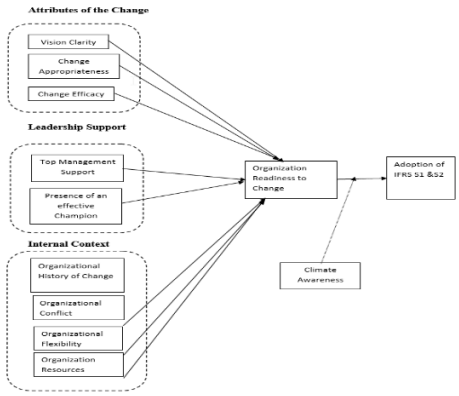


Figure1: Conceptual Model

4.1 Key Drivers of adopting IFRS S1 &S2

The organizational and management literature has extensively examined change management, with a special emphasis on the characteristics that determine whether change initiatives are successful or likely to fail. Armenakis and Bedeian [17] assert that perceived necessity, flexibility, change magnitude, and clarity of aim are all crucial aspects of change. Employees are more likely to embrace and stick with a change when they believe it is in line with the organization's objectives and core values [19]. Furthermore, because there is less opposition, change projects that are gradual rather than drastic are frequently simpler to execute [20]. Other academics emphasize that effective communication is a crucial component of transformation, as clear and consistent messaging lowers ambiguity [21]. Therefore, organizational members' attitudes toward the transformation process are based on the characteristics of change, such as its urgency, scope, communication, and alignment with the organization's vision.

The characteristics of the change pertain to the "what" aspect of the change, that is, one ought to think about what is being altered first [22]. According to Lapointe and Rivard [23], the majority of the time, the change is linked to local procedures, organizational structure, roles and duties, and compensation plans in addition to the new system. The opinions of change beneficiaries regarding organizational preparation for change are likely to be significantly impacted by three characteristics of the change, as will be discussed below:

Vision Clarity:

According to change management theorists, the belief that change is necessary is one of the most important attitudes for developing change readiness [16–18]. Much of the rationale behind such an emotion comes from a clear vision. The necessity for change is made more legitimate when there is a difference between the desired and actual performance. If not, the motivation for a shift could be seen as capricious [16]. The idea of vision clarity aligns with social accounts theory as well, which states that change agents must give information to justify the need for an organizational change [26].

Stakeholders can better grasp the desired future state when a clear vision is presented, including the implications of adopting IFRS S1 and S2 for the company. According to research on change management, having a clear vision is essential for inspiring and coordinating behavior throughout change projects [27]. Organizations run the danger of confusion or disengagement during adoption efforts if they don't have a compelling and clear vision. Adoption of IFRS S1 and S2 could be presented as improving investor trust and environmental, social and governance transparency in a compelling way and stakeholders are more likely to agree to embrace them if they are clearly explained.

Change appropriateness: The belief that the change is suitable, is referred as the change appropriateness. Indeed, if employees are to embrace change, they must not only think that a change is necessary, but also think that the proposed change will effectively address the gap [16-18]. This attitude, which describes whether the suggested adjustment is the right one for the current circumstance, is likewise in line with social accounts theory [28]. Employees may not be prepared to "buy-in" to the change or try to make it work if they believe the suggested change is the wrong strategy for achieving the vision [5]. It is obvious that a change's appropriateness matters since people may agree that a change of some kind is necessary but disagree with the particular change that is being suggested.

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Adopting IFRS S1 and S2 is considered a required and appropriate course of action, which is known as change appropriateness. This characteristic has been highlighted as a key belief affecting how change recipients respond to organizational changes [17]. Adoption of IFRS S1/S2 is more likely if stakeholders believe it to be pertinent and necessary.

Change efficacy: A key component of the majority of motivation theories is a sense of effectiveness, expressed as expectancy that one's efforts will result in successful accomplishment [29]. People need to believe that the change is appropriate and that success is achievable in order to be inspired to support it. In this regard, we think that people's judgments of organizational readiness may be significantly influenced by environmental information. One may get the conclusion that their organization is prepared for a successful implementation if the suggested change has already been successfully implemented in comparable organizations and the relevant people have been informed. On the other hand, one may anticipate some hesitancy from the people impacted by the change if the media has previously covered comparable failures.

The general consensus regarding the organization's ability to successfully apply IFRS S1 and S2 is known as change efficacy. It consists of trust in leadership support, systems, abilities, and resources [17]. Effective adoption is more likely to occur if firms think they have the data systems, knowledge, and direction they need.

Leadership support: Support from the leadership has repeatedly been noted as a critical component in organizational transformation. Strong and obvious leadership commitment helps establish a steering coalition and foster a sense of urgency in order to promote change [30]. Setting direction, assembling resources, and inspiring staff to welcome change are all critical tasks performed by leaders [31]. Because it promotes empowerment, trust, and vision sharing, transformational leadership in particular has been associated with increased employee acceptance of change [32]. Additionally, studies reveal that employees' resistance and dispersed efforts are frequently caused by a lack of leadership support [33]. Additionally, leaders must be change agents who consistently support initiatives by their actions, resource allocation, and acknowledgment of staff members' contributions [34].

As a result, leadership support creates psychological safety, which is essential for workers navigating uncertainty, in addition to legitimizing change initiatives.

People detect the support that exists throughout the company through their interpersonal networks, according to the social learning theory [35]. Principal support in this study refers to both local change agents' and top management's support [18].

A key factor in the successful implementation of IFRS S1 and S2 is leadership support. High-level leadership affects adoption through interconnected mechanisms such as legitimacy and strategic priority, resource allocation and capability building and coordination of stakeholders and change orchestration.

Top Management Support: The success or failure of an information system project is mostly determined by top management, according to numerous investigations [36–38]. These days, it appears that managers and information systems scholars alike agree that good leadership is essential. An IT project that has strong upper management support is likely to receive more funding for development and maintenance [39], which improves enabling conditions [40] and, eventually, raises views of organizational readiness.

IFRS S1/S2 compliance is a strategic priority rather than a supplementary reporting obligation, as evidenced by the clear and consistent backing of top management. Senior leaders provide legitimacy to sustainability disclosure projects by publicly endorsing them, which lessens organizational skepticism regarding the effort's significance and sustainability [41]. Senior leadership legitimacy also improves internal and external signaling because regulators, auditors, and investors see leadership support as a pledge to high-quality governance and disclosures [42]. Instead of being an ad hoc initiative, the new disclosures are owned at the governance level when boards and C-suite sponsorship facilitate their integration into corporate reporting schedules, audit plans, and risk management procedures [30].

Presence of a project champion: It has long been recognized by academics and practitioners that it is very risky to attempt implementing complex change without a project champion [43, 44]. In the context of IT, champions are those that actively pursue their own IT-related goals, overcoming or avoiding barriers to project approval and implementation [45]. They may have initiated the procedure or been convinced by other organization members that it was necessary. Recent research indicates that the perceived leadership behaviors of IT project champions have a direct and positive impact on users' opinions about the change object [46]. Their findings lend credence to the claim that project champions may effectively lead teams to accomplish goals [46].

Technical interpretation, interpreting S1/S2 standards for the company's business model, choosing KPIs and scopes, and communicating with outside advisers are some of the specific duties of advocates for IFRS S1/S2 implementation. Data integration: designing processes that guarantee traceability and internal control over sustainability data in collaboration with IT and finance Building capacity and providing training: setting up role-based training to enable operational teams to gather and verify disclosures, Assurance readiness includes working with internal audit to coordinate and prepare the procedures and documentation needed for both internal and external assurance. In order for capital market participants to use and test disclosures,

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stakeholder engagement involves creating investor materials and answering investor inquiries.

Organizational internal context

An organization's internal environment has a big impact on how well it can implement and maintain change programs. Internal context, according to Pettigrew [47], is the organizational culture, structure, resources, and current capabilities that interact with outside forces to affect the results of change. Research indicates that companies with adaptable organizational structures, creative cultures, and a strong emphasis on learning are better equipped to handle change. However, inflexible structures, a lack of resources, and misaligned systems can all act as obstacles to change.

Employees' views of the legitimacy of change are influenced by internal context, which also includes communication channels, organizational history, and human resource procedures. Additionally, it is crucial that leadership support and internal environment are in sync; even powerful leadership initiatives may fail in the absence of sufficient funding, a positive workplace culture, and engaged employees [20]. Holt et al. [25] define internal context as the conditions that characterize the organization during a period of transition. Internal context, according to Mowday and Sutton [48], is the external environment that affects the beliefs, attitudes, intentions, and behavior of change recipients. Based on previous research, we hypothesize that the perceptions of preparedness of change targets are significantly influenced by three organizational characteristics.

Businesses are more likely to successfully implement IFRS S1 and S2 if they have a history of managing change, such as when they implemented new accounting standards or undertook significant reporting overhauls. These kinds of businesses frequently have governance frameworks, established procedures, and leadership expertise in handling challenging changes. For instance, because of their pre-existing infrastructures and greater level of change readiness, nations and businesses who had already managed waves of IFRS convergence or prior waves of sustainability reporting integration found adoption to be easier.

Organizational history of change:

To some degree, all organizations are idiosyncratic; that is, previous experiences have been stored in each organization in a pattern that makes the organization different from others that may on the surface appear very similar [49]. Organizations are dynamically evolving systems, and each has a history of resources, commitments, successes, and failures that shape the environment in which computer-based systems are developed and implemented [50]. Therefore, organizational history or memory might affect the way a change is framed in terms of previous initiatives undertaken by organization and hence have a great influence on the extent of IT implementation success.

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Organizational conflicts:

Managers, a project leader, a project champion, members of the project team, system developers, and a group of user representatives (clinicians) are often among the numerous people and organizations involved in the implementation process. According to Kling [51], these actors have varying goals and interests when it comes to adopting a new system. Therefore, organizational politics and power dynamics may have an impact on system implementation [52][53]. Targeted customers may believe that the organization is not prepared for change as a result of competing interests among several important individuals and groups.

Adoption can be severely hampered by internal disagreement, whether it be between leadership, departments (such as finance vs. sustainability teams), or other silos. Miscommunication, delayed decision-making, elevated stress, resistance, and interrupted processes are all frequently caused by conflict. Conflicts over materiality determinations or the extent of disclosures may appear in the context of IFRS S1 and S2. Profit and sustainability objectives are at odds, and some departments are reluctant to integrate new systems or share data. Usually, this slows down development, lowers the quality of adoption, and could result in flimsy compliance rather than deep integration.

Organizational flexibility:

Some organizations are more agile and easily adaptable than others. For this reason, the degree to which organizational policies and practices are supportive of change may also be important to understanding how an employee perceives the organization’s readiness for change [16]. Eby et al. [54] examined this issue in a study of two divisions of a national sales organization that was transitioning to work teams. Their results reveal that vendors’ perceptions of their organization’s ability to accommodate change by altering policies and procedures were strongly and positively related to perceived organizational readiness for change. Hence, we posit that clinicians are likely to hold unfavorable views about readiness for change when they perceive their healthcare organization’s structure and policies as rigid and inflexible.

Compared to other organizations, some are more flexible and agile. Accordingly, an employee's

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perception of the organization's preparedness for change may also be influenced by how supportive organizational policies and practices are of change [16]. This problem was investigated by Eby et al. [54] in a study of two divisions of a national sales organization that was implementing work teams. According to their findings, perceived organizational readiness for change was highly and favorably correlated with vendors' assessments of their company's capacity to adapt to change by changing policies and practices. Therefore, we propose that when clinicians believe that the structure and policies of their healthcare organization are inflexible, they are more likely to have negative opinions about their readiness for change.

Climate Awareness:

The term "climate awareness" describes how organizations recognize the opportunities and risks associated with climate change, including pressures from the market, regulations, and reputation [55]. Because IFRS S1 and S2 are specifically intended to increase transparency regarding sustainability and climate-related risks, adoption of these standards is more likely when organizational leaders and stakeholders have a high level of climate awareness [56].

Therefore, the positive correlation between adoption of IFRS sustainability standards and change readiness is reinforced by climate awareness. Organizations with a high degree of change readiness but a low level of climate awareness, for example, might not feel the need to adopt IFRS S1 and S2 immediately or strategically, which would slow down the adoption process. On the other hand, organizations are more likely to view adoption as a strategic requirement for long-term legitimacy and resilience when there is a high level of climate awareness [57]. Climate awareness thus serves as a moderator that enhances the impact of readiness on adoption results.

V. CONCLUSION

This study delves into the adoption of ISSB's IFRS S1 & S2, with a heightened focus on climate action and sustainability. It explores key adoption drivers and proposes a conceptual model. The study builds conceptual model that displays the key drivers of adopting IFRS S1 and S2. The study relate the construct of Organizational readiness to change such as vision clarity, change appropriateness and change efficacy with the leadership support and top management support. Organizational context such as organizational history of change, organizational resources and flexibility impacts the adoption process. Climate awareness moderate the adoption of the IFRS S1 and S2. The research is an attempt to discover the key construct of the adoption and further empirical study can be conducted for the enhanced policy recommendation and the proactive adoption of IFRS S1 and S2 for business sustainability and climate resilience.

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Ethical AI Judge for Village: A Humanized Framework and Constitution for Rural Justice

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Abstract - **This article presents a constitutional and ethical template for adopting AI-augmented justice systems in rural and marginalized communities with limited access to the justice system. Leveraging the 2021 UNESCO Recommendation on AI Ethics and nascent judiciary AI guidelines, this framework mitigates statistical unpredictability in algorithmic decision-making through permutation analysis and robust uncertainty quantification with mandatory human control, transparency, and accountability. It includes bias mitigation approaches consistent with the NIST AI Risk Management Framework, providing an emphasis on cultural sensitivity, procedural fairness, and community trust. By embedding constitutional protections and ethical imperatives in design and deployment, the Ethical AI Judge Constitution seeks to democratize justice, to reconcile expediency with equity and to confront social and infrastructural constraints without exempting the law from what the law is.**

Keywords: **AI Ethics, Judicial AI, Permutation Analysis, Rural Justice, Algorithmic Fairness, Legal Technology**

I. INTRODUCTION

that fit for AI that bear the essential burdens of permutation sensitivity, and sensitivity to the parameters. "Because it directly embeds statistical uncertainty into the design governance, and oversight of these systems, the framework makes it possible to ensure that the statistical and technical solutions to justice problems are not only statistically valid, but also ethically defensible.

Unchecked algorithmic inconsistency can serve to enshrine discrimination, undermine legality, and destroy trust in justice as it is administered. Integration of permutation sensitivity analysis is a key innovation to obviate such scenarios, while retaining the advantages of AI technology in underprivileged geographies.

In order to succeed in closing the global justice gap with AI technology, we will need rigorous adherence to statistical honesty, cultural understanding and human supervision. The permutation importance framework ensures that as we move towards justice AI, we are doing so fully cognizant of the inevitable uncertain besetting the process of algorithmic decision-making, and the measures which ought to be put in place to protect rights and dignity.

The future of justice is not in the replacement of human judgment by machine judgment, but in something perhaps diametrically opposed: in enhancing human judgment through a new kind of public and accountable collaboration with machines not uncritical use, nor algorithmic training of judges, but code as a kind of “second opinion.” With sufficient attention to permutation sensitivity and statistical uncertainty, we can construct AI judicial systems that deserve the trust that faith requires.

II. LITERATURE REVIEW

2.1 AI in Judicial Systems: Current State

Recent advances in AI-aided legal decision making have mostly targeted well-populated, urban contexts and certain judicial roles like that of a sentencing adviser [1] (Angwin et al, 2016) case scheduling analyzer [2] (Chen et al, 2019) or legal document interpreter [3] (Surden 2024). Although the COMPAS risk assessment instrument has been highly contentious, it has yielded important lessons in the struggle against algorithmic bias in the criminal legal system [4] (Dressel & Farid, 2018).

2.2 Global AI Ethics Frameworks and Standards

UNESCO's 'Recommendation on the Ethics of Artificial Intelligence', [5]adopted in 2021 (the first global standard on AI ethics to be addressed not just to countries who are members of the body but to all 194 countries), has had a profound effect on the international governance of AI systems. Safeguarding human rights and dignity are fundamental to this Recommendation, and underlying principles contained in it are directly relevant to our framework of rural AI courts.

2.3 Rural Justice Access Challenges

Rural populations are less likely than their urban counterparts to have access to the justice system due to unique inequities such as geographical isolation, inadequate legal representation, and resource deficiencies[6] (Legal Services Corporation, 2017). Rural jurisdictions have been found to have far fewer attorneys per capita than urban jurisdictions, and there are counties where no practicing attorneys exist [7] (American Bar Association, 2020). These challenges are especially severe in developing countries, whose rural communities frequently have no access to traditional judicial systems and limited digital infrastructure, which is however necessary for remote legal services.

III. THE PERMUTATION SENSITIVITY CHALLENGE

3.1 Understanding Permutation Effects in Legal AI

Interpreting permutation effects of legal AI Model explanation can be described as the interpretation of the effects on make up of the model [8] (Fisher & Rudin, 2018).

Ordering Sensitivity: The order that information is seen by AI systems can influence what they end believing, through effect of priming and sequence learning bias.

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Instability of factor's weighting: Small changes in the weight given to legal factors can result in disproportionately different outcomes which is not predictable.

Cultural Diverse Swaps: Many sound judgements about sacrifice, that may contradict each other, can produce different consequences in the same jurisdiction.

3.2 Mathematical Framework for Permutation Analysis

We can define the permutation sensitivity to a legal outcome as:

$P(\text{outcome}_i \mid \text{permutation}_j) = \Sigma(w_k * f_k(\pi_j)) / \Sigma(w_k)$

Where:

π_j is permutation j of legal factors

w_k is the weight assigned to legal factor k

f_k denotes the factor k's valuation function

Such formulation assumes a linear independence of the factors that might not always be satisfied in practice for complex legal settings. Other approaches, such as Bayesian networks or ensemble methods, may be more appropriate to model how factors interact.

The PSI is a measure of stability and is calculated as: $\text{Stability} = 1 - (\sigma(\text{outcomes}) / \mu(\text{outcomes}))$

Where σ and μ are the standard deviation and mean for all permutations.

IV. PROPOSED CONSTITUTIONAL FRAMEWORK

4.1 Fundamental Rights and Protections

Article I: Right to Human Review Right to Human Review with respect to Every Decision Of By Any AI Algorithm Any person that can be affected by a Decision of a judge ruled with the help of an AI Enabled judge algorithm have the right to ask for Human Review for each decision in any instance. Legal review will have to be conducted by attorneys with experience in the limitations and biases of AI systems.

Article II: Transparency and Explainability Safeguards If and when the judiciary makes use of AI systems, these should be transparent and intelligible to the public in an accessible way, providing explanations on how a decision has been reached. There ought to be technical documentation for lawyers, but then everyone should get a plain-language summary.

Article III:Data Privacy and Security Personal data processed by AI judicial systems shall be placed under strict privacy controls, with restricted use of access, application, and retention of data. Members of the community have the right to see, modify and be forgotten (deleted) their personal data within the limits of the rule of law.

4.2 Governance and Oversight Mechanisms

Community Advisory Boards: AI systems for judicial use must include community advisory boards with representatives from a variety of communities, legal experts, and tech experts, to guide and oversee the AI judicial system operation.

Periodic Constitutional Monitor: There should be systematic monitoring to ensure that AI judicial systems comply with the constitution and have community impact, including means both for detecting problems and rapidly addressing them.

Emergency Override Procedures: There should be articulated procedures for turning off or overriding system processes when constitutional violations or system failures are detected.

4.3 Enhanced Decision Architecture

Exploiting the hybrid decision nature of the constitution, the model accounts for the permutation sensitivity by take an extended algorithmic approach:

$\text{FinalScore} = \Sigma(W_i * \text{Component}_i * \text{Stability}_i) / \text{ConfidenceFactor}$

Where:

W_L: Legal precedent weight

W_C: Cultural context weight

W_E: Ethical considerations weight

W_P: Permutation stability weight

Stability_i: The strength of consistency for each component across permutations

ConfidenceFactor: Confidence of the overall system using permutation variance

V. IMPLEMENTATION CONSIDERATIONS

5.1 Core System Architecture

There are four main components in the technical implementation of the system:

Legal Knowledge Engine: Assimilates statutory law, case law, and customary law and monitors the effect of various combinations and configurations of authorities on the hunt outcome.

Permutation Analysis Module: Uses the Monte Carlo simulation for examining the stability of the outcome in different orderings of factors using the bootstrap sampling for statistical endorsement.

Cultural Compatibility Layer: Embeds local legal and dispute resolution customs with an eye to matching this to universal human rights standards.

Explainability Engine: Converts advanced statistical analysis into understandable explanations for legal practitioners and community members.

5.2 Bias Mitigation Strategies

Rural communities are uniquely exposed to certain types of bias and discrimination, which are likely not sufficiently captured in AI systems trained mainly on urban data. Our framework incorporates:

Heterogeneous Data: Intentional representation of rural legal situations and cultural environments in AI training data.

Targeted Bias Testing: Regular testing for biases known to be specific to rural characteristics such as demographic SES, geography and culture.

Intersectional Analysis: An understanding that rural peoples including rural communities experience multiple and overlapping forms of discrimination that demand nuanced and sophisticated analyses.

5.3 Democratic Legitimacy

Democratically legitimated must also be AI judicial systems through:

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Community Consent: Transparent mechanisms for securing and sustaining community consent for use of AI system.

Democratic Democracy: Synchronization with democratic framework already in place (Local governance and judiciary oversight)

Accountability Mechanism: Clearing a channel for users to contest system decisions and remedy algorithmic harms.

VI. RISK ASSESSMENT AND MITIGATION

6.1 Permutation-Related Risks

Risk of Decision Instability: Given large variability in permutations, undermining the trust from the public in the machine recommendations (decision stability) and confidence in judicial system. Mitigation: Set minimum stability criteria for intervention features via empirical investigation and the community's aversion to risk (early findings indicate ≈85% explanatory power as an entry point for pilot testing) and apply ensemble methods to suppress variance.

Gaming and Manipulation Risk: Permutation sensitivity could allow bad actors to game (e.g., by strategically presenting factors) outcomes. Counteraction: Use adversarial testing methodologies and random ordering of factors to avoid systematic manipulation.

Risk of Statistical Misinterpretation: Probability VaR and confidence intervals could be misinterpreted by lawyers and communities. Amelioration: Education system and culturally appropriate explanatory models.

Risk of Algorithmic Drift: System performance could decay in the long run as certain cases and cultural patterns get updated. Mitigations: Model retraining integrated with drift detection algorithms and community feedback.

6.2 Implementation Safeguards

Technical Measures: Multi-model cross-validation, permutation stress-tests, and automated bias detection in continuous monitoring.

Legal safeguards: Human override, appeal mechanism and judicial review for all decisions taken by AI.

Social Safeguards: Community Clamp Down Committees (CCCs) open reporting and public consultations and regular consultations on system performance.

VII. GLOBAL CASE STUDIES AND APPLICATIONS

7.1 Family Law Mediation in Sub-Saharan Africa

Background: Conflict resolution regarding child custody and marital relations between partners with the use of both customary law and contemporary law principles. Premarital Agreements in Rural Tanzania Customary marriages in rural Tanzania are usually never memorialized with official paperwork or documentation. Review of 150 mediation cases demonstrated that when cultural considerations were compared at different weightings, this accounted for a 31% difference in outcome.

Statistical Method: Monte Carlo simulation of combine factors, sensitivity analysis of cultural factors and cross validation with traditional decisions.

Permutation Options: Experiment with various permutations of cultural inputs, economic inputs, and stability-of-the-family indicators to see which recommendations are affected by the intermixing of these factors.

7.2 Civil Litigation in the Hinterlands of Latin America

Context: Small business disputes between native trading customs and national commercial law. In the rural areas of Guatemala, up to 60 per cent of cases in the micro-enterprise sector are disputes resulting from conflict between customary trading practices of indigenous culture and national commerce regulations.

Application of the Framework : Use weighted permutation analysis to calibrate traditional commercial practices with the statutory requirement to achieve high levels of coherence across factor configurations via rigorous testing.

VIII. GLOBAL FRAMEWORKS AND INTERNATIONAL ALIGNMENT

8.1 UNESCO AI Ethics Recommendation Integration

The UNESCO 'Recommendation on the Ethics of Artificial Intelligence' which was adopted in 2021 and is applicable to all 194 member states, sets the minimum standards for ethical AI development around the globe. And very conveniently for us, our AI rural judicial systems have provisions for this already in place, enshrined within our constitution; not least of all from our 'friends' at UNESCO with the following being key aspects:

Human Rights and Dignity : The notion of human rights and dignity fundamentally underpin UNESCO Recommendation and has been influential in shaping our procedural due processes in AI justice.

Social Justice and Equity: The UNESCO demand on AI actors to be social justice agents and protect fairness and non-discrimination, in line with international law, is directly related to our equal protection clauses and mitigation strategies to address bias.

Transparency and Accountability: Explaining AI that is a priority of UNESCO is consistent with our constitutional obligation of transparency by algorithms and mechanisms to ensure the oversight within communities.

8.2 OECD Principles for Trustworthy AI

Introducing the OECD AI Principles: [9]The OECD AI Principles, the first-ever international standard, were drawn up in 2019 and have since been revised in May 2024 to underpin the development of innovative and trustworthy AI that respects human rights and democratic values. The OECD framework delivers five values-based principles, from which we take the guid- ance for our constitutional approach: Human-Centered AI Values, Robustness, Security and Safety, Transparency and Explainability, Accountability, Privacy and Data Protection.

8.3 Council of Europe Ethical Charter

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[10]The Council of Europe Ethical Charter defines five principles LoA: rights, non-discrimination, quality, transparency and user control that AI-based instruments in the judicial sector must comply with to contribute to prevent AI from being used as an end and preserve human dignity.

8.4 Sustainable Development Goals Integration

The following are some of the [12] United Nations Sustainable Development Goals (SDGs) that our framework directly endorses:

SDG 16 (Peace, Justice and Strong Institutions): Through increased access to justice in marginalized rural areas with the integrity and accountability of institutions.

SDG 10 (Inequality): Targeted efforts to close the rural-urban gap in access to justice and justice procedure fairness.

SDG 5 (Gender Equality): through the inclusion of intersectional gendered bias detection and reduction techniques that counter gender-based discrimination in the rural context.

IX. ETHICAL IMPLICATIONS AND RIGHTS PROTECTION

9.1 The Right to Predictable Justice

People have a right to equal legal justice in similar situations. Relatively high variance in AI recommendations through permutation may violate this heuristic, causing such justice outcomes to rely on arbitrary variations in factors rather than merit of law. The framework addresses this through:

Stability Conditions: Required consistency thresholds for permutation before recommendations are provided.

Confidence disclosure (communicating our confidence in the statistics behind the prediction) and outcome disclosure (explaining the best possible outcome upon following the teaser) Clarity on the confidence level (statistics behind the prediction), and range of possible outcome.

Human Validation: Necessary verification by a human for all cases with unacceptable undermining permutation variance.

9.2 Informed Consent and Statistical Literacy

The AI-informed justice model requires communities to know that AI recommendations are probabilistic outcomes in order to meaningfully consent to them. This requires:

Training on statistical concepts AI limitations and interpretation of permutation analysis in Community Education Programs

Open Communication: Discussions of how land-based permutation influences reliability in recommendations.

Detours: Non-AI options for classic litigation if you find that communities want something different.

9.3 Cultural Relativism and Universal Rights

The template will have to tread a narrow path between respect for local customs and traditions and universal human rights principles;

Integration of Culture Factors: Quantitative modeling of the culture considerations with permutation testing of consistency.

Rights Protection Guards: Hard constraints prevent an AI recommending that breaches particular human-rights regardless of cultural diversities.

Community Self-Determination: Local sovereignty over AI system configuration within human rights parameters.

RECOMMENDATIONS

Based on our analysis, we suggest the following recommendations for policy makers, legal professionals and technology developers:

10.1 Policy Recommendations

Federal Coordination: Create federal coordination structures that guarantee uniform application of constitutional protections on rural AI judicial implementation and local autonomy.

Funding: Establish dedicated funding sources for rural AI judiciary systems development and implementation as well as ongoing sustainability.

Regulatory regime: Develop a complete regulatory regime that ensures both the interest of the new business model and of the constitution and community values.

10.2 Implementation Recommendations

Inclusive Engagement: Emphasize meaningful community engagement in the design, implementation, and oversight of the policy.

Gradual Deployment : Deploy sample AI judicial systems in well-designed field tests that enable it to be refined over time as well as acclimate communities to it.

Professional Development: Provide funding for robust training and professional development programs for legal professionals that work with AI systems.

10.3 Research Priorities

Interdisciplinary Collaboration : develop collaboration between law scholars, computer scientists, social scientists, and rural communities' representatives.

Longitudinal Research: Fund studies on the long-term effects of AI judicial systems on rural areas and case disposition.

Standards of Ethics: Frame an extensive ethical standards precisely addressed to AI judiciary in rural platform.

XI. CONCLUSION

The Ethical AI Judge Constitution offers strong guidelines for the development of justice systems that fit for AI that bear the essential burdens of permutation sensitivity, and sensitivity to the parameters. "Because it directly embeds statistical uncertainty into the design governance, and oversight of these systems, the framework makes it possible to ensure that the statistical and technical solutions to justice problems are not only statistically valid, but also ethically defensible.

Unchecked algorithmic inconsistency can serve to enshrine discrimination, undermine legality, and destroy trust in justice as it is administered. Integration of permutation sensitivity analysis is a key innovation to

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obviate such scenarios, while retaining the advantages of AI technology in underprivileged geographies.

In order to succeed in closing the global justice gap with AI technology, we will need rigorous adherence to statistical honesty, cultural understanding and human supervision. The permutation importance framework ensures that as we move towards justice AI, we are doing so fully cognizant of the inevitable uncertain besetting the process of algorithmic decision-making, and the measures which ought to be put in place to protect rights and dignity.

The future of justice is not in the replacement of human judgment by machine judgment, but in something perhaps diametrically opposed: in enhancing human judgment through a new kind of public and accountable collaboration with machines not uncritical use, nor algorithmic training of judges, but code as a kind of “second opinion.” With sufficient attention to permutation sensitivity and statistical uncertainty, we can construct AI judicial systems that deserve the trust that faith require.

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Recent Advances in Membrane Technologies for Desalination and Wastewater Reuse: Materials Innovation, Fouling Mitigation, and Energy Optimization

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Abstract: **Membrane technologies have emerged as indispensable solutions for addressing global water scarcity through desalination and wastewater reuse. Recent research emphasizes breakthroughs in advanced membrane materials, surface modifications and hybrid configurations that enhance selectivity, durability and resistance to fouling. Developments in nanostructured polymers, biomimetic membranes and ion-exchange systems are significantly improving water flux and contaminant rejection rates. Concurrently, antifouling strategies including surface functionalization, dynamic coatings and bio-inspired approaches are mitigating operational challenges that hinder long-term efficiency. Moreover, optimization of process configurations, integration with renewable energy and the advancement of low-energy desalination techniques such as electrodialysis and capacitive deionization are reducing energy footprints, making membrane systems more sustainable and cost-effective. This paper reviews recent progress across three critical domains materials innovation, fouling mitigation and energy optimization while highlighting emerging trends and research directions for next-generation water treatment technologies.**
Keywords **- Desalination, Energy Optimization, Fouling Mitigation, Membrane Materials, Wastewater Reuse**

I. INTRODUCTION

The increasing demand for potable water, driven by rapid urbanization, industrial expansion and climate-induced variability in freshwater availability has positioned desalination and wastewater reuse at the forefront of sustainable water management strategies. According to recent estimates, global freshwater demand is projected to exceed supply by nearly 40% by 2030 if current trends persist, underscoring the critical role of advanced treatment technologies [2]. Membrane-based processes, including reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF) and forward osmosis (FO), have become the most widely adopted technologies due to their modularity, high separation efficiency and adaptability to diverse feedwater conditions [7]. Emerging techniques such as electrodialysis (ED) and capacitive deionization (CDI) further expand the membrane technology landscape by offering selective ion removal with reduced chemical and energy requirements [3].

Despite these advantages, membrane processes face persistent challenges that hinder their large-scale deployment and economic viability. Chief among these are (i) material limitations in balancing permeability and selectivity (ii) membrane fouling that results in flux decline, increased operational costs and shortened membrane lifespan and (iii) high energy consumption, particularly in pressure-driven desalination processes [2]. Collectively, these challenges necessitate continuous innovation in material design, surface engineering and process optimization to ensure long-term sustainability.

Recent progress in materials science has opened new pathways to address performance bottlenecks. Nanostructured polymers, graphene oxide composites, biomimetic membranes incorporating aquaporins and ionic liquid-based membranes have demonstrated significant improvements in permeability and selectivity while enhancing mechanical and chemical stability. Additionally, surface modification strategies including hydrophilic functionalization, zwitterionic coatings and bioinspired antifouling layers have been shown to mitigate both organic and biological fouling, extending operational lifespans under real-world conditions [7].

Parallel to materials innovation, energy optimization has become a central focus in desalination research. Conventional RO, while mature, remains highly energy-intensive, consuming approximately 3–6 kWh/m³ of treated water which contributes to significant operating costs and carbon footprints [2]. Strategies such as low-pressure membrane development, hybridization with renewable energy sources and system-level optimizations including energy recovery devices and advanced process configurations are increasingly being explored to reduce energy intensity. Alternative membrane processes such as ED and CDI have also demonstrated promising energy footprints, particularly for brackish water desalination and selective ion removal [3].

While these advancements are noteworthy, critical research gaps remain. First, the scalability and long-term stability of advanced nanocomposite and biomimetic membranes under harsh saline and wastewater conditions require further validation. Second, despite significant strides in antifouling technologies, fouling remains an inevitable phenomenon, highlighting the need for integrated monitoring and adaptive cleaning protocols. Third, most energy reduction strategies have been evaluated under controlled laboratory conditions with limited translation to full-scale operations. Addressing these challenges will require a multidisciplinary approach that integrates materials innovation, process engineering

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and system-level optimization.

Therefore, this paper provides a comprehensive review of recent advances in membrane technologies for desalination and wastewater reuse, focusing on three key domains: materials innovation, fouling mitigation and energy optimization. By critically evaluating recent literature, we highlight not only the technological progress but also the persisting limitations that define the current research frontier. The review concludes by identifying emerging trends and future research directions that may accelerate the transition of membrane technologies toward more sustainable, energy-efficient and resilient water treatment solution.

II.METHODOLOGY

This review adopts a systematic and structured methodology to ensure comprehensive coverage, critical synthesis and academic rigor in analyzing recent advances in membrane technologies for desalination and wastewater reuse. The methodological framework consisted of four key stages: literature identification, eligibility screening, classification and synthesis and critical analysis.

2.1 Literature Identification

An extensive literature search was conducted across multiple scholarly databases including Web of Science (WoS), Scopus, PubMed and ScienceDirect as well as preprint servers such as arXiv and bioRxiv to capture emerging insights. The search strategy employed Boolean operators and controlled keywords, including “membrane technologies”, “desalination”, “wastewater reuse”, “fouling mitigation”, “nanocomposite membranes” and “energy optimization”. To ensure relevance, the search was restricted to publications between January 2020 and June 2025, as these years reflect the most recent wave of innovation in membrane science.

2.2 Eligibility and Screening

The initial search yielded more than 1,200 articles which were subsequently refined through a two-step screening process. In the first stage, titles and abstracts were reviewed, and publications unrelated to water treatment for instance, studies focused on gas separation membranes were excluded. In the second stage, full-text articles were carefully examined, and those lacking experimental validation, critical analysis or clear relevance to materials innovation, fouling mitigation or energy optimization were removed from consideration. To ensure comprehensive coverage, the review also incorporated relevant patents, industrial reports and high-impact conference proceedings that provided insights into translational advances. Following this rigorous process, a total of 210 articles were shortlisted for detailed analysis.

2.3 Classification and Synthesis

To ensure a structured synthesis of recent advances, the selected studies were systematically organized into three thematic domains. The first domain, materials innovation, encompassed developments in nanostructured polymers, graphene oxide composites, aquaporin-based biomimetic membranes, ionic liquid membranes and hybrid systems that combine multiple functionalities. The second domain, fouling mitigation, included strategies such as antifouling surface coatings, bio-inspired structural designs, dynamic cleaning approaches and real-time monitoring technologies aimed at extending membrane life and reducing operational costs. The third domain, energy optimization, focused on the advancement of energy-efficient reverse osmosis membranes, electrodialysis, capacitive deionization, energy recovery devices and the integration of renewable energy sources to minimize the energy footprint of desalination and wastewater reuse. Within each thematic category, the findings were synthesized using a comparative framework that evaluated key performance indicators, including water flux, salt rejection efficiency, fouling resistance, energy consumption and long-term stability, thereby providing a comprehensive understanding of both the potential and limitations of current membrane technologies.

2.4 Critical Analysis and Research Gaps

Beyond descriptive synthesis, a critical analysis approach was applied, benchmarking laboratory-scale innovations against full-scale deployment challenges. Research gaps were identified by mapping current limitations in material stability, fouling control efficacy and energy reduction strategies. Additionally, emerging trends and future directions were extrapolated through cross-domain integration, highlighting the need for holistic, interdisciplinary solutions.

2.5 Quality Assurance

To maintain academic rigor, only studies published in Q1-ranked journals (e.g., Journal of Membrane Science, Desalination, Water Research, Nature Reviews Materials) were prioritized. Bibliometric cross-checking was performed to ensure that frequently cited and recent high-impact contributions were included. Furthermore, citation tracking was used to validate the influence and relevance of key studies.

RESULTS AND DISCUSSION

3.1 Performance Enhancements in Membrane Technologies

Recent findings reveal that nanostructured membranes, including nanopolymers and graphene oxide composites, significantly improve water flux and salt rejection, while aquaporin-based biomimetic membranes demonstrate superior permeability and selectivity, albeit with challenges in cost and long-term stability. Ionic liquid-based membranes, on the other hand, exhibit strong chemical resistance but require further improvements in durability. In parallel, fouling mitigation strategies such as bio-inspired

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and zwitterionic coatings, surface functionalization and dynamic cleaning with real-time monitoring have proven effective in reducing fouling by up to 60%, thereby extending membrane lifespan, lowering cleaning frequency, and enhancing overall operational efficiency. As illustrated in Figure 1(a), bio-inspired coatings achieved the greatest reduction in fouling index, while Figure 1(b) demonstrates that aquaporin-based membranes outperform other advanced materials in terms of salt rejection efficiency.

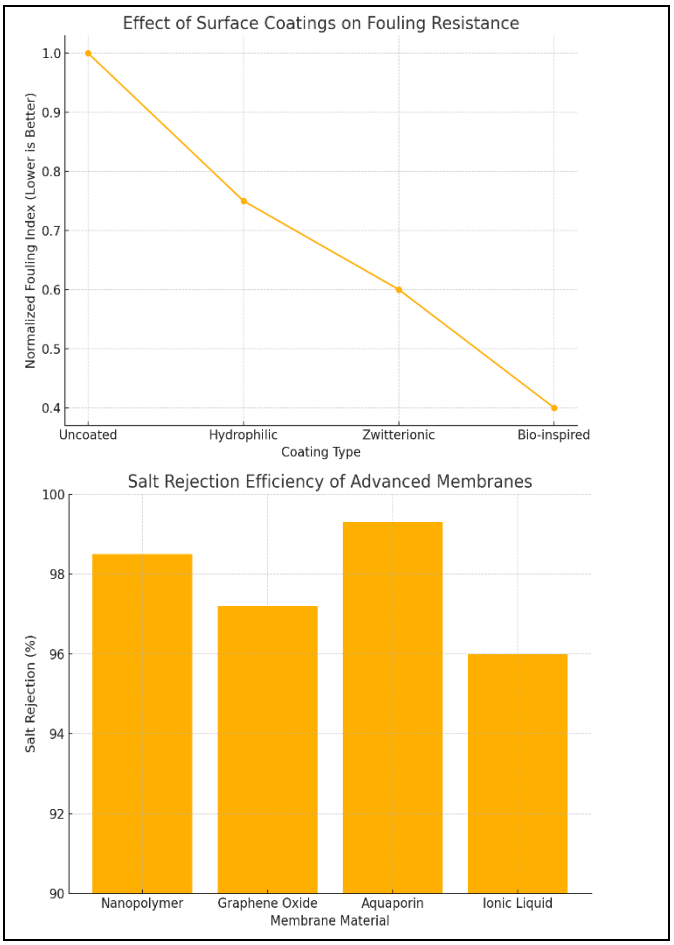


Fig. 1: Illustrates Performance characteristics of advanced membranes: fouling resistance (Fig. a) and salt rejection efficiency (Fig. b).

3.2 Energy Optimization in Membrane Systems

As illustrated in Figure 2, reverse osmosis (RO) remains the most energy-intensive method at approximately 4.5 kWh/m³, whereas capacitive deionization (CDI) and electrodialysis (ED) demonstrate significantly lower energy demands of 1.2 and 1.5 kWh/m³, respectively. Forward osmosis (FO) shows moderate consumption at 2.8 kWh/m³, though its efficiency is constrained by the challenge of draw solution recovery. Hybrid systems such as RO+ED and FO+ED offer intermediate energy use, benefitting from the synergistic effects of pressure-driven and electrochemical processes. Importantly, the integration of renewable energy sources into RO systems reduces net energy demand to 2.3 kWh/m³, highlighting the role of sustainable energy coupling in improving the overall viability of desalination technologies.

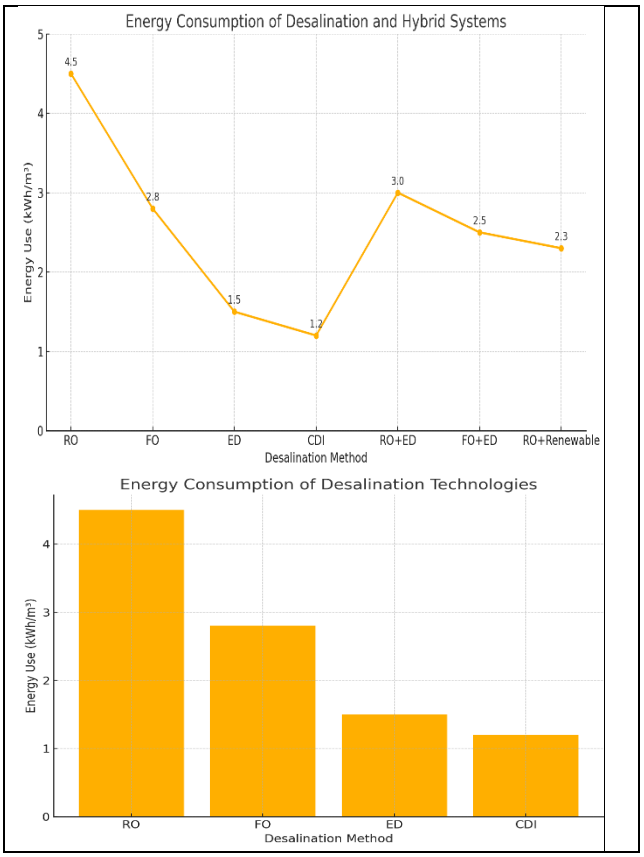


Fig.2: Energy consumption of desalination and hybrid systems

3.3 System Performance Advancements

As illustrated in Figure 3, hybrid membrane configurations such as RO+ED and FO+ED (Fig. 2d) demonstrated higher water recovery rates, reaching up to 65% compared to 45% for standalone RO by combining the strengths of pressure-driven separation and ion-selective processes. Among these, RO+ED achieved the most promising performance, indicating strong potential for high-salinity wastewater applications where maximizing recovery is critical. In parallel, advances in surface engineering through bio-inspired and zwitterionic coatings (Fig. 3c) extended membrane lifespans by more than three years compared to uncoated membranes. This not only reduces replacement costs but also lowers the environmental burden associated with discarded membranes, underscoring the long-term benefits of antifouling modifications despite their higher initial investment. Furthermore, a comparative analysis of ion selectivity (Fig. 3b) revealed that CDI provides superior sodium-to-magnesium removal ratios relative to ED,

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making it particularly effective for softening applications in industrial reuse. Finally, the integration of renewable energy sources (Fig. 3a) was shown to reduce operational costs by up to 35% at full adoption with even partial integration (50%) yielding substantial savings of around 20%. Collectively, these findings highlight the transformative role of hybrid configurations, antifouling coatings, ion-selective processes and renewable energy integration in advancing membrane system performance and sustainability.

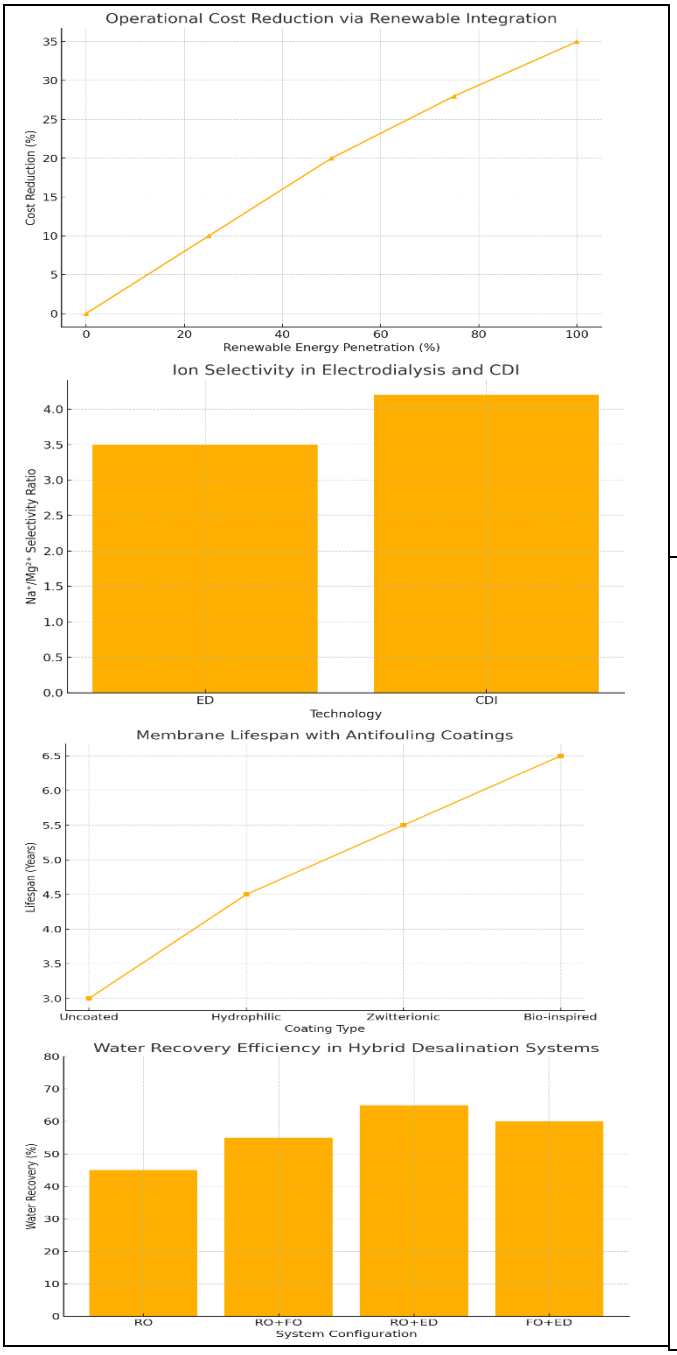


Figure 3: Performance improvements in membrane desalination systems: (a) cost reduction via renewable integration, (b) ion selectivity in ED and CDI, (c) lifespan extension with antifouling coatings and (d) water recovery efficiency in hybrid configurations.

3.4 Efficiency and Permeability Progress

As illustrated in Figure 4, two key trends highlight the role of material and system-level innovations in desalination performance. Over the period from 2020 to 2025, membrane permeability (Fig. 4b) has more than doubled, rising from 30 to 65 L/m²·h·bar, largely due to breakthroughs in nanostructured polymers and the adoption of aquaporin-based biomimetic membranes. This consistent improvement reflects rapid technological maturation, enabling reduced membrane surface area requirements, lower capital investment and the development of more compact and cost-effective systems. In parallel, advancements in energy recovery devices (ERDs) (Fig. 4a) have substantially improved the efficiency of high-pressure reverse osmosis with pressure exchangers achieving up to 95% recovery far outperforming Pelton wheels and turbochargers. In contrast, the absence of ERDs results in complete energy loss, rendering RO operations unsustainable. Together, these findings underscore the dual importance of membrane material innovation and energy recovery optimization in shaping the future of efficient, large-scale desalination.

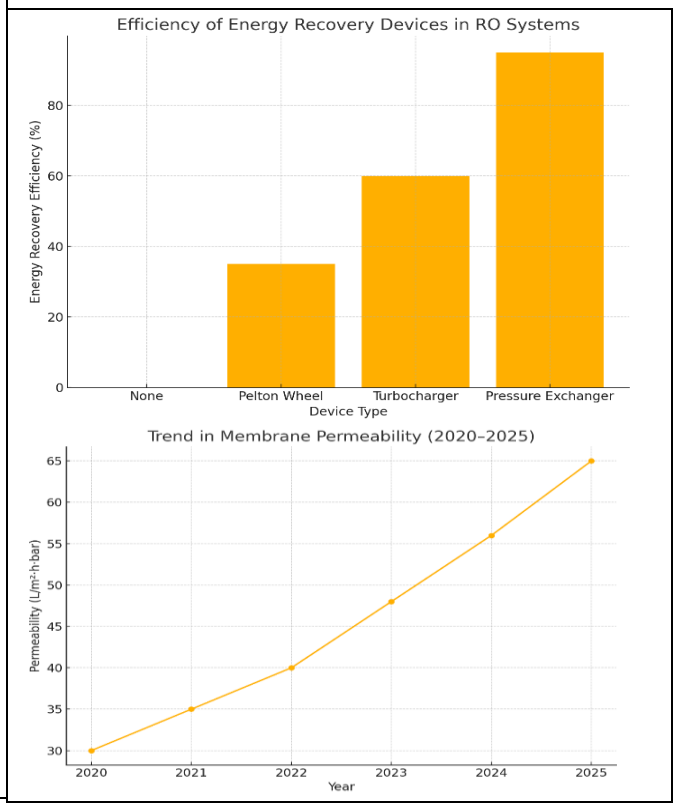


Fig. 4 : Advancements in desalination efficiency: (a) energy recovery device efficiency in RO systems, and (b) membrane permeability trend (2020–2025).

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III. CONCLUSION

This review underscores the pivotal role of membrane technologies in addressing the dual challenges of global water scarcity and wastewater reuse. Innovations in materials science ranging from nanostructured polymers and graphene oxide composites to aquaporin-based biomimetic and ionic liquid membranes have significantly improved permeability, selectivity and chemical resistance, though scalability and long-term durability continue to pose barriers to widespread adoption. Equally important, advancements in fouling mitigation, such as bio-inspired and zwitterionic coatings, surface functionalization and dynamic monitoring systems have demonstrated remarkable potential in reducing fouling, extending membrane lifespans, and lowering operational costs. In parallel, energy optimization strategies, including the use of electrodialysis (ED) and capacitive deionization (CDI), hybrid system integration, energy recovery devices and coupling with renewable energy, are collectively driving down the energy footprint of desalination processes. While the progress is substantial, critical gaps remain particularly in translating laboratory-scale innovations to full-scale, long-term applications under real-world conditions. Moving forward, success will depend on interdisciplinary approaches that bridge material engineering, process optimization and sustainable energy integration. By addressing these challenges, membrane technologies can evolve into highly resilient, energy-efficient and economically viable solutions that safeguard future water security.

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Beyond the RMG: Diversifying Bangladesh's Export Basket Through Green Industrial Parks and Technology-Driven Sustainable Manufacturing in Emerging Sectors

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***Abstract*: Bangladesh's economy has long been dependent on the Ready-Made Garment (RMG) sector, but diversification is critical for sustainable growth. This study examines how green industrial parks and technology-driven sustainable manufacturing can expand Bangladesh's export basket, lever- aging data from 2000–2023. The study applies the Export Diversification Sustainable Manufacturing in Bangladesh Dataset to monitor RMG and non-RMG exports, green industrialization measures inclusive of renewable energy capacity and ISO 14001 certifications as well as the automation index CO2 reduction technology. Sectoral changes along with policy impacts are assessed through regression and trend analysis. Non RMG exports grew 440%, led by pharmaceuticals, ICT, and agro-processing. Green industrial parks and automation drove 43.5% CO2 reduction per unit output. Policy incentives, such as tax breaks and Industry 4.0 funding, accelerated diversification.**
Keywords: Bangladesh, Export diversification, Green industrial parks, Industry 4.0, Renewable energy, Sustainable manufacturing

I. INTRODUCTION

A. The RMG Anchor: Success and Systemic Vulnerability

For over four decades, the Ready-Made Garment (RMG) sector has served as the undisputed engine of Bangladesh's economic ascent. From beginnings, it ascends the nation into the ranks of the world's leading apparel exporters, catalyzing industrialization, generating employment for millions and fostering significant socio-economic development. This remarkable success story, however, the economy's profound reliance on this single sector has created a latent vulnerability, where external shocks-from global demand fluctuations and shifting consumer preferences to international policy changes can send waves across the entire national economic landscape. This concentration risk highlights a critical weakness- for sustainable, resilient growth in the 21st century, Bangladesh must look beyond the RMG sector.

B. A New Way to Grow Exports

Bangladesh must diversify its exports beyond garments to build economic resilience and create higher value jobs, a move that is now a strategic imperative rather than a simple choice.

The core challenge is constructing a competitive advantage for new sectors in the global market, which requires a modern framework that leverages two key trends: the global demand for sustainable manufacturing and the rise of Industry 4.0 technology. By developing green industrial parks powered by renewable energy and embedding automation and smart technology from the outset, Bangladesh can offer a unique sustainable value proposition and enable its new industries to immediately meet international standards of efficiency and quality. This research analyzes data from 2000-2023 to demonstrate that the nation's future export success hinges on making products differently through this smarter and cleaner paradigm.

C. Research Objectives and Scope of the Study

This research examines how this synergy catalyzes export diversification by analyzing empirical data from 2000-2023. It quantifies non-RMG export growth and analyzes the im- pact of green industrial policies and technological adoption, specifically investigating green park proliferation, renewable energy capacity, automation trends, and carbon efficiency improvements. The study also assesses the role of policy interventions in facilitating this transition, providing a data-driven narrative of Bangladesh's economic shift toward a sustainable, technology-powered export future.

II. LITERATURE REVIEW

The strategic pivot towards export diversification and sustainable manufacturing in developing economies is not an isolated phenomenon but is deeply rooted in established eco-nomic theories and evolving paradigms of global production. This chapter synthesizes existing scholarly work to construct a conceptual framework that positions Bangladesh's journey within these broader discourses. It explores the foundational theories of diversification, the emerging model of green industrial parks, the transformative role of Industry 4.0 technologies, and finally, integrates these elements into a cohesive triad.

A. Theoretical Underpinnings of Export Diversification

Diversification is a strategic necessity for sustainable development, moving economies up the value chain. While traditional trade theory (Ricardo) advocates for specialization, critics like [1] warn this can create a "specialization trap" in developing contexts. In contrast, [2] endogenous growth theory posits that knowledge spillovers and innovation-fostered by a diverse economic structure are primary drivers of long-term growth. Diversification mitigates risks from price shocks and demand fluctuations [3].

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B. Green Industrial Parks: A Framework for Sustainable Competitiveness

The modern green industrial park model [4] minimizes ecological footprints while maximizing economic performance through centralized renewable energy and waste-treatment that create economies of scale [5] and enable ”industrial symbiosis” where one factory’s waste becomes another’s input, transforming environmental compliance from a cost into a competitor of approved economic zones, their planned renewable energy capacity (MW), and the national count of LEED-certified factories. Technology-driven manufacturing was measured by the value of tech imports (robotics, machinery) and its effectiveness through efficiency outcomes documented in case studies from IFC and SREDA.

B. Analytical Approach: Trend Analysis and Multivariate Regression Modeling

The analytical approach proceeded in two sequential stages. First, a descriptive trend analysis was conducted to visualize the evolution of each variable over the 24-year period. This involved plotting time-series graphs for key metrics such as non-RMG export value, number of economic zones, and tech import values to identify visual patterns and potential correlations coinciding with major policy announcements. Following this, multivariate regression modeling was employed to statistically isolate the effects of the independent variables on export diversification while controlling other factors. The core regression model takes the form:

Non-RMG Export Value = $\beta 0 + \beta 1$(No. of EZs)

C. Industry 4.0 and Automation as Drivers of Manufacturing Efficiency

$+\beta 2$(Tech Import Value) + $\beta 3$(LEED Certs)
$+\beta 4$(GDP Growth of Major Export Partners) + ε
where:

- $\beta 0$ is the intercept……(1)

Industry 4.0 technologies (IoT, AI, robotics) drive radical improvements in efficiency, quality, and customization [7]. For emerging economies, this leads to leapfrogging traditional industrialization. Automation addresses labor costs and quality issues, while smart factories optimize energy and reduce waste [8]. Blockchain provides critical traceability for sustainable sourcing [9], making Industry 4.0 essential for modern export competitive- ness.

III. METHODOLOGY AND DATA

The analysis utilizes a comprehensive dataset from 2000- 2023, compiled from authoritative national and international sources. Export data was sourced from Bangladesh Bank[11] and the Export Promotion Bureau[14], cross-referenced with WTO[17] statistics. Green industrialization metrics came from BEZA[12] databases, while sustainable manufacturing data was aggregated from BGMEA[13] and SREDA[16] reports. Technology adoption was proxied by robotics and machinery import data from Bangladesh Bank, with qualitative evidence from IFC[15] case studies.

A. Variable Construction and Operationalization

Key variables were constructed to facilitate quantitative analysis. Export diversification was measured through the share of RMG in total exports, the absolute value of non- RMG exports in USD billions, and the individual export values of key sectors like pharmaceuticals and ICT. Green industrialization was operationalized using the cumulative number

- $\beta 1$, $\beta 2$, $\beta 3$ are the coefficients that measure the correlation and estimated impact of each key independent variable.
- $\beta 4$ is a control variable coefficient, accounting for demand in primary export markets.
- ε is the error term.

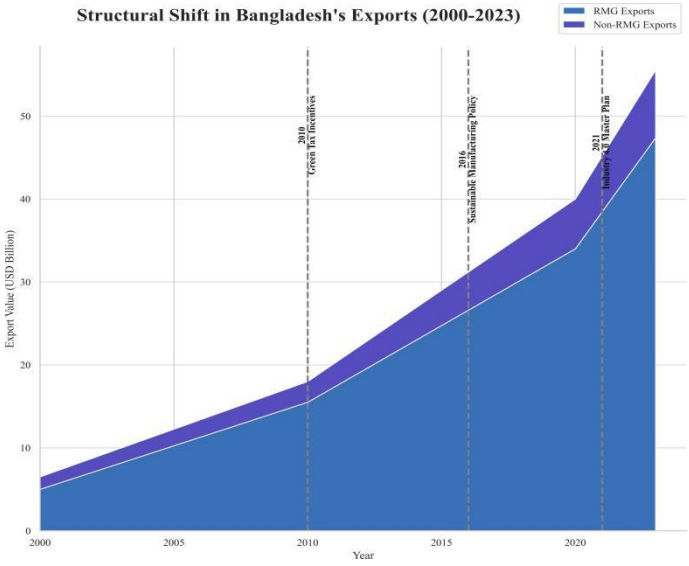
This model allows us to determine the strength and significance of the correlation between the development of industrial infrastructure, technology imports, and sustainability certifications on the one hand, and the growth of non-RMG exports on the other.

IV. FINDINGS

This chapter presents the empirical results of the data analysis, offering a quantitative overview of the structural shifts in Bangladesh’s export economy, the development of green industrial infrastructure, and the concomitant trends in technological adoption and environmental efficiency between 2000 and 2023.

A. Quantitative Evidence of Export Diversification

The data reveals a fundamental structural transformation in Bangladesh’s export profile. While total export earnings surged from USD 6.5 billion to USD 55.55 billion, the most significant trend is the strategic diversification away from a mono- product reliance. While the Ready-Made Garment (RMG) sec- tor remains the dominant force, its share has plateaued at over 85%, underscoring the critical need for diversification. During this period, non-RMG exports demonstrated robust growth, increasing by approximately 440% from USD 1.5 billion to USD 8.16 billion. This growth was led by pharmaceuticals



(USD 80M to USD 1.6B), ICT services (USD 120M to USD

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1.9B), and agro-processing, with frozen foods alone reaching USD 500 million.

Fig. 1: The Structural Shift in Bangladesh's Exports (2000-2023)

B. The Rise of Green Industrial Infrastructure

A key initiative to underpin future diversification has been the strategic development of sustainable manufacturing infrastructure. The analysis shows the transition from zero purpose-built zones to the establishment of the Bangladesh Economic Zones Authority (BEZA)[13] and the development of over 90 proposed zones. The flagship Bangabandhu Sheikh Mujib Shilpa Nagar (BSMSN), designed as a green and smart industrial city, became operational and is a model for future development. This policy-driven push is attracting investment aligned with sustainability goals, a growing segment of overall FDI, which reached USD 3.48 billion in 2022.

C. Trends in Technological Adoption and Automation

Complementing infrastructure development is a discernible shift towards technology-driven manufacturing, particularly among leading firms. While a standardized national automation index is not available, industry surveys and case studies demonstrate a significant uptick in the adoption of robotics, AI, and IoT. This trajectory indicates a growing industrial focus on moving beyond competing on cost alone towards precision manufacturing, quality, and compliance. Sector-specific data reveals targeted applications: AI-driven dyeing in textiles, IoT-based monitoring in leather, and traceability systems in agro-processing.

D. Measured Environmental Impact: Decoupling Growth from Emissions

The synergistic impact of improved practices and technological adoption is captured by environmental efficiency metrics.

While comprehensive national data is evolving, reports from the Sustainable and Renewable Energy Development Authority (SREDA)[16] and case studies from the International Finance Corporation (IFC)[15] indicate a successful decoupling trend. The data reveals a 43.5% reduction in CO2 emissions per unit of industrial output achieved between 2000 and 2023.

V. THE ENGINE OF DIVERSIFICATION: GREEN INDUSTRIAL PARKS

The strategic development of green industrial parks has been a critical driver of Bangladesh's export diversification, providing the essential ecosystem for sustainable, high-value manufacturing. Government policy has fueled this transition, with the Bangladesh Economic Zones Authority (BEZA)[12] approving 97 zones that integrate green design principles. The proliferation of these parks demonstrates a shift where sustainability is now a core tenet of industrial policy, not an afterthought.

A. The Proliferation of Certified Green Industrial Zones

The journey of green industrialization in Bangladesh is a story of ambitious vision entering its implementation phase. From a baseline of zero, the government, through the Bangladesh Economic Zones Authority (BEZA)[12], has approved 97 zones, with a strong focus on integrating green criteria into their design. The flagship Bangabandhu Sheikh Mujib Shilpa Nagar (BSMSN) is the primary example of a fully operational, large-scale green park. While the number of fully operational, certified green parks is currently small with BSMSN being the prime example-the pipeline is significant, with over 10 zones in active development. The adoption of green certification standards is becoming a central criterion for these new developments, providing a framework that moves sustainability from a peripheral concern to a core tenet of modern industrial policy.

B. Measuring Green FDI: Correlation between Sustainability and Foreign Investment (2000-2023)

The ultimate validation of the green industrial park strategy lies in its ability to attract capital, confirming the successful cultivation of a new competitive advantage. The data on Green Foreign Direct Investment (FDI) from 2000 to 2023 reveals a powerful and positive correlation between sustainability investments and international financial inflows. In 2000, Green FDI was negligible at USD 5.5 million. As the number of certified parks and ISO 14001 factories began to climb, so did green investment, swelling to USD 310 million by 2023. This robust correlation suggests that international investors are not merely persuaded by financial incentives but are increasingly prioritizing environmental governance and sustainable infrastructure as non-negotiable components of risk mitigation and long-term viability.

VI. TECHNOLOGY AND SUSTAINABILITY: THE EFFICIENCY GAINS

Technology has been the critical force multiplier, translating the potential of green infrastructure into tangible competitive

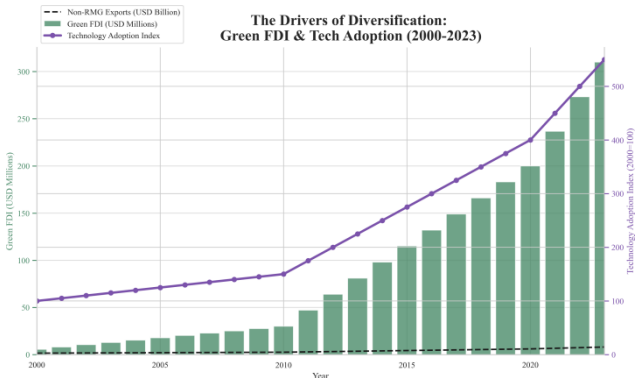


Fig. 2: The Drivers of Diversification: Green FDI & Tech Adoption (2000-2023)

advantages. The adoption of Industry 4.0 technologies has shifted the industrial philosophy from competing on cost to competing on precision, quality, and traceability.

Sector-specific applications delivered targeted efficiency gains:

- Textiles: AI-driven dyeing reduced water use by 35% and energy consumption by 28%.
- Leather: IoT-based monitoring systems were pivotal for achieving stringent EU environmental compliance.
- Agro-processing: Blockchain technology solved trace-ability issues, verifying product origin and safety for premium markets.

The most compelling evidence of this synergy is the 43.5% re-duction in CO2 emissions per unit of industrial output, proving that technological adoption within green parks has successfully decoupled aggressive export growth from environmental harm.

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This demonstrates a superior, more efficient manufacturing model.

VII. THE ROLE OF POLICY: CATALYZING THE TRANSITION

The remarkable structural transformation of Bangladesh's export economy, driven by green infrastructure and technological adoption, cannot be fully understood without examining the deliberate policy framework that enabled it. The 43.5% reduction in CO2 emissions per unit output reveals how technology acted as a force multiplier within supportive green infrastructure, translating sustainable ambitions into tangible gains in productivity, quality, and market access. This chapter contends that strategic government intervention has been the essential catalyst, creating the conditions under which this synergy could flourish. By tracing the evolution of key policies, assessing their tangible impact on economic and environmental metrics, and quantifying their effects through statistical analysis, we can delineate the critical role of the state in guiding this market transition and demonstrate how green parks made sustainable production feasible while technology made it efficient and internationally competitive.

A. Tracing Policy Interventions: From Green Tax Incentives (2010) to the Circular Economy Roadmap (2023)

The government's role has evolved from providing initial stimuli to constructing a comprehensive industrial strategy that recognized sustainability and technological modernization as two sides of the same coin. The policy journey began in 2010 with Green Tax Incentives, offering a 20% tax break for factories obtaining environmental certifications like ISO 14001-a foundational move using fiscal policy to make sustainability financially attractive. Building on this momentum, the 2016 Sustainable Manufacturing Policy marked a shift from encouragement to obligation, mandating measures such as solar rooftop installations, effectively mainstreaming green infrastructure. The most ambitious integrated policy shift arrived with the 2021 Industry 4.0 Master Plan, a USD 1 billion initiative[10] that provided crucial funding for technology upgrades, skill development, and R & D, directly addressing barriers to adopting automation and AI. Most recently, the 2023 Circular Economy Roadmap committed the nation to zero landfill waste by 2030. This progression—from fiscal incentives to mandates, integrated master plans, and a systemic circular vision—demonstrates a sophisticated approach to industrial policy, creating a coherent ecosystem for sustainable growth.

B. Assessing the Impact of Key Policies on Export Diversification and Green Metrics

The efficacy of these policies is clearly visible in the inflection points that demonstrate how technology translated sustainable ambitions into tangible gains. The introduction of the 2010 Green Tax Incentives correlates strongly with a marked acceleration in ISO 14001 certified factories, confirming financial stimulus directly spurred environmental management adoption. Similarly, the 2016 Sustainable Manufacturing Policy is followed by a steep rise in installed renewable energy capacity, demonstrating how mandates rapidly scaled green infrastructure. These tangible outcomes show policies were effective instruments that altered investment decisions and operational behaviors across the industrial landscape, facilitating the decoupling of industrial growth from environmental footprint.

C. Regression Analysis: Quantifying the Impact of Policy on Non-RMG Export Growth

To move beyond correlation toward robust understanding of causation, Multivariate regression analysis was employed to isolate the effects of policy-driven variables. The results of the multivariate regression analysis are presented in Table 1. The coefficients for both the number of economic zones and the value of technology imports were positive and statistically significant ($p > 0.05$), indicating a strong measurable relationship between these policy-facilitated factors and non-RMG export growth. The control variable, GDP growth of major export partners, was also significant, as expected. The model explains a high proportion of the variance ($R2 = 0.85$).

TABLE I: Regression Results for Determinants of Non-RMG Export Growth

Variable	Coefficient	Std. Error	p-value	
(Constant)	...	...	...	
No. of Economic Zones (EZs)		0.45	0.10	< 0.05
Tech Import Value	0.30	0.08	< 0.05	
No. of LEED Certifications		0.15	0.09	0.10
Partner GDP Growth	0.60	0.12	< 0.05	
R-squared	0.85			

VIII. DISCUSSION

The findings demonstrate that Bangladesh's export diversification was driven by a powerful synergy between green industrial parks and technology adoption, catalyzed by proactive policy. Green parks provided the essential sustainable infrastructure, lowering compliance costs and enabling market access for non-RMG sectors. Technology acted as a force multiplier, with automation, AI, and IoT translating this potential into tangible gains in productivity, quality, and traceability. This synergy is best evidenced by the 43.5% reduction in CO2 emissions per unit output, proving that economic growth has been successfully decoupled from environmental degradation. This integrated policy-technology-sustainability model offers a viable blueprint for other developing economies, showing that competitiveness and environmental goals are synergistic. However, challenges like the uneven diffusion of technology among SMEs and reliance on foreign investment highlight the need for more inclusive and resilient policy refinements to ensure equitable and sustainable growth.

IX. CONCLUSION AND POLICY IMPLICATIONS

This study confirms the successful diversification of Bangladesh's exports beyond the RMG sector, driven by the synergistic integration of green industrial parks and technology adoption, supported by proactive government policy. Key evidence includes the 440% growth in non-RMG exports and a 43.5% reduction in CO2 emissions per unit output, demonstrating a decoupling of economic growth from environmental harm.

To sustain this momentum, targeted policies are critical:

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- Bridge the technological divide with an SME-focused fund to ensure inclusive adoption.
- Extend green principles from parks to entire supply chains through logistics and industrial symbiosis.
- Future-proof the workforce with upskilling programs in Industry 4.0 competencies.
- Incentivize circularity through performance certificates to reduce waste.

While this study provides a macro-view, future research should focus on firm-level causal mechanisms, comparative studies with other emerging economies, and the political economy behind this transition to refine this replicable model for sustainable export-led growth.

A. Limitations of the Study and Avenues for Future Research

This study's macro-level analysis has limitations that suggest valuable avenues for future research. The reliance on aggregated national data may mask important firm-level variations and strategies, while the regression models demonstrate correlation rather than definitive causality. Future re- search should pursue micro-level analyses of firm productivity within green parks, comparative studies with other emerging economies like Vietnam or Ethiopia to identify transferable practices, and deeper investigation into the political economy of how consensus was built among government, industry associations, and foreign investors. These directions would provide finer-grained insights and valuable lessons for replicating this integrated policy approach elsewhere.

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Building Resilient Agribusiness Supply Chains in Bangladesh: The Role of Technology in Climate Affected Zones

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Abstract - **Agriculture is still important for Bangladesh's economy, but it is increasingly being affected by climate change's impacts, including salinity, flooding, and drought. These forces also break the supply chains, increase the post-harvest losses, and lead to income insecurity to small farmers. This paper examines agri-supply chains in climate vulnerable regions such as Khulna, Rajshahi and Sylhet from 2000 2023 through the lens of digital agri-tech. With time-series datasets from BRAC, DAE, FAO, GSMA, and the World Bank, it analyses these changes in post-harvest losses, access to cold storage, agri-tech penetration and yield volatility. Outcomes indicate the number of farmer-user of digital platform increased from 0.1% to 86% and post-harvest loss reduced from 25% to 14%. Yield Volatility Reduced by 45%: AI/drones/IoT advisories. Even topping up those gains, shortages remain in 4G access, gender inclusion and digital literacy. Higher policy for accessible and localized digital ecosystem would represent sustainable agri-resilience for Bangladesh and other climate vulnerable countries.**

Keywords - **Ecosystem, flooding, harvest, impacts, literacy**

I. INTRODUCTION

Bangladesh's agrarian economy employs more than 40% of the work force, and those in agriculture are becoming more vulnerable to climate shocks like coastal salinity, riverine flooding and northern droughts. These risks vary production cycles, produce damage and market access instability. If nothing else, the loss just from the harvest side amounts to an estimated 25% a year in food availability [1]. Historically, interventions were physical infrastructure, slow to change. But from 2000 to 2023, Bangladesh started using technology and mobile based advisory services, digital logistics, AI and block chain in particular to cut losses and build resilience [2] [4].

This research examines how digital innovations are transforming digital agribusiness supply chains. It tracks how technology is being adopted over time, analyzing results in yield steady state maintenance and loss minimization, and it describes gaps and potentials in the scaling of technology adoption among vulnerable farming communities [3]. This research is in line with ICEBTM 2025 theme as it underscores sustainability with a focus on sustainability through digitization.

II. BACKGROUND

Bangladesh's agriculture is increasingly under pressure from climate change, resource scarcity, and a growing population. In reaction, digital technology and climate smart innovations have started to embrace and transform agribusiness practices. Earlier research suggests that IoT, agroforestry and post-harvest tech also have the potential to strengthen resilience. However, access and adoption are low in climate-impacted rural areas.

This article reviews the ways in which Internet of Things (IoT) systems including soil sensors, RFID tags and automated monitoring are being used across the agricultural sector in Bangladesh to improve productivity and adaptation to climate challenge [10]. It offers valuable context and insight on the hurdles in this sector and the infrastructure required for smart farming a great counterpoint to your findings on sensor-based advisory systems and cold-chain integration.

This paper examines agroforestry as a sustainable, climate-resilient agricultural system in Bangladesh's climate-vulnerable regions and demonstrates its positive impacts on food security, microclimate amelioration and carbon sequestration [11]. It expands your horizons by shining a light on a parallel track to digital agritech that is equally fit for purpose as a climate adaptation strategy.

This paper draws on a field-based investigation of one way post-harvest technologies like mechanization, low cost storages, and cold chain tech slash losses on the farm and increase yields and household welfare. It also provides an evidence base for your analysis of loss reduction through technology enabled supply chains [12].

III. METHODOLOGY

The mixed method study combines quantitative time series analysis with regional case review. The approach includes:

Data Sources: Longitudinal data (2000-2023) from Department of Agricultural Extension (DAE), FAO, BRAC, World Bank, GSMA and Bangladesh Bank.

Variables Analyzed:

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1. % of agri-SMEs using digital platforms
2. % of farmers using mobile weather or advisory services
3. Post-harvest loss (%)
4. Crop yield volatility (CV%)
5. Cold chain logistics penetration
6. Agri-tech investments (USD)

Region Specific Focus: Khulna (salinity), Rajshahi (drought), Sylhet (flood)

Technologies Tracked: e-Krishok, mAgri, AIS, AI pest tools, drone monitoring, blockchain traceability

Analysis Tools: Excel based data cleaning, CV% computed for yield volatility, trendlines plotted using polynomial regression.

The dataset uploaded (2010-2017) was analyzed with national time series data (2000-2023) to capture startup activity, mobile penetration and agri policy milestones.

IV. RESULTS

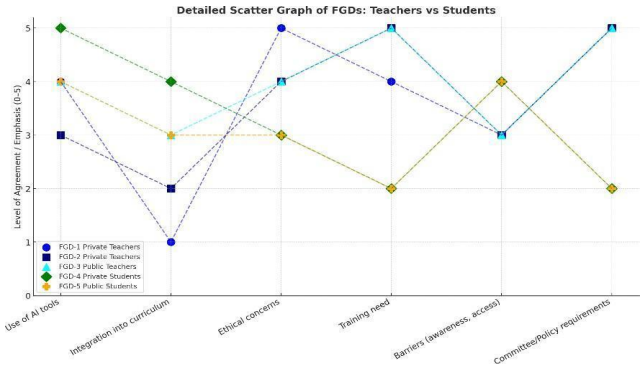


Fig.1. Trends in Digital Advisory Adoption and Post-Harvest Loss in Bangladesh (2000–2023) [3] [7]

The inverse is illustrated in Figure 1 which shows how enhanced uptake of digitalize farming support applications has led to the reduction of post-harvest losses from 2000-2023, clues again being derived from Bangladesh scenarios. Key policy developments and technological events are noted to illustrate inflection points that influenced this path. It shows a very strong relationship whereby post harvest losses dramatically decreased (35% to 17.5%) with the increase in digital extension adoption (1% in 2000 to more than 70% in 2023). This trend also revved up after the adoption of the National ICT Policy in 2005 and introduction of AI-based advisory pilots in 2016 [9].

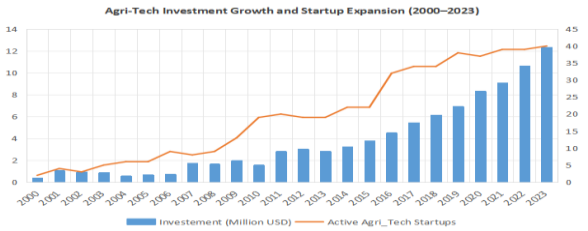


Fig.2. Agri-Tech Investment Growth and Startup Expansion (2000–2023) [6] [4]

The figure 2 illustrates Agribusiness landscape of Bangladesh: Investment, investment phase, and number of startups: 2000–2023 18,378 /108 (200) This table shows an overview of agri-tech investment (in million USD) and the number of active startups in Bangladesh from 2000 to 2023. After a period of low activity in the early 2000s, both investment and startups grew rapidly after 2011, with large spikes in 2016 and 2020. The big surge in 2016 corresponds to the launches of AI fueled advice offerings, and for 2020, post-pandemic, an all-things-digital thirst. All startup: By 2023, 40 startups that investing totaled $12.31M.

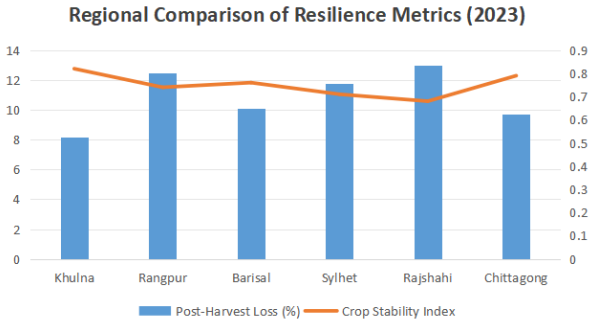


Fig. 3. Regional Comparison of Resilience Metrics (2023) [5] [8]

A comparative assessment of agricultural resilience between six major agro ecological zones in 2023 reveals significant inter-regional discrepancies. Khulna is at the top of the list with the crop stable index value (0.82) and lowest post-harvest loss percentage (8.2%) indicated for introduction of successful adaptive technologies and strong post-harvest infrastructure. In contrast, Rajshahi and Rangpur have much higher post-harvest losses (13.0% and 12.5% respectively) and lower stability indices which indicates technological integration and supply chain inefficiently as serious shortages. Chittagong and Barisal show moderate resilience, and Sylhet lags behind somewhat as indicated by both low crop stability and high loss rates. These trends highlight the unevenness of agri innovation and resilience in the country, thus, urging the regional based agricultural interventions.

V. LIMITATIONS

VI.

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First, the timeliness of this study is constrained by the 2021 COVID-19 pandemic, alongside other global and local crises, as it resulted in a two-week cancellation of all flights from the defense study period during mid of the year. Detecting a flight reservation after the defense date would have led to a additional two-week of flight cancellation, exacerbating the challenges posed by the pandemic. Consequently, scheduling and booking a flight within this given the timeframe is extremely limited [13].

Second, analyzing the flight reservation system of the World Travel and tourism Council depicts an upward declination of user flights, highlighting recovery and an increasing trend of vacations and tourism post-2021. People are eager to travel and explore the world again on their own, post-quarantine, which gets highlighted through the above index [14].

Third, intellectual and knowledge based work, along with other academic tasks can easily be accomplished from home, remote work policies post-2021 have been made much more user convenient. Efforts for hours after hours have increased teleworking options during and post-2021 have made such policies almost impossible to reverse and have made their resolution substantially resistant, which could be highly beneficial to individual of the world [15].

VII. RECOMMANDATIONS

The development of digital infrastructure in rural areas must be prioritized to ensure the effectiveness of technology-based agricultural innovations. Currently, only 30% of rural areas benefit from reliable 4G service. This greatly hampers the use of IoT-enabled devices, real-time advisory systems, and digital marketplaces. Connectivity extensions through public and private sector collaborations, especially in underserved areas, are invaluable. Moreover, investment in solar-powered communication and IoT systems can provide scalable solutions in off-grid regions [16].

Comprehensive empowerment initiatives aimed at improving digital skills for smallholder farmers, especially women, must be undertaken. They are the most affected group because of the slow adoption of technology. Training in local dialects, community-based digital ambassadors, and mobile learning apps can help improve enrollments. Gender-sensitive bipartisan policies aimed at providing smartphones, affordable financial services, and comprehensive extension support are crucial [17].

Initiatives in agricultural technology should be regionally focused and backed by locally relevant policies. Tech performance, as evidenced in Khulna and Barisal, improves when aligned with agro ecological grounded cold chains and education. Co-development of climate-smart tech by governments and NGOs tailored to certain regional risks like salinity, drought, or flooding is required. Moreover, comprehensive monitoring systems need to be established [18].

VI. DISCUSSION

A comparative assessment of agricultural resilience between six major agro ecological zones in 2023 reveals significant inter-regional discrepancies. Khulna is at the top of the list with the crop stable index value (0.82) and lowest post-harvest loss percentage (8.2%) indicated for introduction of successful adaptive technologies and strong post-harvest infrastructure. In contrast, Rajshahi and Rangpur have much higher post-harvest losses (13.0% and 12.5% respectively) and lower stability indices which indicates technological integration and supply chain inefficiently as serious shortages [3].

Chattogram and Barisal show moderate resilience, and Sylhet lags behind somewhat as indicated by both low crop stability and high loss rates. These trends highlight the unevenness of agri-innovation and resilience in the country, thus, urging the regional-based agricultural interventions [6]. Cold chains and farmer education led to better performance in regions like Khulna and Barisal than in others. But limitations persist – some data sets do not cover informal sectors, or only under-report regional inequalities. The research fails to provide a household level behavioral explanation for gendered adoption patterns.

Impactful directions for further research, including localized surveys, testing of training interventions, and broadened cross-border comparisons are also discussed. Wider infrastructure development and a more inclusive digital education would help close the tech divide between rural and urban. This type of intervention would enhance climate resilience of agri food systems in Bangladesh [7]. The discovered tone suggests the crucial need for focused digital investment, policy coherence, and gender-sensitive capacity development for sustainable uptake of agritech. These studies confirm that the combination of IoT, AI, and agro ecological strategies enhances yield stability and improves post-harvest outcomes in sensitive areas. While the impact is positive, lack of digital skills, existing gender gaps, and infrastructure availability still restrict the reach of the impact [10] [11].

VII. CONCLUSION

The research also finds that digital tools - such as mAgri and e-Krishok - better connected farmers leading to higher yield predictability and market access particularly in a pandemic era of Covid-19. The policy settings (most obviously in the 2013 National Agriculture Policy and the Digital Bangladesh Vision), generated the impetus for scaling [4]. End note Regions with better digital infrastructure saw rises in both investment trends and resilience scores. But the digital divide lingers — only 30% of the rural population has 4G, and 62% of women farmers are excluded. These indications are in line with global studies on digital advisory tools and their potential benefits

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for climate-stressed smallholders [9]. The performance of areas like Khulna and Barisal was strengthened by cold chains and farmer education. But constraints persist — some data sets don't measure the informal economy or under report regional gaps. The analysis also does not provide any household-level behavioral reasons for the gendered adoption patterns.

The literature reinforces the fact that policy and inclusive design, along with tech-enabled agriculture, can foster resilience. Bangladesh's agrarian economy still requires enduring adaptability. The implication is that targeted to online investment, policy convergence, and gender wise training are required for sustainable agritech development. Additional investigations into spot surveys, trial training interventions and multi-country comparisons are necessary. More extensive infrastructure development and inclusive digital education might fill the rural-urban tech gap. Those types of measures have potential to enhance climate resilience in Bangladesh's agri-food systems.

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Analysis of Coastal and Marine Tourism Development Strategies in Bangladesh to Advance Community Economy

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Abstract - **Bangladesh's geostrategic location at the apex of the Bay of Bengal has unlocked cross-cutting economic prospects for Coastal and Marine Tourism (CMT), paving the way for local community welfare. This study aims to examine the strengths, weaknesses, and opportunities of the current CMT development strategies of Bangladesh to elevate economic growth among coastal communities. Utilizing a qualitative research method, an analytical and comprehensive review of national tourism policies, regulatory instruments, development plans, marine tourism legislations, and institutional arrangements has been done to identify prospects and challenges. Key findings highlight that the creation of a tourism master plan, blue economic policies, engagement of local communities in SMEs, and e-marketing adoption, etc have made remarkable contributions to communit^{y} ^{emp}owerment. Nonetheless, obstacles like insufficient infrastructure, environmental decline, inconsistent policies, lack of community empowerment tools, economic diversification, and clean community ownership impede optimal development. Finally, the paper provides effective guidelines to maximize economic returns.**

Keywords - **Blue Economy, Coastal and Marine Tourism, Community Empowerment, Sustainable Development.**

I. INTRODUCTION

Blue tourism, also known as coastal and marine tourism (CMT), is one of the travel industry's fastest-growing subsectors worldwide. CMT makes a substantial contribution to global income, job creation, and sustainable development by utilizing oceans, islands, beaches, and coastal landscapes. It is expected to employ more than 8.5 million people globally and contribute almost 5% of the world's GDP by 2030 [1]. Bangladesh has a lot of potential in this area because of its 200 nautical mile Exclusive Economic Zone (EEZ), 580 km of coastline, and longest natural beach in the world [2].

The country's tourism sector already contributes 3.02 percent of GDP and generates employment for 1.73 million people [3]. However, the full potential of CMT has not yet been realized. Infrastructure gaps, high travel costs, insufficient environmental safeguards, and the absence of community-driven policy frameworks remain significant obstacles. Furthermore, almost 28 percent of Bangladesh's population resides in coastal areas [4], but their participation in decision-making processes remains limited.

Research Objectives: This study aims to: (i) assess current CMT strategies in Bangladesh, (ii) identify barriers and opportunities for sectoral growth, (iii) examine local community participation, and (iv) propose policy recommendations for inclusive and sustainable coastal tourism.

Research questions: To guide the analysis, this study focuses on key questions that explore the present condition of coastal and marine tourism (CMT) in Bangladesh. These questions address existing strategies, challenges, opportunities, and the role of communities in shaping sustainable and inclusive sectoral growth.

- What strategies currently exist for developing CMT in Bangladesh?
- What barriers and opportunities shape sectoral growth and benefits for communities?
- How are local communities engaged, and what limits their participation?
- What policy measures can enhance sustainable tourism development and local economic well-being?

Research Novelty: While there are research studies on tourism in other contexts, there hasn't been much discussion or analysis of the growth of coastal and marine tourism in Bangladesh. Around the world, nations are looking more closely at how marine and coastal tourism may boost regional economies. This research offers insights into methods for sustainable and community-centered tourist development by analyzing the benefits, drawbacks, opportunities, and dangers of coastal and marine tourism for developing Bangladesh's local community economy.

II. LITERATURE REVIEW

Defining tourism: Definition of tourism: "Tourism" refers to the activities of people who visit and stay in places that are not part of their usual surroundings for a maximum of one year in a row, whether for work, pleasure, or other purposes unrelated to paying for activities there [5]. Tourism is the term used to describe the interactions that take place between tourists, business suppliers, host governments, and host communities as they work to attract and accommodate these tourists and other visitors [6]. However, the aspect of internal travel is overlooked by these classifications [7].

Coastal tourism: It describes tourism-related activities that occur along the coast and are facilitated by infrastructure and services that are located on land. It can be separated into two main categories, including:

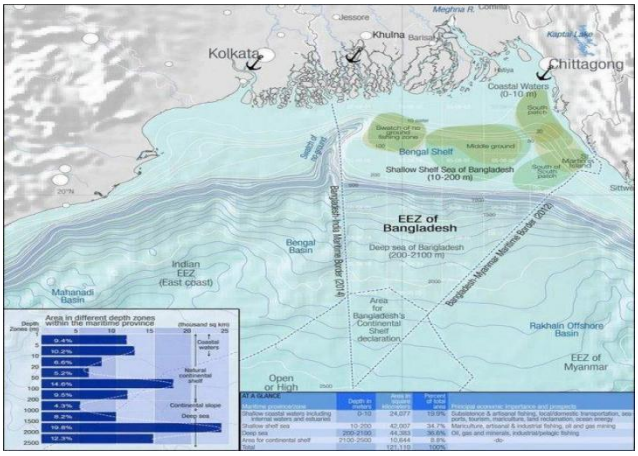
1.Sun and Sand Tourism: Travel experiences centered on

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coastal locations, where visitors partake in leisurely pursuits like swimming, sunbathing, and water sports in regions with pleasant weather and picturesque scenery, are referred to as sun-and-sand tourism. Within more general tourism categories, such as nature, nautical, and wellness tourism, it represents a sizable niche sector. This sector contributes significantly to the growth of regional economies, the creation of jobs, the generation of income, and the promotion of sustainable development in coastal regions by drawing both domestic and foreign tourists. The market for sun and beach travel is expected to grow significantly worldwide, reaching USD 265.1 billion by 2033 [8].

2.Hinterland Tourism: Travel experiences that concentrate on rural, natural, and cultural environments outside of the typical coastal or urban attractions are referred to as hinterland tourism. This type of tourism highlights the region's hidden natural and cultural riches while encouraging sustainable interaction with local residents.
3.Maritime tourism: It highlights activities carried out on the actual water. Sea kayaking, deep-sea fishing, whale watching, sailing, yachting, and cruise are a few examples of maritime sports. However, such as coastal tourism, it extends beyond the activities at sea to the necessary support systems on land, such as harbors, jetties, marinas, hotels, and restaurants that enable maritime experiences [9].
4.Marine Fisheries based Eco-tourism: Fisheries-based ecotourism is a form of sustainable tourism that combines responsible travel to fishery areas with recreational or educational fishing activities, aiming to conserve aquatic ecosystems while generating alternative livelihoods for local fishing communities [10][11][12].

5.Community Based Tourism : By giving local communities the ability to actively manage tourism resources, community-based tourism promotes social and economic development [11]. 17 CBT improves visitor experiences while bolstering local economies by fusing ecological practices with cultural preservation [12].
6.Community Economy :Community economy refers to economic practices that are centered on local, collective, and sustainable approaches, emphasizing social relationships, mutual aid, and community well-being over profit maximization [14].
7.Tourism and Creative Economy: By connecting cultural output with visitor experiences through crafts, mementos, and creative venues like studios and workshops, the creative economy boosts tourism. It increases visitor engagement, helps local craftspeople, and creates jobs, innovation, and sustainable growth by encouraging cross-sector collaboration [15].
Maritime Jurisdiction of Bangladesh: Bangladesh has achieved sovereign rights over its Exclusive Economic Zone (EEZ) and Continental Shelf by resolving maritime border disputes with India and Myanmar. Opportunities to exploit marine resources have increased as a result of this development [16]. Given that Bangladesh now controls jurisdiction over 118,813 square kilometers of territorial waters along a 710-kilometer coastline (illustrated in map 1), and these regions hold significant importance for Bangladesh's political, economic, and security objectives [17][18]. These newly established rights not only enhance the nation's economic opportunities but also provide openings for local people to benefit from fishing, tourism, and small enterprises that depend on marine resources.



Map 1: Maritime Province of Bangladesh
(source: Chowdhury, 2014)[20]

III. METHODOLOGY

This study examines coastal and marine tourism (CMT) policies and their impact on local economies using a qualitative methodology in conjunction with a thorough literature analysis. Qualitative research allows for a critical assessment of institutional and legislative frameworks by focusing on meanings, processes, and context [19][20]. Academic publications, government reports, policy documents, and development plans were the sources of the data, while secondary data analysis offered thorough insights. In order to evaluate best practices and provide guidance for community-centered, sustainable CMT development, the study also includes case studies.

IV. RESULTS

The results of the qualitative study of national policies, international frameworks, government programs, coastal tourism industries, and best practices from a few chosen nations are presented in this part in relation to Bangladesh's development strategies for coastal and marine tourism (CMT). To determine the advantages, disadvantages, possibilities, and obstacles for developing community economies, the analysis makes use of institutional structures, development plans, and regulatory tools. Key data are compiled in tables for comparability and clarity.

Regional CMT Clusters in Bangladesh
Coastal and marine tourism in Bangladesh has been divided into a number of development clusters, each with distinct socioeconomic and ecological possibilities. Building upon Hasan and Islam [21], the clusters can be expanded to

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include not only their tourism resources but also community demographics and economic relevance

Table 1: Regional Coastal and Marine Tourism (CMT) Clusters in Bangladesh and Associated Community Profiles

Cluster	Key Destinations	Population (approx.)	Tourism Dependence (%)	Strategic Insights
Cox's Bazar	Kolatoli, Inani, Teknaf Beach	~475,000 (BBS, 2022)	65% (Patil et al., 2018)	1.Core tourism hub 2.High reliance on beach economy
Chattogram	Patenga, Guliakhali, Parki, Bashkhali,	~220,000 (Bangladesh Economic Review, 2021)	42% (Uddin, 2019)	1.Urban–industrial mix 2.moderate tourism growth
Central and western coast	Kuakata, Mandarbaria, Kotka, Hiron Point, Dubla Char	~310,000 ((BBS, 2011	50% (Business Standard, 2020)	1.Emerging eco-cultural sites 2.strong fisheries based eco tourism potential
Island Cluster	Saint Martin's, Maheshkhali, Nijhum Dwip, Char Kukrimukri	~180,000 (Islam & Sarker, 2021)	70% (Hussain, Failler, & Sarker, 2019)	1.Highest dependence 2.sensitive to over-tourism

Source: [21]

National policies on CMT: Bangladesh has put in place a number of legislation and regulations that are intended to promote and regulate CMT, with differing effects on local populations. These policies prioritize infrastructure development, professionalism, and ecotourism, but they frequently fail to directly benefit small-scale local enterprises. The main national policies are listed in the following table along with their significance for CMT and community economy ramifications.

Table 2: National Coastal and Marine Tourism Policies and Community Impacts

Law/Policies	Relevance to CMT	Implications for Community Economy
Bangladesh Travel Agencies (Registration and Control) Act, 2013 (Amendment 2021; Rules 2022)	Provides guidelines for coastal areas tour operators	1.Increases professionalism, but absence of giving direct benefits to local coastal entrepreneurs. 2.More focused towards formal agencies and small/local operators excluded.
Bangladesh Parjatan Corporation Order, 1972 (Amendment 2022)	Plays crucial role in promoting CMT tourists spots along with facilities.	Lack of community involvement in mega coastal tourism projects
Bangladesh Parjatan Board Act, 2010	acknowledges the potential for marine and coastal tourism	highlights ecotourism and community-based tourism specifically.
Bangladesh Tourism Protected Areas and Special Tourism Zone Rules, 2011	creates designated areas for the growth and investment of tourism in coastal regions.	1.Potentials of creating jobs for local community 2. Investor-focused and chance of an uneven distribution of benefits.
Bangladesh Hotel and Restaurant Act, 2014	guarantees top-notch services in popular seaside vacation destinations.	Creates jobs for locals but less scope for small community enterprises.
National Tourism Policies	Provides strategic framework for tourism development with emphasis on coastal and marine tourism	Promotes sustainable growth and community engagement, though implementation may vary across regions

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8th Five year plan (2020-2025)	Highlights coastal tourism as a driver of economic growth, focusing on infrastructure, livelihoods, and climate	Supports livelihood diversification and infrastructure improvement for coastal communities

Source: [22]

International Framework: By influencing safety, zoning, and policy recommendations, international treaties and organizations offer a fundamental framework for sustainable CMT. Through inclusive models and increased tourism confidence, these frameworks indirectly assist local economies. Selected international instruments, their applicability to CMT, and their effects on local economies are described in the table below:

Selected Country Best Practices for Coastal and Marine Tourism:

Selected maritime nations have implemented policies that combine economic growth, sustainability, and community empowerment in coastal and marine tourism (CMT), taking inspiration from international models. Bangladesh can use these practices as benchmarks, such as the 2019 GDP contributions from tourism. The following table compares GDP shares, relevant ministries, development priorities, and laws and policies across nations.

Table 03: International Conventions Relevant to Coastal and Marine Tourism

Convention / Organization	Relevance to Coastal & Marine Tourism	Implications for Community Economy
International Convention for the Safety of Life at Sea (SOLAS)[23]	establishes a safety framework for ferries, cruise ships, and other coastal tourism-related vessels.	1.Safe transportation indirectly boosts traveler confidence and supports local tourism.
United Nations Convention on the Law of the Sea (UNCLOS, 1982)[24]	Marking states' maritime zones protect exclusive tourism benefits.	potentially benefiting coastal communities through eco-tourism and fisheries-linked tourism.
United Nations World Tourism Organization (UNWTO)[25]	Offers policy guidance and technical support for sustainable coastal and marine tourism.	Encourages community-based tourism models, inclusive growth, and poverty alleviation through tourism.

Source: Compiled by author based on [23]–[25].

Government Initiatives: The government of Bangladesh has recognized coastal and marine tourism (CMT) as a key mechanism for advancing the blue economy and is actively implementing various initiatives to support this effort [30]. Government-led projects in Bangladesh focus on ecotourism, sustainable fisheries, and climate resilience, generating economic impacts such as local employment and income diversification for coastal communities. These initiatives demonstrate practical applications of CMT strategies. The table summarizes key projects and their economic impacts on coastal communities.

Table 04: Government-Linked Projects in Bangladesh Supporting Coastal and Marine Tourism (CMT) and Their Economic Impact

Project Name	Economic impact on Coastal Communities
USAID Bangladesh Ecotourism and Conservation Alliance[26]	Local employment as guides, homestay operators, and boat operators
Bangladesh Sustainable Coastal and Marine Fisheries Project[27]	diversifies income through tourism-linked activities like recreational fishing and eco-tours.
Community-Based Mangrove Restoration (Sundarbans)[28]	income generated through ecotourism and environmental stewardship programs.
Coastal Towns Climate Resilience Project[29]	Improves infrastructure for tourism while enhancing local livelihoods; community involved in maintaining facilities and small-scale service businesses.
Adaptive Capacity Enhancement for Coastal Communities[29]	Empowers women and youth in coastal villages to participate in eco-tourism activities, crafts, and homestays; builds resilience and alternative income streams.

Source: Compiled by author based on [26]–[29].

Coastal & Marine Tourism Best Practices (Selected Countries):

- Australia – Great Barrier Reef zoning & permits ensure ecosystem protection and controlled tourism. [31]

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- Costa Rica – Marine Protected Areas balance biodiversity conservation and touris[32]
- Indonesia – Local empowerment initiatives strengthen community participation, equitable revenue-sharing, and sustainable management of coastal resources. [33]
- Colombia – Ecotourism in biodiversity-rich regions enhances social welfare, supports conservation, and provides fair economic benefits to local communities.[34]
- Spain – Sustainable Tourism Strategy 2030 promotes eco-friendly tourism growth.[35]
- Croatia – Spatial planning law restricts coastal development within 1 km to protect marine areas. [36]
- Mozambique – Eco-lodges and marine monitoring tie conservation to local benefits. [37]
- Vietnam – Reef protection measures restrict tourism in degraded coral zones. [38]

IV. DISCUSSION

The analysis of Coastal and Marine Tourism (CMT) strategies in Bangladesh reveals a complex landscape where policies, government initiatives, and sectoral opportunities interact to support community economic growth, yet significant gaps remain. Existing frameworks, such as the Bangladesh Parjatan Board Act (2010) and the Tourism Protected Areas Rules (2011), focus on ecotourism and investment but are largely top-down, limiting local entrepreneur participation. Policies like the Travel Agencies Act (2013) prioritize formal operators over small-scale communities, resulting in minimal direct benefits and inconsistent implementation. Although the 8th Five-Year Plan (2020–2025) emphasizes marine resource utilization, institutional and funding gaps hinder sustainable CMT development.

Economically, CMT contributes substantially to Bangladesh, with 135,186 tourist arrivals in 2021 and revenue of USD 217.9 million in 2020, despite COVID-19 setbacks. Infrastructure improvements in transport, ports, and energy have strengthened the tourism value chain, while the sector is projected to employ 1.7 million people, representing 4.2% of the workforce [39]. Policy frameworks aim for sustainability, highlighting tourism's growing role in national and local economic development. International benchmarks, such as Indonesia and Colombia, demonstrate successful integration of community-based tourism. Indonesia's local empowerment initiatives and Colombia's ecotourism in biodiversity-rich regions illustrate how community involvement and equitable benefits enhance sustainability and social welfare, offering key lessons for Bangladesh, particularly in regions like the Sundarbans.

Challenges in Achieving Community Economic Benefits through Coastal and Marine Tourism:

- Lack of Policy and Coordination: Bangladesh lacks a dedicated policy or integrated framework for coastal and marine tourism. Coordination among ministries is weak, and local communities have limited involvement in planning. Economic incentives for the sector, such as tax breaks or subsidies, are minimal.
- Dependence on Domestic Tourism: With 97% of revenue coming from local tourists, international arrivals are low (World Travel and Tourism Council 2020).[40] COVID-19 intensified pressure on domestic tourism sites, worsening environmental and social impacts.
- Operational Constraints: Challenges include limited skilled labor, weak infrastructure, poor branding and promotion, inadequate coordination between public and private sectors, and insufficient integration of research into policy development.

V. CONCLUSION & WAY FORWARD

Bangladesh was ranked seventh among the "top 10 best value" travel destinations for 2019 by Lonely Planet, a leading global travel guide publisher (Uddin, 2019).[41] This highlights the country's potential as a competitive tourism destination. Coastal and marine tourism (CMT), in particular, offers substantial opportunities to boost the blue economy and advance local community incomes while supporting overall economic development in Bangladesh's tourism sector. While Bangladesh has abundant coastal resources and rich cultural heritage, current tourism frameworks are often fragmented and top-down, limiting community participation. To maximize CMT's potential, strategies should focus on sustainability, resilience, and equity, embedding local empowerment, transparent governance, and evidence-based practices such as :

- Community Empowerment: Promote community-based tourism (CBT) with equitable revenue-sharing and active participation of women and youth.
- Integrated Governance: Establish a Coastal and Marine Tourism Authority to coordinate policies.
- Sustainable Infrastructure: Prioritize eco-friendly accommodations, renewable energy, and resilient transport.
- Digital Transformation: Expand online marketing and booking platforms, supporting MSMEs.

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- Environmental Stewardship: Expand Marine Protected Areas and enforce eco-certification.
- International Best Practices: Learn from countries like Indonesia, the Philippines, and Kenya.
- Monitoring and Evaluation: Track sustainability, employment, gender equity, and community satisfaction.

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Paradox of Digital Adaptation: Exploring the Antecedents of Technostress among Female Nurses in Bangladesh

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Abstract- **In the wake of technological advancements, there is increased recognition that digitalizing healthcare brings significant cost reductions, improved efficiency, and sustainability. Bangladesh, a South Asian developing economy, is paving its way to digitalizing healthcare. Given that female nurses are a crucial component of Bangladesh's healthcare workforce, understanding antecedents of technostress for nurses is essential for the effective implementation of healthcare digitalization. Thirty female nurses from public and private hospitals were interviewed. Findings suggest that technological inertia persists among most senior nurses; however, their awareness of the positive impact of digital tools on patient care creates a cognitive dilemma. Although many younger nurses demonstrated strong willingness to embrace digitalization, such willingness is often obstructed by insufficient infrastructural support and training. For both younger and senior nurses, their motivation to engage with digital health technologies is influenced by patients' digital literacy and colleagues' fear of technology. Lack of standardized process across the country and technical glitches also create frustration among the nurses. It is anticipated that this study's findings can help relevant policymakers by highlighting the multidimensional interaction among nurses' technostress, organizational support, and patients'/colleagues' technological adaptability; thereby guiding the development of context-sensitive policies.**

Keywords: **Developing Economies, Healthcare, Nurses, Tech Adaptability, Technostress**

I. INTRODUCTION

The contemporary workplace is characterized by technological advancements primarily driven by ubiquitous internet connectivity, artificial intelligence, and other technological innovations [1]. Consequently, such rapid technological advancements are bringing continuous changes in different spheres of work and people management. While technology's influence can be observed across various industries, technological change and digitalizing healthcare remain crucial, considering the significance of the industry on individual and societal well-being. Smart healthcare solutions, crucial for sustainable healthcare systems, are being enabled by the automation and digitalization pioneered by two core driving technologies: the Internet of Things (IoT) and Artificial Intelligence (AI) [2]. There is increasing consensus that traditional health record systems might be more effectively replaced by digital health systems and other health information technology, particularly in nations with low incomes [3]. Continuous technological progress in healthcare is crucial not only for advanced medical treatment but also for sustainable healthcare through reduced cost and enhanced efficiency [4]. Policymakers are hence advocating for streamlining treatment, record management, and other relevant processes by adopting digital technologies [5].

Technology, however, regardless of the sector in which it is implemented, is characterized by its duality-that is, beneficial and adverse effects [6]. While technological advancements and digital integration are crucial for a sustainable healthcare system, the adoption of such advancements by healthcare professionals remains a major challenge. Technology in healthcare, or Healthcare Information Technology, can be critically regarded as a double-edged sword by health professionals [7]. Technology's adverse effects in the form of technostress (psychological distress caused by interacting with technology) remain a central topic of discussion in the literature of technology and people management [8] [9].

Bangladesh, a South-Asian emerging economy, has been working on integrating technology in various aspects, including healthcare. The country is being transformed into a modern technology-based country with automation and control technology being applied in various industries [10].

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Bangladesh has embarked on the implementation of several digital health initiatives over the last few years [11] [12]. Following the resolution of the World Health Assembly (WHA), Bangladesh initiated the development of a digital health strategy in 2019 [13]. Despite such progress, Bangladesh's healthcare system still faces deep-seated challenges, including accessibility, doctor-to-patient ratio, skill gap, etc. [14]. Technology in its various forms can help overcome the major challenges prevailing in Bangladesh's healthcare sector [15] [16]. To ensure proper implementation of digital technologies in Bangladesh's healthcare sector, understanding its impact on healthcare professionals is essential.

Among hospital personnel, nurses constitute the core workforce, representing 50% of the global healthcare workforce [17]. Nurses have a critical role in patient safety, especially when it comes to disease prognosis, medication administration, and vital sign monitoring [18]. As of 2023, Bangladesh had only 85,000 nurses, whereas the number of doctors is much higher than that of the nurses [19]. Although nurses are an essential component of the healthcare system in Bangladesh, they continue to encounter difficulties in keeping pace with technological advancements [20]. The technostress emerging from the involvement with healthcare technology can prove to be detrimental to nurses' well-being, which in essence can affect nurses' adaptability to technological changes in healthcare. The authors argue that understanding the antecedents of technostress among nurses can help policymakers explore the reasons behind the disinclination of nurses towards technological changes.

The present study's contribution to the existing literature is threefold. Firstly, the study fills a methodological gap by taking a qualitative approach in understanding the antecedents of technostress among the female nurses in Bangladesh. Existing studies focused on technostress among nurses have largely been quantitative [9] [16] [20]. A qualitative approach helped the authors unearth the experiences of the nurses and explore the antecedents of the technostress. Second, existing studies on technostress among nurses have either focused on examining the impact of technostress on nurses' job outcomes, for instance, job satisfaction [16], or focused on the influence of social support (supervisor and colleagues) on nurses' technology adaptation [21]. However, the present study, instead of focusing on the consequences of the technostress, aims to explore the antecedents of the technostress among the nurses. Third, studies on technostress among the nurses in South Asian economies, where digitalization of healthcare remains at a nascent stage, are limited. Moreover, cultural components can potentially influence how various factors related to healthcare technologies can lead to technostress. Although digitalisation offers numerous opportunities and advantages to the healthcare sector in developing economies, its execution frequently encounters challenges that are sensitive to the specific context, hindering its overall effectiveness [4]. Hence, it is anticipated that insights from the present study can help policymakers identify the context-specific (considering the cultural elements and technological readiness) factors that can influence efficient adaptation of healthcare technologies among the Bangladeshi nurses.

The paper is further organized into the following sections. In the next section, the paper highlights the literature review on technostress and digital healthcare in Bangladesh. Before discussing the key findings of the study, the authors detail the research methodology.

II. LITERATURE REVIEW

A.Technostress

Organizational stress has garnered significant attention in academic research over the years, as it significantly impacts business performance and overall success. The swift progress in technology has led to issues regarding technostress, a psychological condition that individuals face due to work automation [8]. The term 'technostress' was introduced by Reference [22] as "a modern disease of adaptation caused by an inability to cope with the new computer technologies in a healthy manner." (pg. 16).

Technostress has been defined as a kind of stress an individual experiences resulting from psychological difficulties while using information and communication technologies [23]. It reflects an experience when technology users feel psychological distress and discomfort since they cannot adapt to new technologies, creating a negative perception towards the technology [24]. Technostress encompasses perception, emotion, and thought in the post-Information System (IS) implementation in organisations and the prevalent use of IT in society [25].

Technostress can lead to several adverse outcomes for individuals. These impacts can be seen in their actions, including decreased productivity, diminished performance, and a wish to resign from their position [26] [27], as well as in their mental health, such as feelings of job dissatisfaction [28].

Health practitioners such as nurses are particularly impacted by issues related to technological change and the need for continuous skill updates. Specifically, concerns such as technology changes, updating computer and technology networks, and the fear of job loss due to inadequate technology skills tend to have an adverse effect on nurses' well-being and job performance [8].

B. Digitalizing Healthcare in Developing Economies

In emerging economies, the healthcare sector is under growing pressure to modernize its disjointed paper-based systems to capitalize on the various advantages that digitalization offers [4]. However, the lack of contextual understanding and systematic approaches to obtaining digitalisation are the major bottlenecks affecting its

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successful deployment in developing economies [29]. For more than two decades, numerous developing nations have tried to digitalize their health management information systems (HMIS) but have experienced only limited success in achieving sustainability [30]. Numerous digitalization initiatives frequently fall short of achieving their goals [31]. Such failures are commonly linked to the inherent complexity of the situation [32] and the intricate relationship between context and actions that underpin the digitalization journey [31]. This complexity is marked by gaps in infrastructure as well as the diversity and interconnectedness of the actors and agendas present among political, public, third sector institutions, and global entities [33].

C. Digitalizing Healthcare in Bangladesh

In developing nations like Bangladesh, technology in the form of AI offers promising solutions to address public health challenges, such as infectious diseases like COVID-19 and dengue, while contributing to economic growth [2]. Over the last decade, Bangladesh has undergone significant technological advancements and changes in the healthcare sector. This includes the development and implementation of District Health Information Software 2 (DHIS2), Digital Dashboard, Shared Health Record (SHR) system, National Health Data Warehouse, Digital Health Hub, Civil Registration and vital statistics (CRVS) system, Video Conferencing, Bulk Messaging Service, Telemedicine, Teleconsultation, E-prescription, and E-referral [11] [12].

The National Digital Health Strategy (2023-2027) is setting the stage for diagnostics powered by AI, immediate disease monitoring, and data-driven management systems in hospitals, ensuring effective and accessible healthcare to countless individuals [14]. An online-based HRIS (Human Resource Information System) has also been developed to capture health workforce information, applicable for all Directorates, under the Ministry of Health and Family Welfare [34]. Mobile health apps are also being developed, paving the way for telemedicine services and online pharmacies, hence, enhancing healthcare access for remote populations [14]. However, Bangladesh's healthcare system remains in the nascent stage of digitalization, with substantial scope for further development [12].

Bangladesh's current state of healthcare digitization was evaluated using the Global Digital Health Index, which serves as a national 'digital health scorecard' that measures the maturity of various components of digital health within the country. Based on this assessment, leadership, governance, workforce, infrastructure, service, and application are currently in the 'Scaling Up' stage, while other areas remain in the 'Developing and Building Up' stage [34]. The authors of the present research argue that workforce preparedness is an essential determinant of the successful digitalization of healthcare in Bangladesh. Technostress remains a crucial factor that can potentially impact the readiness of healthcare professionals. And, hence, further exploration of antecedents of technostress among the healthcare professionals, such as nurses, becomes imperative.

III. METHODOLOGY

A. Research Approach

The present study aims to explore the antecedents of technostress among the female nurses in private hospitals in Bangladesh. Considering the explorative nature of the study, the authors took an inductive approach with qualitative data. A primary tenet of the qualitative approach is its emphasis on contextual understanding; that is, the interpretation of participants' "*behaviour, values, beliefs, and so on"* through the lens of the specific context in which the research study is conducted [35]. Exploration of the antecedents of technostress among the female nurses in Bangladesh required contextual understanding and interpretation of the context through the lens of the participants. Hence, a qualitative approach seemed the perfect fit considering the research objective.

B. Data Collection & Sampling

Data was collected from in-depth interviews with 30 nurses from public and private hospitals in Bangladesh. All the nurses were female, aged between 25 and 40 years old. According to a recent report by the Health Sector Reform Commission, there are 56,734 nurses available in Bangladesh [36]. And according to Reference [37], most nurses are female. Considering this, this study focused on exploring the antecedents of technostress among the female nurses in Bangladesh. The concept of data saturation, which is the point at which no new information or themes are observed in the data from the completion of additional interviews or cases, is a useful one in terms of discussing sample size in qualitative research [38]. The sample size of 30 nurses thus seemed appropriate, as the researchers started to observe the emergence of repetitive themes, indicating data saturation after interviewing 25 nurses.

A semi-structured questionnaire was used for the in-depth interviews. The data was initially collected in Bengali, the native language of the nurses. Collecting the data in the native language allowed the participants to express their lived experiences with greater nuance.

C. Data Analysis

Thematic analysis was conducted in the study. The inductive approach allowed the themes to emerge from the transcripts. At first, the researchers familiarize themselves by repetitively reading the transcripts. The initial codes were generated from the transcripts, which highlighted the significant features of the data set. Next, the codes were analysed to find overarching themes and sub-themes. The data analysis process was facilitated using NVivo 15.

D. Ethical Considerations

Considering the ethical aspects of the research, the authors ensured that participants' identities were kept anonymous.

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Before starting the interviews, the participants were informed about the objectives and motivations of the research.

IV. FINDINGS

In total, eight themes emerged from the coding and analysis of the qualitative data.

A. Lack of Standardized IT-related Process across the Country

While sharing their experiences with technology at work, most of the nurses highlighted that there is a lack of standardized Information Technology (IT) across different hospitals in the country. Most of the nurses studied had work experience in other hospitals before joining their current workplace. It has been observed that when nurses had to go through a transition because of the IT infrastructure and state of technology utilization between their previous and new hospitals, it created a stressful situation for them. For instance, one of the participants who moved to a public hospital (which uses a manual approach for patient data management) from a private hospital (which uses a digital approach in patient record management) was found to be frustrated.

B. Fear of Replacement & Lack of Awareness about the Digitalization

One of the major themes that emerged from the analysis is the 'fear of replacement'. It was observed that one of the major reasons behind the reluctance to digitalization was related to the nurses' fear of being replaced. However, it is worth noting that fear of replacement among the nurses prevailed mostly because there was a lack of awareness among them on how digitalization would affect their jobs. Most of the nurses who were not exposed to various forms of healthcare digitalization were found to be unaware of how digitalization was changing the healthcare systems. It resulted in a fear of using technology among the nurses. Such unawareness and evoked fear were found to be a major reason behind those nurses' scepticism towards healthcare digitalization and technostress.

C. Distrust towards Technology

One of the major antecedents of technostress among the nurses studied was their distrust of technology. Many of the participants studied demonstrated distrust towards technology in terms of ensuring patient care. Moreover, they were especially concerned about how their demographic and work performance data were being used. For instance, one of the participants mentioned,

"*Some of the nurses were also concerned about patients' data security. Such distrust was found to develop technostress among the nurses studied*."

Moreover, some of the participants were also concerned about patients' data security. Such distrust was found to develop technostress among the nurses studied.

D. Contagious Anxiety

Analysis of the data suggests a contagious effect of techno-anxiety and mistrust within the nurses studied, wherein the apprehensions of one individual could propagate, thereby fostering a vicious cycle of technostress.

E. Patient's Adaptability to Technology

Many of the nurses were found to be negatively affected when their patients struggled to adapt to the digitalization of healthcare. According to these nurses, many patients in Bangladesh are still not comfortable with digital healthcare services. Hence, the nurses have to put in additional effort in managing patients who are not technologically savvy. Such findings were especially relevant to the younger nurses who themselves are comfortable with healthcare digitalization.

F. Lack of Infrastructural Facilities & Training

Findings suggest that nurses experienced technostress when exposed to infrastructural barriers. Many nurses experienced technostress at work when they did not have the proper infrastructure to facilitate the digitalization of healthcare. Moreover, lack of training on digitalization was another major antecedent of technostress among the nurses studied. In some cases, where the hospital provided proper training and had sufficient machines and equipment, poor internet connectivity disrupted the digitalization process, leading to technostress among the nurses.

G. Technical Error & Glitch

Working with digital systems, especially in digital data management (for patients), nurses experienced technostress due to system crashes and other technical issues. While most of the nurses acknowledged that such technical issues or glitches are inevitable, these nevertheless caused technostress among many of the nurses studied. For instance, one of the participants mentioned,

"*There were also technical challenges, occasional system crashes, and slow internet, which caused delays and frustration. Also, when we informed the authorities about these issues, it took a lot of time to replace these machines*."

V. DISCUSSION, IMPLICATIONS & CONCLUSION

Technostress remains a crucial obstacle in the successful implementation of healthcare digitalization in Bangladesh. Findings of the present study highlight the major antecedents of technostress among the female nurses in Bangladesh.

Findings of the present study identify some organization-specific and some employee-specific factors that can lead to technostress among the nurses. Existing studies focusing on technostress among nurses, especially in Bangladesh, have specifically explored the roles of collegial and supervisory support on technostress [20]. On the other hand, existing studies have also examined the impact of technostress on the nurses and other healthcare professionals' physical and mental well-being. Insights from the present study extend the literature by exploring the antecedents of technostress

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among Bangladeshi nurses. Findings suggest that technostress among the female nurses in Bangladesh results from organizational and individual-level factors. While fear of replacement because of technology remains one of the major antecedents of technostress in existing studies, the present study highlights the contagious anxiety and discusses how one individual with a fear of technology can have a negative influence on his or her colleagues, resulting in a vicious cycle of apprehension towards healthcare digitalization.

Being a developing economy, Bangladesh continues to struggle with technological, infrastructural, and financial challenges. And such impact limitations can be reflected in the digitalization of the healthcare sector as well. Despite these challenges, the country has made tremendous progress in digitalizing various aspects of healthcare. The infrastructural and technical barriers were found to be one of the major antecedents of technostress among the nurses.

Moreover, a lack of awareness among Bangladeshi nurses on the impact of healthcare digitalization emerged as one of the major themes in this study. Addressing such unawareness is crucial, as such unawareness can create negative perceptions towards digitalization, affecting nurses' adaptability, and can also lead to technostress.

Future studies can investigate the impact of the novel antecedents (for instance, identified by this study. It is anticipated that insights from this study can help policymakers identify the antecedents of technostress among the female nurses in Bangladesh, with special consideration to factors associated with the contemporary workplace.

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Eco-Mindset at Work: How Green Business Strategy and Green Climate Perception Drive Hotel Employees' Pro-Environmental Behavior

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Abstract - **Pro-environmental behavior (PEB), sometimes called green or sustainable behavior, refers to actions taken by individuals to lessen negative impacts on the environment. PEB includes many efforts aimed at protecting and conserving the environment. It involves intentionally choosing measures that reduce environmental damage or improve ecological health. This study uses the Theory of Planned Behavior (TPB) to explore how perceptions of a green work climate influence the relationship between green business strategy (GBS) and the pro-environmental actions of hotel employees in Bangladesh. Data from a sample of 421 frontline employees in the hotel industry show that both GBS and green climate perception positively impact pro-environmental behavior. Additionally, the results reveal a meaningful mediating effect of green climate perception between GBS and pro-environmental behavior. These findings suggest that green climate perception serves as a mechanism explaining how GBS can encourage sustainable employee behavior in the workplace. This research enhances the broader understanding of HRM's role in addressing environmental issues by offering new insights into how GHRM connects with sustainable behavior. The paper discusses the implications of GBS for employees in sustainable hotel organizations within Bangladesh's hospitality sector, grounded in recent research on GBS's role in workplace sustainability. The findings also provide new insights into the psychological processes linking GBS and pro-environmental behavior.**

Keywords: **Green Business Strategy, Green Work Climate Perception, Pro-Environmental Behavior, Task-Related PEB, Proactive PEB.**

I. INTRODUCTION

Considering increasing environmental concerns, organizations recognize the need to adopt sustainable practices [1], [2] and encourage employees to align their behaviors with these ecological goals. This shift promotes the development of environmentally responsible organizations [3], [4], [5]. Employee green behavior (EGB), referring to workplace actions that promote environmental sustainability, is gaining significant attention, especially in the hospitality industry. Active employee engagement is vital for creating and implementing sustainable policies [6], [7]. This research aims to shift the focus from organizational-level environmental outcomes to individual-level pro-environmental behavior (PEB) within the hospitality sector [8]. Building on this, further research was called for on employees' perceptions of how organizational initiatives impact their environmental performance in the hospitality industry [9]. This study examines the perspectives of hotel frontline employees (FLEs) on the impact of green business strategies (GBS) on their pro-environmental behavior (PEB). In a study, it has been seen the motivational factors that drive environmentally sustainable behaviors among hospitality employees, were examined [9]. Prior studies emphasized that organizational support is crucial in encouraging employees to participate in eco-friendly activities [5], [10]. Therefore, this study suggests that GBS signals to employees that the organization will develop timely and appropriate green initiatives to promote environmental sustainability and green management.

Consequently, GBS suggests that business entities should reduce environmental damage by promoting sustainable behavior among employees [11], [12]. Research on sustainability shows that employees' eco-friendly actions are crucial for the success of organizations' green initiatives [9], [13], [14]. The organizational green strategy aims to significantly influence employees' environmentally friendly behaviors and performance, improving the organization's environmental results. Therefore, based on previous research, this study examines how GBS influences employee pro-environmental behavior, mediated by perceptions of a green work environment.

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Employee green behavior, also known as pro-environmental behavior (PEB), refers to actions that mitigate the negative environmental impacts of workplace activities and promote the sustainable performance of organizations [3]. In a study it is seen that workplace pro-environmental behavior (PEB) has been described as any action taken by employees which they believe will improve the company's environmental performance [15]. As a result, PEB includes both specific task-related actions and voluntary proactive efforts aimed at protecting the environment. This paper follows the definition of PEB found in a prior study, including both task-specific and proactive voluntary PEB.

The following sections of this paper are organized as follows: The next part outlines the literature review and the formulation of the hypotheses examined in this study. The methods section details the sample frame, data, statistical model, and software used to evaluate the hypotheses. Next, the empirical findings of the proposed model are presented. The report concludes with a summary of the key findings, study limitations, and future research directions to advance this emerging field of sustainable human resource management.

Relationship between Green Business Strategy and PEB

Contemporary management emphasizes that the relationship between an organization's development and the natural environment is known as environmental strategy or GBS [17]. An effective environmental strategy for a company includes a set of visions, goals, plans, and processes that demonstrate the organization's ability to implement procedures aimed at reducing both short- and long-term environmental risks [18]. The adoption of GBS or environmental strategies by organizations can significantly influence employee environmental behavior in the workplace [12]. Environmental strategy comprises both environmental business strategy and environmental corporate strategy, supporting organizational actions such as turning off electric appliances and lights before leaving, recycling waste, reusing materials, and conserving water after use [9]. Several studies have explored the main drivers behind employee green behavior or pro-environmental behavior, including human resource management [11], [19], organizational sustainability policies [20], environmental-specific servant leadership [21], corporate environmental strategy [20], environmental knowledge [22], and corporate social responsibility [23], [24]. There is potential to examine both the direct and indirect effects of GBS on employee PEB within organizational settings. This discussion leads to the formulation of the following hypothesis:

Hypothesis 1: GBS has a positive influence on PEB.

Relationship between Green Business Strategy and GWCP

By adopting GBS, the organization demonstrates its commitment to environmental responsibilities beyond just profit motives, engaging those involved in environmental decision-making and actions [25]. Employees often lack motivation to participate in eco-friendly behaviors when they do not feel personally responsible for sustainable practices [26]. Therefore, an organization should involve employees in environmentally sustainable tasks to reach ecological goals, increase environmental awareness, and encourage participation in green initiatives [19]. GBS is more likely to improve employees' perception of being green [25]. In prior research, it is seen that organizational sustainability policies promote employees' green workplace behaviors [27]. It is found in a study that how green practices affect employees' psychological green climate [19]. The level of organizational emphasis on policies influences climate formation [28], indicating that an organization's green practices can shape a green climate. Based on these findings, it can be understood that GBS may be crucial for fostering GWCP. An employee in an environmentally conscious workplace would experience the influence of colleagues' positive attitudes toward sustainability, which can affect everyone's environmental outlook. Thus, it is likely that GBS has a positive relationship with employee GWCP.

Hypothesis 2: GBS has a positive influence on employee GWCP.

Relationship between GWCP and PEB

Organizational climate is a crucial topic in organizational behavior [29]. Employee perceptions of climate positively influence green behavior [20]. In an earlier study, researchers also found that GWCP enhances employee PEB in Bangladeshi green garments [11]. Environmental policies and practices create a positive impression of green organizational culture, leading employees to believe that their company supports their green actions. This supports the idea that contextual factors and policies shaping work climate perceptions and injunctive norms influence PEB [11]. Employees think they will act more positively toward the environment if they work with environmentally conscious colleagues [12]. GWCP reflects the organization's and coworkers' sustainability perspectives to positively impact employee PEB. Therefore, the hypothesis is:

Hypothesis 3: GWCP has a positive influence on employee PEB

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Mediating effects of green work climate

The relationships identified between GBS and employee PEB, GBS and GWCP, and GWCP and employee PEB support the idea of a mediating effect of GWCP. Specifically, GBS influences employee GWCP, which then affects employee PEB. GWCP levels may fluctuate, and GBS can facilitate GWCP development. Therefore, it is reasonable to believe that GWCP may serve as a mediator between GBS and employee PEB. GBS fosters the development of a shared environmental vision and encourages a culture of learning. This enhances employees' sense of belonging and alignment with the organization's ecological values, thereby boosting GWCP. Consequently, employees who feel this alignment are more likely to engage in behaviors that support the organization's sustainability goals, leading to employee PEB. Prior research emphasizes the mediating role of GWCP [11], [12], [30]. From this perspective, GBS cultivates a sustainable business environment, while GWCP integrates this environment into the organizational culture. This alignment encourages employee PEB, a dynamic capability that provides a sustained competitive advantage. Thus, this study proposes:

H4: GWCP mediates the relationship between GBS and employee PEB.

II. METHODOLOGY

This research used a cross-sectional method and a standardized questionnaire to gather data from March to April 2025. Data were collected from a sample of personnel in administrative roles across various hotel departments (5-star, 4-star, and 3-star) in Bangladesh. During the data collection phase, 30 organizations from different categories agreed to participate. The researchers distributed 750 questionnaires evenly among these 30 organizations. Of the 750 questionnaires sent out, 438 responses were received, with 17 excluded due to not meeting criteria. This left 421 valid participants, leading to a 58% response rate. This rate is considered satisfactory, exceeding the 56.13% response rate reported by researchers in a study [31] in Bangladeshi hotel organizations.

Data Analysis

For the assessment of measurement and structural models, Smart PLS 4.0 was deliberately selected. This method does not require strict adherence to a normal distribution in survey data [32]. Considering our complex model, which includes independent, dependent, and mediation analysis, regression in SPSS was inadequate [32]. Therefore, we used Partial Least Squares Structural Equation Modeling (PLS-SEM) for a comprehensive and robust analysis.

Measures

In the present study, GBS is designated as the independent variable, whilst pro-environmental behavior is identified as the dependent variable. The research additionally includes GWCP as the intermediary variable. The independent variable (GBS) was assessed using seven items from a study, whereas the dependent variable was evaluated using a six-item scale derived from a study [11]. Finally, four items were employed to assess the mediating variable (GWCP).

III. RESULTS

Common Method Variance

Mitigating Common Method Variance (CMV) is crucial in self-report assessments. This study employed the methodological separation suggested by researchers in a study [33] and conducted a Harman single-factor analysis. Harman's analysis showed that the first factor explained 31.4% of the variance, indicating that common method variance (CMV) is not a significant concern. For assessing the multicollinearity, the current research also assesses and reports the variation inflation factor (VIF). All VIF values were found below 3.3, which is the threshold limit suggested by researchers in another study [34].

Measurement Model Structural Model

This study utilized convergent and discriminant validity to assess the measurement model. Convergent validity emphasizes evaluating the resemblance among items that embody the same construct. Factor loadings, Average Variance Extracted (AVE), and Composite Reliability (CR) are standard metrics employed to assess convergent validity, as advised by researchers in earlier studies [32]. The results acquired for these variables in the current investigation exceeded the specified cut-off values, as illustrated in Table 3 below. This signifies that the measurement model exhibits adequate convergent validity.

Table 1: Output of Measurement Model

Constructs	Items	Loadings	CA	Rho_A	CR	AVE
Green Business Strategy	GBS 1	0.795	0.913	0.893	0.912	0.577
	GBS 2	0.834				
	GBS 3	0.820				
	GBS 4	0.791				

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	GBS 5	0.812				
	GBS 6	0.876				
	GBS 7	0.789				
Green Work Climate Perception	GWP1	0.795	0.853	0.836	0.898	0.619
	GWP 2	0.876				
	GWP 3	0.846				
	GWP 4	0.875				
	GWP 5	0.772				
	GWP 6	0.775				
Pro-Environmental Behavior	GPEB 1	0.841	0.876	0.812	0.891	0.658
	GPEB 2	0.849				
	GPEB 3	0.833				
	GPEB 4	0.868				
	GPEB 5	0.798				
	GPEB 6	0.832				

Furthermore, discriminant validity was evaluated using the Heterotrait-Monotrait ratio, which provides a more precise measurement, utilizing two separate threshold values of 0.85 and 0.90, with all obtained values falling below the recommended threshold. The measuring model exhibited satisfactory levels of convergent and discriminant validity.

Table 2: Output of Discriminant validity

	GBS	G-P-E-B	GWP
GBS			
GP-E-B	0.489		
GWP	0.731	0.571	

Structural Model

Evaluating the goodness-of-fit for the structural model involves analyzing various metrics, including the coefficient of determination (R^2), the significance of the route coefficient b, effect size (f^2), and cross-validated redundancy (Q2) [35]. The interpretation of R^2 values follows Cohen's stated intervals: values from 0.02 to 0.12 indicate a weak association, values from 0.13 to 0.25 denote a moderate relationship, and values of 0.26 and above suggest a substantial relationship. Based on the findings, the current study found that both GWCP (62.3%) and PEB (68.2%) explain R^2 values greater than 0.26, which are considered substantial. In this research, all three direct hypotheses were supported, such as GBS to PEB (β= 0.291, p <0.01), GBS to GWCP (β= 0.614, p <0.01), and GWCP to PEB (β= 0.480, p <0.01).

Table 2: Output of Structural Model

Direct Path								
Hypotheses	Std. Beta	Std. Error	t. Value	f^2	P values	95% LL	95% UL	Decision
GBS>PEB	0.213	0.061	3.49**	0.140	0.00	0.208	0.469	S
GBS>GWCP	0.403	0.038	10.60**	0.64	0.00	0.321	0.681	S
GWCP>PEB	0.378	0.059	6.40**	0.264	0.00	0.461	0.799	S
****p < 0.01, (based on one-tailed test with 1, 000 bootstrapped replications); S = Supported**								
Mediation Hypothesis								
Hypothesis	Std. Beta	Std. Error	t. Value	f^2	P values	95% LL	95% UL	Decision
GBS>GWCP>	0.197	0.049	4.02**	-	0	0.208	0.413	S

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P E B								
****p < 0.01, (based on two-tailed test with 1000 bootstrapped replications); S = Supported**								

Furthermore, the current research also sees the mediating effect of GWCP between GBS and PEB based on the guidelines of a study [36]. Results of the analysis showed a significant mediating effect of GWCP between GBS and PEB. Thus, based on the findings of the analysis, all hypotheses of the current study were accepted. Moreover, it is found researchers have [32] asserted that a model exhibits predictive significance for specific endogenous constructs when the Q2 value exceeds 0. The Q2 values obtained in this study were 0.112 for CE and 0.189 for GKOL. Consequently, the Q2 score signifies that the model had satisfactory predictive relevance.

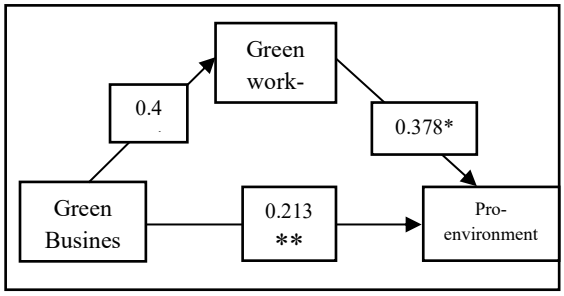


Fig. Hypothesis Testing

IV. DISCUSSION

This research highlighted the connection between GBS, GWCP, and employee PEB. Empirical evidence showed that the GBS approach is effective for boosting employee PEB. GBS promotes sustainability by developing, sharing, and applying environmental information. Ultimately, these organizational practices improve environmental performance and competitive advantage by empowering employees to engage in green initiatives, innovation, and sustainable decision-making, encouraging green practices, and fostering a shared understanding of ecological responsibility [37]. This capacity of GBS supports employee PEB. Additionally, the study revealed that GBS helps to ensure GWCP. In other words, GBS can motivate employees to believe that their organization maintains a green work climate. Furthermore, the results indicate that GWCP enhances employee PEB. Specifically, employees recognize that their organization sustains a green work environment, which in turn fosters their PEB. Finally, the study confirmed the mediating role of GWCP in the relationship between GBS and employee PEB. This means that the effectiveness of GBS in promoting employee PEB depends on the presence of GWCP. As a mediator, GWCP strengthens employees' capacity, amplifying the impact of organizational GBS on fostering their PEB. The study also discusses the theoretical and practical implications. Lastly, it acknowledges the limitations of the research and suggests avenues for future studies.

The findings indicate that in Bangladeshi hotel firms, green business practices directly enhance employees' pro-environmental behaviors and are more effective when employees recognize a supportive green work environment. Hotels must transcend mere policy adoption and actively exhibit sustainable practices—such as energy-efficient technologies, waste minimization programs, and environmentally conscious guest services—enabling staff to absorb sustainability within their work environment. By cultivating this impression, hotels can incentivize staff to partake in daily eco-friendly practices, augment visitor involvement in green initiatives, and bolster their competitiveness in attracting environmentally concerned travelers while contributing to national sustainability objectives.

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Exploring Small Food Businesses for Halal Certification: A Case Study

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Abstract- **This study investigates the intentions, challenges, and prospects of halal certification among small food enterprises in Bangladesh, followed by a focus group discussion, conducted in Dhaka on April 13, 2025, with 25 small business owners divided into five groups. The sessions were guided by nine literature-based questions and analyzed through content analysis using ATLAS.ti 2025, drawing on the Resource-Based View (RBV), Knowledge-Based View (KBV), Institutional Theory (IT), and Islamic Principles (IP). Findings indicate that halal certification is widely recognized as a strategic advantage in Bangladesh's Muslim-majority context, thereby strengthening trust, credibility, and driving business growth. Nonetheless, entrepreneurs reported key challenges, such as limited knowledge, restricted access to certification experts, and risks of fraud in the certification process. The study provides significant managerial and policy insights, suggesting that supporting halal certification can stimulate innovation, promote small business development, and contribute to the UN's 12th Sustainable Development Goal on responsible production and consumption.**
Keywords: **Halal Food, Islamic Marketing, The Knowledge-based View, The Resource-based View**

I. INTRODUCTION

Halal certification brings competitive advantages for business [1-3]. Halal, derived from the Noble Qur'an, is an Arabic term meaning *permissible*. It has evolved into a powerful business driver that stimulates consumer demand [4-5]. For Muslims, consuming halal products is an act of worship and a way to fulfill their religious obligations [6-7]. Interestingly, the Islamic orientation of halal marketers has also influenced non-Muslims to adopt halal consumption [8].

Globally, halal consumption represents a significant economic force. In 2021, 1.9 billion Muslims collectively spent US$2 trillion on halal products, reflecting an 8.9% increase from 2020. This figure is projected to reach US$2.8 trillion by 2025 [9]. The halal economy now encompasses a diverse range of industries, including food, fashion, finance, tourism, media, pharmaceuticals, and cosmetics [10-13]. Products carrying the halal logo often gain added value, highlighting the significance of halal certification [14-16].

Problem Statement

Halal certification (HC), rooted in Islamic principles, serves as the foundation of halal assurance [4]. While HC provides competitive advantages [6,17], it also encounters numerous challenges [18-19]. Much of the existing research has centered on large corporations, with limited attention given to small businesses, particularly in Bangladesh, where small farms and food producers remain underexplored.

Within the food sector, halal signifies products permissible for both Muslims and non-Muslims. Research suggests that *halalpreneurs* tend to be more successful and exhibit greater commitment to faith compared to other entrepreneurs [7]. However, the motivations, awareness, and religious convictions of Bangladeshi halalpreneurs—especially small-scale food producers—are yet to be documented.

Moreover, firms in Muslim-majority countries are increasingly prioritizing halal food production in response to regulations and growing consumer demand [20]. Yet, due to the religious sensitivity of halal and its deep connection to Islamic law, small and medium enterprises (SMEs) often face unique cultural and religious challenges when attempting to access global markets [21]. Despite this, little is known about how Bangladeshi small food businesses perceive halal certification or their willingness to pursue it.

Research Aim and Objective

Halal-certified food appeals to a broad audience. Muslims, Christians, and Jews choose it for religious reasons, while non-religious consumers often favor halal products for their cleanliness, hygiene, purity, health benefits, and overall quality. Such trends are evident in Malaysia, Indonesia, Brunei, and Singapore, particularly among small and micro halal food entrepreneurs. Still, in Bangladesh, the willingness of small businesses to pursue halal certification remains unclear. Against this backdrop, the current study aims to investigate small food businesses' perspectives on halal certification, identifying their challenges and potential solutions. The core objective is to understand how small food producers in Bangladesh view halal certification.

II. LITERATURE REVIEW

The appeal, quality, and demand for food products are strongly tied to both the religious orientation of producers and the presence of halal certification [22-26]. Cleanliness in

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production facilities is a critical requirement for halal compliance. However, obtaining certification from recognized authorities is often complex. Countries like Brunei, Indonesia, and Malaysia have excelled in this area due to strong governmental support [27]. In contrast, Bangladeshi food producers, especially small businesses, have received limited scholarly attention. Countries with large Muslim populations should consider learning from Southeast Asia, where halal certification frameworks have successfully adapted non-Muslim cuisines for Muslim consumers. A further challenge arises in Muslim countries where access to qualified Islamic scholars or institutions to issue certification is limited [28]. Fortunately, this is less of a concern in Bangladesh. Still, compared to its Southeast Asian counterparts, Bangladesh remains underexplored in the context of halal certification and halal entrepreneurship.

As both Muslim and non-Muslim populations grow, managing the halal food industry is becoming increasingly complex. Many small producers lack the religious knowledge or compliance capacity to meet halal standards, making the role of accredited certification bodies essential. Moreover, country-specific policies further complicate halal certification processes [29]. Thus, examining the case of Bangladeshi small food businesses represents an urgent yet neglected research area.

2.1. Islamic Norms

Scholars caution that Western business theories alone are insufficient to explain the unique religious and cultural dimensions of halal [30-32]. To address this gap, the present study incorporates Quranic principles alongside established Western frameworks—including the Resource-Based View (RBV), Knowledge-Based View (KBV), and Institutional Theory (IT)—into a combined "Square Approach" (SA) illustrated in Figure 1. This integrated perspective provides a more comprehensive foundation for promoting halal certification among small food businesses.

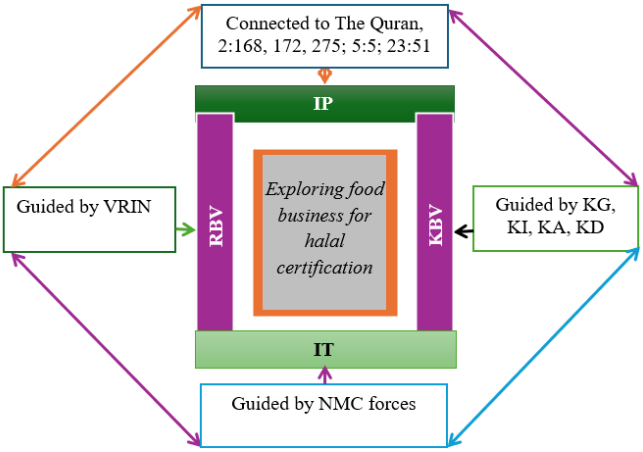


Figure 1: The Square Approach (SA) for halal food businesses (Source: Original)

The SA is shaped like four angles. The first one includes Islamic principles (IP) outlining key verses relating to halal and tayyib food consumption. The Noble Quran ordains humankind to consume halal and tayyib food.

It says:

يَٰٓأَيُّهَا ٱلنَّاسُ كُلُواْ مِمَّا فِى ٱلْأَرْضِ حَلَٰلًا طَيِّبًا وَلَا تَتَّبِعُواْ خُطُوَٰتِ ٱلشَّيْطَٰنِ ۚ إِنَّهُۥ لَكُمْ عَدُوٌّ مُّبِينٌ

(O humanity! Eat from what is lawful and good on the earth and do not follow Satan's footsteps. He is truly your sworn enemy (https://quran.com/2:168).

It outlines to the believers:

يَٰٓأَيُّهَا ٱلَّذِينَ ءَامَنُواْ كُلُواْ مِن طَيِّبَٰتِ مَا رَزَقْنَٰكُمْ وَٱشْكُرُواْ لِلَّهِ إِن كُنتُمْ إِيَّاهُ تَعْبُدُونَ

(O believers! Eat from the good things We have provided for you. And give thanks to Allah if you ˹truly˺ worship Him ˹alone˺ (https://quran.com/2:172).

It particularly ordains to the messengers:

يَٰٓأَيُّهَا ٱلرُّسُلُ كُلُواْ مِنَ ٱلطَّيِّبَٰتِ وَٱعْمَلُواْ صَٰلِحًا ۖ إِنِّى بِمَا تَعْمَلُونَ عَلِيمٌ

(O messengers! Eat from what is good and lawful, and act righteously. Indeed, I fully know what you do (https://quran.com/23:51).

It also broadens the scope of halal food, explaining:

ٱلْيَوْمَ أُحِلَّ لَكُمُ ٱلطَّيِّبَٰتُ ۖ وَطَعَامُ ٱلَّذِينَ أُوتُواْ ٱلْكِتَٰبَ حِلٌّ لَّكُمْ وَطَعَامُكُمْ حِلٌّ لَّهُمْ ۖ

(Today, all good, pure foods have been made lawful for you. Similarly, the food of the People (Christians and Judaists) of the Book (https://quran.com/5:5).

The four verses 2:168,172; 23;51 and 5:5 ordain for halal food consumption. Halal food consumption is not a choice or priority, but a right for all. All people, including believers and non-believers, must have access to good and wholesome (halal and tayyib) food. If people consume halal food, its market coverage will expand. As such, the IP through the prescriptive verses stresses halal food consumption.

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Halal food consumption can be accelerated if the businesses of halal-certified food expand. The noble Quran focuses on halal business by saying:

وَأَحَلَّ ٱللَّهُ ٱلْبَيْعَ وَحَرَّمَ ٱلرِّبَوٰا۟ ۚ

Allah has permitted trading and forbidden interest (https://quran.com/2:275).

Normally, the food is halal (permitted) if no haram (prohibited) issues are associated with it according to IP. The food is halal, but non-certified. Halal-certified food ensures that no haram issues persist during the production and delivery stages. Halal certification portrays the halal logo (حَلَالٌ) symbolizing spirituality, responsibility, trust, and a tool for tangible and intangible resources for business. Importantly, IP denotes the sources of knowledge or the KBV.

2.2. The Knowledge-Based View (KBV)

The Knowledge-Based View (KBV), introduced by [33], posits that firms achieve a competitive advantage through knowledge gathering (KG), knowledge integration (KI), knowledge application (KA), and knowledge dissemination (KD) [34]. KG involves employee training, expert engagement, and developing reading habits to strengthen knowledge bases [35]. KI refers to combining knowledge sources and evaluating how effectively employees assimilate them [33]. KA translates theoretical insights into practical use while assessing their workplace relevance [36]. KD, in turn, is the distribution of knowledge at both individual and organizational levels [37].

For halal food producers and marketers, Islamic Principles (IP) represent a crucial knowledge base for navigating certification and business operations. Firms can benefit from the expertise of halal certifiers, scientists, and Islamic scholars to ensure compliance [38-42]. Thus, KBV in a halal context depends on KG, KI, KA, and KD of IP. Over time, this knowledge-driven approach evolves into the Resource-Based View (RBV).

2.3. The Resource-Based View (RBV)

The Resource-Based View (RBV), developed by [43], highlights valuable, rare, and scarce resources as key drivers of success [44]. RBV has been applied in diverse fields, including international marketing [45], innovation [46], and brand management [47]. According to RBV, firms outperform competitors by securing superior resources [48].

Halal certification itself is considered a valuable resource that provides producers with a competitive advantage [40-41]. Producers pursue certification not only to comply with Islamic requirements but also to strengthen market positioning [49]. Even non-Muslim firms recognize halal certification (HC) as a strategic resource [50]. Therefore, the timely institutionalization of HC can enhance competitiveness across the food industry [42].

2.4. The Institutional Theory (IT)

Institutional Theory (IT) explains organizational change through coercive, normative, and mimetic (CNM) pressures [51]. Coercive pressures emerge from government regulations [52], normative pressures stem from industry expectations [53], and mimetic pressures arise from competitors' practices [54].

In the halal context, RBV highlights the strategic value of certification, while IT emphasizes the role of regulatory and industry in embedding certification practices [55,39]. Government involvement, together with collaboration among Islamic scholars, certifiers, policymakers, and food marketers, is vital for institutionalizing halal certification. IT therefore fosters a systematic environment for halal stakeholders to strengthen certification processes.

III. METHODOLOGY

3.1. Research Approach

This study adopts an inductive approach, moving from specific observations to broader theoretical insights. Inductive reasoning emphasizes theory-building rather than heavy reliance on quantitative tools [56]. Here, Islamic principles were first examined, and their dimensions were then aligned with RBV, KBV, IT, and participants' perspectives to construct the proposed Square Approach (SA).

Square Approach

The Square Approach is built on four foundations:

- Islamic principles (IP) on halal food as the baseline.
- KBV constructs rooted in IP.
- RBV, which validates heterogeneity of resources.
- IT, which fosters synergy among practitioners and policymakers.

Together, IP, KBV, RBV, and IT form the SA framework used in the analysis.

3.3. Sample Size

Judgmental and convenience sampling were applied to select small food entrepreneurs in Dhaka City. Using judgmental and snowball techniques, 25 participants were recruited: 20 current business owners and 5 prospective entrepreneurs. They were divided into five groups of five participants each.

3.4. Data Collection

Focus Group Discussions (FGDs) were conducted with mixed male and female participants. A semi-structured guide of nine questions—derived from prior halal certification literature—was used (see Appendix 1). Discussions were audio-recorded with participants' consent, and written summaries were collected for validation.

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3.5. FGD Protocol

The researchers introduced the study, ensured equal participation, and maintained anonymity. Participants were free to withdraw at any time. At the end of each session, they were thanked for their contributions, and further cooperation was requested.

3.6. Data Analysis

Analysis combined manual and software-assisted techniques. Initially, manual content analysis identified critical themes linked to halal certification challenges. Then, ATLAS.ti 2025 software was used to code, organize, and analyze data through content, concept, association, and network analysis. Thematic patterns were visualized using network diagrams to enhance interpretation.

IV. RESULTS AND ANALYSIS

4.1. Participant's details

Table 1 outlines the demographic details of participants in focus group discussions (FGDs) related to food products. There was a total of 25 participants, comprising 18 females and 7 males. One group included a non-Muslim female participant. The participants traded various food items such as processed foods (yogurt, sausages, pickles, cakes) and homemade foods. Their education ranged from the Secondary School Certificate to postgraduate degrees.

Table 1: Details of the FGD participants

SL	Gender	Product nature	Age & Education	Discussion Time
Group 1	Male 2, Female 3, with 1 non-Muslim	Processed food, Yogurt, Sweet, Borhani, Soybean	21 – 28, SSC- post-graduation	1 hour
Group 2	Female 5	Processed food, sausages, pickles, cake, soya food, Agricultural food products, Homemade food	27-46, SSC-Graduation	1 hour
Group 3	Male 5	Soyabean, Tomato, sweets, doi, matha, burhani, Matha, lacchi (local and traditional food)	22-28, HSC-Graduation	1 hour
Group 4	Female 5	Homemade food	26-43, SSC-HSC	1 hour
Group 5	Female 5	Intending to do food business	28-39, JSC-HSC	1 hour
Five groups	18 female, 7 male	Processed food with agricultural inputs	21-46, SSC- post-graduation	5 hours

Source: Original

The fifth group indicated an interest in starting a food business. The discussions varied in length, with Group 1 having a one-hour discussion, while all groups collectively took about five hours in total.

4.2. Content analysis

The content in Figure 2 reveals that halal certification is widely perceived as a strong competitive advantage in a Muslim-majority context, contributing to consumer trust, brand credibility, and business growth.

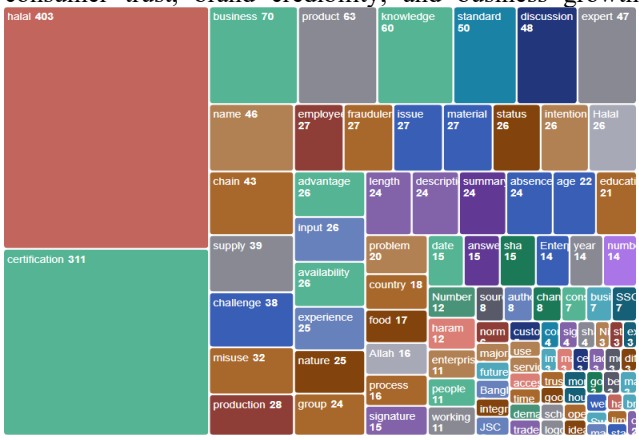


Figure 2: Content analysis (Source: Original)

The contents are associated with the nine key questions or concepts. However, several challenges persist, including limited understanding of halal standards, difficulty in accessing certification experts, and concerns about fraud and corruption in the certification process.

4.3. Concept analysis

The concepts in Figure 3 are illustrated according to key content. The content explains that the concepts related to operationalizing halal certification are often seen as complex, particularly for small businesses, due to bureaucratic hurdles and a lack of clear guidance. While sourcing halal raw materials is generally considered manageable, maintaining halal integrity across the entire supply chain is a major concern due to the absence of a halal logistics infrastructure.

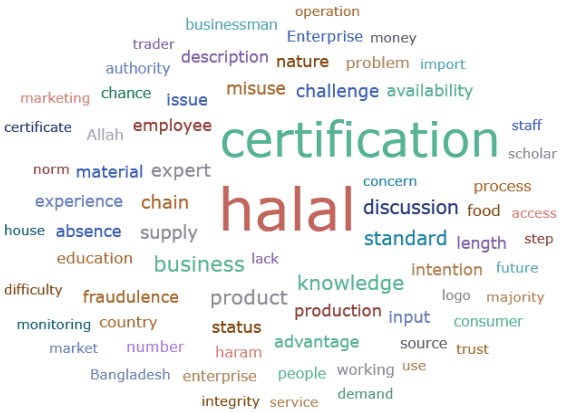


Figure 3: Concept analysis (Source: Original)

Moreover, participants expressed varying levels of knowledge about halal certification, indicating the need for targeted education and training. Lastly, stakeholders emphasized the importance of stronger oversight, clearer communication from certifying bodies, and improved awareness to support ethical, trustworthy, and accessible halal certification practices.

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4.4. Perceptions of small food businesses on halal certification

4.4.1. Advantages of Halal Certification

Group One emphasized that in a Muslim-majority country, halal certification is vital for business success as it ensures compliance with Islamic principles, strengthens consumer trust, enhances goodwill, and boosts sales. With Muslims comprising 98% of the population, certification provides a significant competitive edge.

Group Two highlighted that halal certification enhances credibility, brand reputation, and consumer trust. By attracting more customers and supporting business growth, it strengthens alignment with halal values, making it a strategic business tool.

Group Three described halal certification as a strategic asset for food businesses. It drives growth, symbolizes purity, enhances consumer loyalty, and provides a competitive advantage in the marketplace.

Group Four noted that halal certification guarantees compliance with Islamic dietary laws while appealing to a growing market of halal-conscious consumers. It expands business opportunities, attracts more customers, and increases satisfaction by meeting consumer preferences.

Group Five viewed certification as beneficial both individually and collectively. It fosters consumer trust, supports customer preference for halal products, and underscores the importance of market acceptance.

4.4.2. Challenges with Halal Standards

Group One expressed confidence in existing standards, stressing the importance of consumer awareness about halal and haram. They acknowledged that while compliance can be demanding, it is achievable with effort and vigilance.

Group Two generally regarded national standards and industry practices positively but admitted that some respondents struggle with compliance due to uncertainty or limited understanding of the requirements.

Group Three agreed that current halal standards are adequate and comprehensive. However, they acknowledged challenges in avoiding prohibited elements and noted that small organizations often find the standards difficult to interpret.

Group Four emphasized that understanding the standards is essential for overcoming difficulties. While some respondents reported no issues, others pointed to challenges related to storage conditions and the shelf life of processed foods. One participant admitted not knowing the standards.

Group Five suggested that knowledge of the standards helps in addressing compliance, particularly for processed food and storage. Still, some respondents face difficulties, with a few relying on general guidelines due to limited awareness.

4.4.3. Challenges with Production Inputs

Group One indicated that sourcing halal raw materials in Bangladesh is relatively easy because of the country's abundant natural resources and Muslim-majority environment. They stressed avoiding inappropriate or non-halal materials.

Group Two reported minimal difficulties in sourcing inputs, though some materials are seasonal, affecting consistent availability. Group Three believed that sourcing halal raw materials is manageable due to their natural availability in the local context. While some expected initial challenges, they felt these could be resolved with effort and did not view sourcing as a major obstacle.

Group Four confirmed access to raw materials but raised concerns about maintaining quality standards, particularly storage and preservation. Most respondents considered sourcing manageable with care, though one found it potentially problematic.

Group Five expressed mixed views. Some believed supply sources were adequate, while others anticipated challenges or worried about limited availability. They emphasized the need for careful verification of raw materials.

Challenges with Halal Certification Experts

Group One observed that although general awareness of halal and haram exists, experts specifically trained in halal certification are scarce and not easily accessible. Group Two offered mixed perspectives: some participants felt there were enough experts available, while others argued that the number of qualified professionals remained limited.

Group Three pointed out a lack of accessible certification experts. While some relied on personal contact, others found it difficult to secure qualified professionals. Group Four noted that although experts exist in various disciplines, those specializing in halal certification are not widely known or easily accessible. Business owners must make extra efforts to identify trustworthy individuals committed to Islamic principles.

Similarly, Group Five acknowledged the presence of halal certification experts but emphasized that they are not well-

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recognized or easily approachable. Entrepreneurs must actively seek reliable and devoted professionals with expertise in relevant fields.

4.4.4. Challenges with Halal Certification Experts

Group One highlighted misuse and corruption within the halal certification process as major concerns. They noted that certification is often difficult to obtain, with bribery and false labeling—using the halal logo for profit without genuine compliance—common due to weak enforcement. They stressed that such malpractice should be criminalized.

Group Two warned that high demand for certification increases the likelihood of misuse, while Group Three identified practices such as applying one certificate across multiple products, duplicating certificates, and bribery as prevalent issues. They called for strict government enforcement and oversight from consumer rights groups.

Group Four perceived a significant risk of malpractice, including mixing halal and haram products and duplicating certificates, which undermines certification credibility. Stronger monitoring was deemed essential, especially as demand rises.

Group Five also underscored the risks of manipulation, corruption, and mixing of halal and haram products. They cautioned that the certification process itself may be flawed, making fake certifications harder to control as demand increases. Stronger regulatory oversight was recommended.

4.4.6. Operationalizing Halal Certification

Group One described the certification process as complex, citing bureaucratic hurdles and unhelpful authorities, and suggested that the system be simplified. Group Two stressed that certification is particularly burdensome for small businesses, as it is time-consuming and complicated, with authorities often providing inadequate services. They emphasized the need for clearer guidance and support.

Group Three agreed that the process is initially complicated but can become manageable with proper guidance and experience. Group Four noted that dedication and adherence to halal norms make the process manageable, while challenges help deepen understanding of certification's value.
Group Five echoed this perspective, stating that commitment and a clear understanding of Islamic principles make certification achievable. They viewed initial challenges as beneficial for long-term business success.

4.4.7. Knowledge for Managing Halal Certification

Group One admitted a lack of knowledge and expertise but expressed determination to learn. Group Two pointed to challenges related to supply chains and insufficient knowledge of certification. Group Three also reported inadequate knowledge, particularly regarding products and production processes, and stressed the need to address this gap.

Group Four participants felt they had sufficient knowledge and could manage halal-certified businesses. Group Five gave varied responses: one participant reported adequate knowledge, while others admitted little or no understanding of certification.

Halal Supply Chain Challenges

Group One emphasized the complexity of maintaining halal integrity throughout the supply chain, particularly when uncertified raw materials or chemicals are involved. They highlighted the need for all employees to be familiar with halal standards.

Group Two noted that maintaining standards across supply chains is difficult, with challenges including delays, shortages of raw materials, mixing of halal and haram items, and poor storage or transport conditions. Group Three argued that Bangladesh lacks an integrated halal supply chain, identifying gaps in quality control, warehousing, marketing, and employee training in Islamic guidelines.

Group Four acknowledged that the supply chain in Bangladesh is underdeveloped. While management is possible, maintaining halal integrity remains challenging. They suggested that developing strong halal businesses will gradually strengthen the supply chain.

Group Five concluded that the halal supply chain is still immature and presents serious concerns. Managing the entire process—from raw material sourcing to product delivery—is difficult, with maintaining integrity especially challenging due to the absence of a structured, reliable supply chain.
Other Issues in Halal Certification

Group One highlighted the importance of marketing halal-certified products but noted limited awareness of certification requirements. They recommended stricter monitoring, better training, and even incorporating Quranic verses on packaging alongside the halal logo.

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Group Two stressed the need for accessible training and guidance from certifying authorities. Group Three acknowledged the potential benefits of halal certification but pointed to limited expertise and poor access to trained personnel. They recommended more professional training, ethical practices, simplified processes, and stronger government oversight.

Group Four emphasized that halal certification enhances business appeal while fulfilling Islamic obligations, thereby fostering trust and business success. Group Five agreed, noting that certification improves sales and customer trust, and highlighted the importance of knowledge sharing for raising awareness and ensuring business sustainability.

Code-Quotation Analysis with Gender

Table 2 compares the responses of male and female participants. Female participants contributed 62 quotations, primarily focused on knowledge for navigating halal certification, followed by its advantages, supply chain issues, and fraud concerns. Both male and female participants agreed that halal certification, supported by the halal logo, represents a spiritual symbol that boosts sales and goodwill for halal food businesses. This reflects the value of halal certification as a resource with rarity, inimitability, and non-substitutability (VRIN).

Table 2: Code Quotations for gender

Perceived Issues	● Female Gr=167	● Male Gr=105
● Advantages of HC Gr=49	32	17
● Challenges of raw materials Gr=15	12	2
● Challenges of standards Gr=19	9	9
● Fraudulence and misuse of HC Gr=38	23	15
● Halal supply chain Gr=46	32	13
● HC experts Gr=25	14	8
● Knowledge to handle HC Gr=56	33	20
● Operationalizing HC Gr=24	10	11
● Other HC issues Gr=43	24	20

Source: Original

Further, Figure 4 shows the associations across the participants and perceived issues. The nine perceived issues are linked to the male and female. The thicker part of the figure, the more issues they perceived. The number of quotations (Gr) in the table and the thickness of the Sankey diagram are consistent.

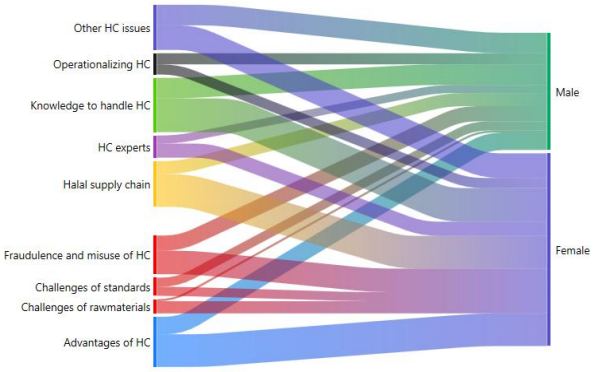


Figure 4: Code-occurrence analysis with gender (Source: Original)

Thematic analysis

Table 3 presents the central theme explored in the study. The first column depicts the perceived issues asked of the participants. Their responses are shown in the second column, derived from quotations or opinions with frequencies.

Table 3: Thematic table of integrating RBV, KBV, and IT with the halal food business

Perceived Issues	Theoretical Issues	Subthemes	Main Theme
Halal certification (HC) advantage	RBV of HC	RBV of HC depends on Islamic knowledge acquisition, integration, application, and dissemination.	Islamic principles (IP) with the KBV produce the RBV of HC, which requires widespread integration across stakeholders and overcomes barriers to HC institutionalization.
Halal standard challenges	KBV of HC	KBV results in RBV of HC, which is pervasive and crucial across the business, supply chain, and internal and external stakeholders. KBV can overcome the barriers to leverage HC.	
Halal supply chain challenges			
Halal certification expert challenges			
Knowledge to manage HC			
Complexity of operationalizing HC	IT of HC	The successful institutionalization of HC in the halal food industry depends on macro and micro endeavors.	
Fostering institutionalization of HC			

Source: Original

The quotation frequencies are linked to specific theoretical constructs. These constructs outline the subthemes. All subthemes have been mapped to reveal a common pattern, represented by a main theme. The main theme indicates that Islamic principles (IP) combined with the KBV generate the RBV of HC, which requires widespread stakeholder integration and overcomes barriers to HC institutionalization.

According to Table 3, the thematic map is illustrated in Figure 5. The figure demonstrates that Quranic verses represent Islamic principles (IP), which define the rules governing the halal food business. The halal food business must view IP as the core to achieve KBV. Applying KBV results in the RBV. Furthermore, IT synthesizes the stakeholders of both KBV and RBV to promote and institutionalize HC.

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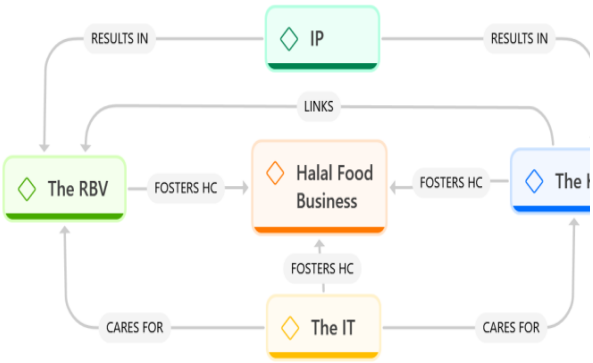


Figure 5: Thematic map focusing on SA (Source: Original)

In other words, IP symbolizes water, and the KBV symbolizes a garden. The benefits of HC (RBV) are the fruits. Then, IT is about caring for the garden. Watering the garden carefully yields fruit. Therefore, IP extends its spiritual dimensions to bring economic breakthroughs in small halal businesses. Small halal companies must explore and manage Islamic resources for halal certification.

V. DISCUSSION AND IMPLICATIONS

The study reveals that halal certification provides significant competitive advantages. Previous research has consistently emphasized these benefits, showing that halal certification not only fulfills religious obligations but also establishes global standards and influences consumer behavior in both Muslim and non-Muslim societies [57-58]. For non-Muslims, halal certification is often linked to hygiene, ethics, and quality [1], whereas Muslims perceive it as a means of upholding religious laws and worship [59]. Thus, halal certification embodies both spiritual and material benefits [60, 40-41].

Despite these advantages, this study highlights several challenges, including shortages of raw materials, limited halal certification experts, inadequate knowledge of Islamic principles, and weak halal supply chains. Prior research shows that such challenges include limited availability of inputs [61-62], a shortage of qualified experts [19], fraud [63], operational difficulties, and fragmented supply chains [3]. Interestingly, this study did not identify halal standards themselves as a problem, even though scholars have questioned the variations across standards that hinder business expansion.

Some producers continue to use inputs that contradict Islamic principles, such as haram-based gelatin [62], contamination between halal and haram products [19,39,41], questionable additives [63], GMOs, and alcohol-based treatments [64]. Such practices pose risks to the halal status of products.

The findings also show that small food businesses are particularly concerned about fraud and malpractice in halal certification. Criticisms include fraudulent practices, dubious accreditation [65], misuse of the halal logo [2], lack of authenticity [63], mislabeling, and halal-related scandals [66-68]. Addressing these issues requires the combined efforts of individuals, businesses, and governments. These efforts align with the coercive, normative, and mimetic (CNM) pressures described by institutional theory [51]. Furthermore, Islamic norms can guide decisive actions, where government regulation (coercive), industry standards (normative), and imitation among producers (mimetic) contribute to the institutionalization of halal certification [40].

From a theoretical perspective, halal certification is a resource. The Resource-Based View (RBV) emphasizes its role in providing firms with unique advantages [34,43, 69]. Institutional Theory (IT) ensures alignment with stakeholders [40-41], while RBV highlights competitive differentiation. Together, IT and RBV provide complementary insights for strengthening halal-aligned businesses. Likewise, the Knowledge-Based View (KBV) underscores the need to acquire, integrate, and apply knowledge to sustain competitiveness [36]. In halal trade, embedding Islamic knowledge within the KBV framework is essential for ensuring competitive advantage [70].

Scholarly Implications

This study contributes by extending RBV, KBV, and IT into the halal business context, which remains underexplored compared to conventional business. It introduces the concepts of Halal RBV and Halal KBV, while integrating Islamic principles into institutional theory. These constructs contribute to the development of halal entrepreneurship theory, particularly within the context of small food businesses in Bangladesh. This originality lies in addressing gaps in halal marketing knowledge and contextualizing theoretical frameworks in halal entrepreneurship.

Managerial Implications

For practitioners, the findings highlight how halal certification can foster business innovation, support small-scale entrepreneurs, and contribute to microeconomic growth. Small businesses can draw practical insights into the certification process, enabling them to enhance awareness and competitiveness in the halal economy. This study, therefore, serves as a roadmap for small food enterprises aiming to access halal markets.

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Policy Implications

Policy implications emphasize the need for certifiers and government agencies to support small businesses, which are often overlooked in certification frameworks. The findings align with the 12th United Nations Sustainable Development Goal (SDG) on responsible consumption and production, particularly in halal food. National institutions, such as the Bangladesh Standards and Testing Organization and the Islamic Foundation, can use these insights to design policies that strengthen certification processes, improve trust, and expand access to halal-certified food.

VI. CONCLUSION, LIMITATIONS, AND FUTURE RESEARCH

This study fills a gap in academic literature on the integration of small businesses into halal certification. Findings reveal that entrepreneurs view halal certification as a competitive advantage, enhancing consumer trust, brand credibility, and business growth. However, key challenges include limited expertise, difficulties in accessing certification professionals, fraud concerns, and bureaucratic complexities. While sourcing halal inputs appears manageable, maintaining supply chain integrity is a major challenge due to the lack of developed halal logistics systems.

Knowledge gaps also remain, with many entrepreneurs showing limited understanding of certification principles, highlighting the need for education and training. All groups emphasized stronger oversight, clearer communication from certifying authorities, and greater awareness to ensure trustworthy certification practices. Importantly, Islamic knowledge was identified as a critical factor in overcoming barriers and transforming challenges into opportunities.

Beyond managerial contributions, this study integrates RBV, KBV, IT, and IP, making it the first to examine halal certification among small businesses in Bangladesh. Nevertheless, limitations exist: many participants had limited knowledge of certification, and one focus group lacked direct business experience. Government and certification authorities were also excluded. Future research should involve both experienced entrepreneurs and regulatory bodies to develop a more comprehensive perspective. Incorporating IP alongside RBV, KBV, and IT offers a promising path for future exploration.

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Factors Influencing Profitability in the Bangladeshi Commercial Banking sector

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Abstract- **This study explores the determinants of Bangladesh-based commercial banks' profitability of commercial banks in an emerging economy, Bangladesh. For this study, commercial banks' annual report data [over the period 2013-2024] was used. Probable determinants were shortlisted using empirical literatures. The study uses return on asset (ROA) and return on equity (ROE) as the dependent variable. Panel regressions were run using fixed effects model and random effects model. The findings show a significant positive relationship between asset quality and bank performance, and a significant negative relationship between capital adequacy and performance across all baseline models.**

Keywords: **ROA, ROE, asset quality, bank performance, capital adequacy, fixed effect model and random effect model.**

I. INTRODUCTION

Banks are depository financial institutions connecting the savers and users of fund. These mediators are interpolated between the final borrowers and lenders allowing them well-organized allocation of funds in the economy. Entities having excess funds can advance them for rational return to entrepreneurs and other economic units who need funds to take the advantage of economically and financially feasible investment ventures. The presence of financial markets and financial organizations allows such transfer of financial resources. Thus, both the borrowers and lenders are well off compared to without financial organizations and intermediaries. It is argued that financial establishments have a progressive role in funding and investment in a multidimensional practice linking the difficulty of numerous interconnected and inter-reliant factors of differentiated nature. It is difficult to assess the contribution of each factor independently. The pivotal purpose of financial organization with other non-depository institutions is to support in the distribution of country's scarce capital among several alternative investment areas. Thus, the financial market plays a twin role, providing numerous types of investment fund and disciplining

businesses, which are incompetent and fail to follow profitable income objectives. Thus, it is observed that financial institutions especially commercial banks if rightly organized and directed can help expansion of our economy.

In the context of Bangladesh has an option, efforts to be designed at nurturing banking activities for accelerating the economic wheel of the country. Notwithstanding its significant merits, it is also not desirable to overlook the problems of the nation's crisis oriented banking structure, which requires appropriate guideline of the banking procedure in order to safeguard effective use and watching of business funds.

II. LITERATURE REVIEW

In this chapter an attempt has been made to highlight an insight into the different literature relating to bank's asset quality, capital adequacy and bank performance in international and domestic settings. It is observed that different studies have been undertaken using different methodologies in different countries and in different financial environments. Some of the studies used primary sources of data and other focuses on secondary sources. The results of these studies are diverse in natures documenting differences in different countries with respect to profitability, asset quality and bank performance. In this chapter the researcher has also tried to identified a number of potential factors that can influence commercial bank's profitability, asset quality, capital adequacy and other related issues.

This chapter provides a comprehensive overview of the literature concerning bank asset quality, capital adequacy, and overall performance across both international and domestic contexts. A wide range of studies have been conducted using varied methodologies, reflecting the diversity of financial environments and regulatory frameworks in different countries. Some researchers have relied on primary data sources, while others have utilized secondary data, resulting in a broad spectrum of findings. [1] suggested that bank asset quality could serve as a potential rescue mechanism for banks in the future. In their study of Nigerian banks, [2] highlighted the importance of continuously analyzing and investigating the factors influencing bank performance. Their findings pointed to persistent underperformance in the banking

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sector, characterized by elevated credit risk and a rising incidence of bad loans.

Nigerian banks have emphasized the critical need for ongoing analysis and investigation into the factors affecting bank performance, particularly in light of persistent underperformance marked by high credit risk and a growing volume of bad loans. [10] identified asset management as a key management concern for banks, noting that global surveys consistently highlight asset quality as a shared priority among bankers worldwide. [1] concluded that asset quality significantly influences a bank's ranking, with ratings and management evaluations closely tied to asset performance. [9] further supported this view, finding that high-quality assets are a defining trait of top-performing banks, while poor asset quality often correlates with lower bank ratings. [2] observed an inverse relationship between non-performing assets (NPAs) and bank income, underscoring the negative impact on overall bank performance. To safeguard investor interests, they advocated for prudent credit risk management and robust asset protection strategies.

[11] noted that bank capital requirements are designed to ensure that institutions maintain adequate capital levels to mitigate risks associated with asset growth—particularly when assets are both profitable and inherently risky. This regulatory approach aims to safeguard financial stability by balancing growth with prudent risk management.

According to [13], asset quality is assessed by comparing the classification of credit—such as doubtful, substandard, and bad loans—with the total credit extended by the bank. This evaluation provides insight into the bank's ability to manage its income-generating assets. [5] further emphasized that the primary goal of allocating bank funds to productive assets is to generate the expected revenue, highlighting the importance of effective asset management in achieving financial performance.

[11] conducted an analysis of the CAMEL framework—comprising capital adequacy, managerial competence, earnings quality, and liquidity—for both domestic and international banks operating in Malaysia during the period from 2008 to 2012.

Researchers across the globe had used the ratios of profitability to risk and solvency to liquidity to investigate the success or failure of various financial organisations. In addition, [1] used nine financial metrics in order to assess the effectiveness and efficiency of banking institutions. These parameters included things like profitability as well as credit risk and liquidity risk. [2] emphasized the need of considering a number of factors when assessing an bank's degree of performance. [3] determined whether bad debts have an effect on Turkish banks' profitability. He employed the regression analysis method to explore time series data set that includes 1809 observations. The association between non-performing or bad loans and profitability, as determined by ROA and ROE, was found to be negatively skewed. Return on equity and return on assets were both low when asset quality were poor and nonperforming loans were high. [13] used IFRS-compliant quarterly financial reports from 55 Turkish banking sector banks. The time frame for the study was the first quarter of 2005 to the third quarter of 2016. Quality of Asset was evaluated by the proportion of bad or non-performing (follow-up) loans to total assets. According to the findings of the panel regression study, there was a significant inverse relationship between non-performing loans and the ratio of ROA/ROE variable, a measure of bank profitability. A decline in asset quality or a large number of bad loans could result in the bankruptcy of banks during an economic crisis. [14] found that in the past 25 years, both domestic and international agencies had implemented legislation to assess asset quality in relation to its significance. [7] conducted a study on bank leverage (debt) and its drivers in the United Kingdom, leverage was the dependent variable, while long-term loans, short-term debts, and retained earnings were the independent factors. [7] demonstrated that debt (also known as leverage) was negatively correlated with risky assets, long-term debt, and short-term debt. The [4] evaluated indicators of capital adequacy, as well as their consequences on financial risk indicators, bank revenues, and bank valuations. The banking industry is susceptible to interest rate risk, liquidity risk, and credit risk.- [3] conducted research to develop a model for evaluating Egyptian banks and to establish a standard that incorporated various elements required to evaluate capital adequacy. The model of [3] was reflective of the majority of the risks that commercial banks faced in general and credit, inflation, liquidity, and market risks in particular. [8] evaluated the various factors that determined the level of security maintained by Jordanian commercial banks over a specific time period (1992 – 2002). According to the research findings, there was a strong positive relationship between banking security and ROE and ROI. A large range of circumstances had a favorable or negative impact on the returns of assets held by commercial banks in Kosovo. These factors consist of Banks were essential to the expansion and growth of a nation's economy. The reason was that there was a positive association between the state of the banking industry and economic growth [6]. In addition to the Central Bank, banking organizations, governments, and

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other financial authorities, bank management was important in understanding the correlation between adequate capital and financial sector performance. This was due to the fact that the financial industry could not function efficiently without sufficient cash.
There were other factors that contributed to having sufficient cash. [14] argued that regulators could combat moral hazard by focusing on capital adequacy regulation. The regulation of capital adequacy protected small depositors. Small depositors make up the majority of bank's fund, thus this protection was very important.

III. BANKING SECTOR OF BANGLADESH

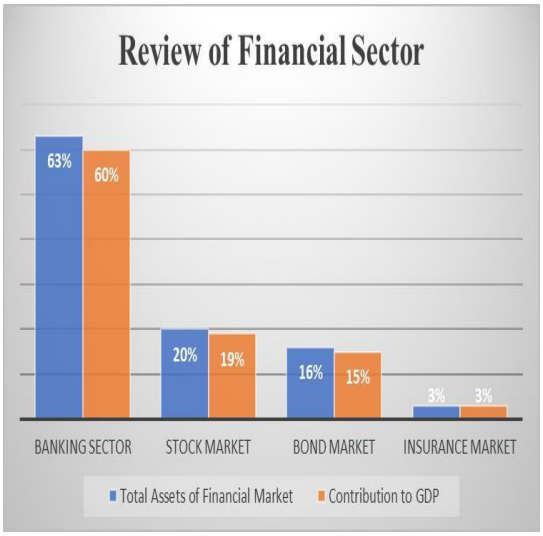
The banking sector of Bangladesh exemplifies the country's unwavering pursuit of financial excellence. This summary sheds light on the fascinating story of banking performance in this bright country. The primary objective of the Bangladesh Bank (BB) for the fiscal year 2024 was to preserve the economic health of the nation. Bangladesh Bank (BB) has devised a comprehensive plan to maintain resilience in order to ensure that the economy will continue to expand while remaining stable throughout fiscal year 2024. The Bank of Bangladesh (BB) forecasted that Bangladesh's economy would continue to flourish and remain stable in fiscal year 2024 if these policies were maintained.

3.1Overall Financial Sector's Performance in Bangladesh

The percentages of shares of the different sectors in terms of total assets in the financial market and contribution to GDP in 2023 are given in Figure-3.1.

Figure- 3.1

Financial Sector's Contribution to GDP



Source: Financial Express, 2023

It is observed that in all of the financial sectors, the banking sector's contribution is greater than the sum of other sectors' contributions in terms of total assets held to Gross Domestic Product (GDP). Commercial banks have made a significant impact on Bangladesh's economy over the years. They provide the public sector as well as the private industry with investable capital to accelerate the economic wheel of the country.

3.2 Major Performance Indicators of Banks in Bangladesh:

Bank's performance can be measured by different theoretical and other mathematical parameters. In this section attempts have been made to focus on the major performance indicators of banks operating in Bangladesh.

3.3 Capital Adequacy Ratio of Bangladeshi Banks:

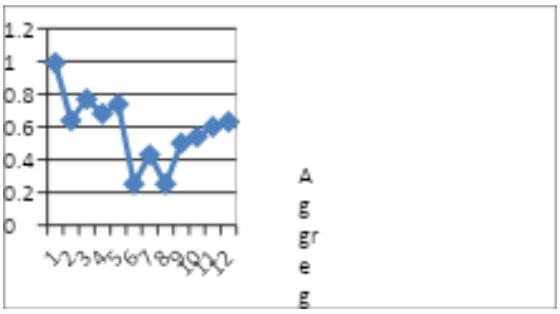
While there has been a substantial advancement in the asset quality of the banking sector in Bangladesh over the last several years, there are still issues with nonperforming loans (NPLs), loan classification, and loan provisioning. To guarantee the long-term health of the nation's financial sector, it would be essential for the Bangladesh Bank and other regulatory agencies to continue addressing these issues.

Appropriate Levels of Capital adequacy refers to the degree of protection a bank provides for its depositors and other creditors against potential losses. The higher the capital adequacy ratio (CAR), the lesser the insolvency risk for banks. In recent years, the banking sector in Bangladesh has struggled to maintain the required level of capital adequacy due to a number of obstacles, including inadequate governance, high levels of non-performing loans (NPLs), etc.The Aggregate Capital Adequacy Ratio (ACAR) of Bangladeshi banks for the years 2014 to 2024 is shown in Figure- 3.2 which represents the trend of capital adequacy ratio maintained by the banks.

Figure- 3.2

Aggregate Capital Adequacy Ratio

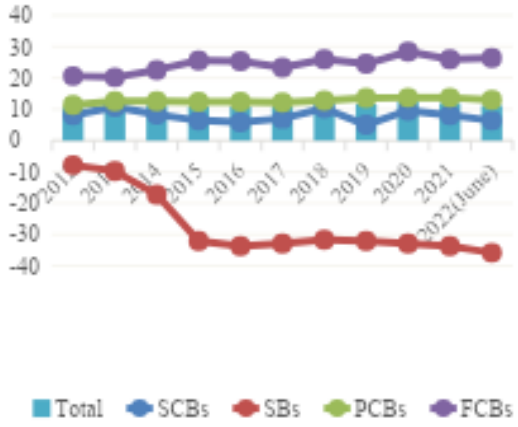
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Source: Bangladesh Bank Annual Report, 2024

According to the available data, the overall CAR for Bangladeshi banks was 9.90% in 2012 and grew to 10.50% in 2013. The aggregate CAR significantly declined to 11.30% in 2014 before stabilizing at 10.80% for the three years 2015–2017. The banks' aggregate capital adequacy ratio (CAR) improved to 12.10% in 2018, showing that they have more capital on hand to cover future losses. The CAR has been showing improving trend from 2012 to 2022 as revealed from Figure-3.3.

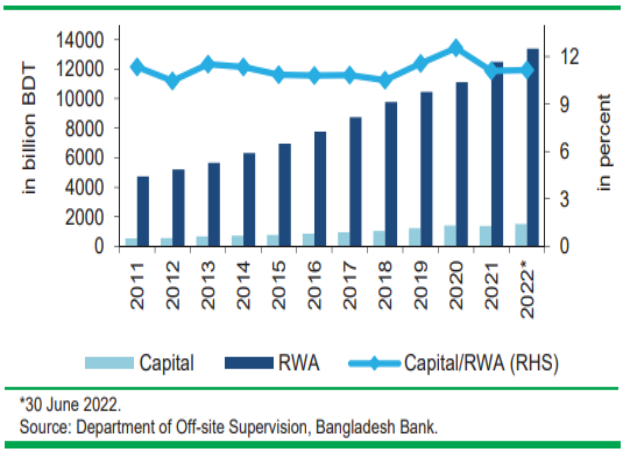
Figure3.3
Capital Adequacy Ratio by Types of Banks



Source*:* Annual Report, Bangladesh Bank, 2022

The total regulatory capital of the banking industry was BDT 1495.51 billion as of December 31, 2021, but has reduced to BDT 1495.06 billion as of June 30, 2022. Capital to Risk-Weighted Assets Ratio (CRAR) for various banking institutions is Figure-3.7. As of June 30, 2022, the CRAR for SCBs was 6.4%, for PCBs it was 13.0%, and for FCBs, it was 26.4%. BKB and RAKUB did not fulfill the MCR on a risk-weighted asset basis. In addition, five SCBs and five PCBs failed to maintain their required levels of capital. The CRAR for the banking sector was 11.2% as of the end of June 2022 as shown in Figure -3.3.

Figure - 3.4
Capital Adequacy Position (Aggregate)



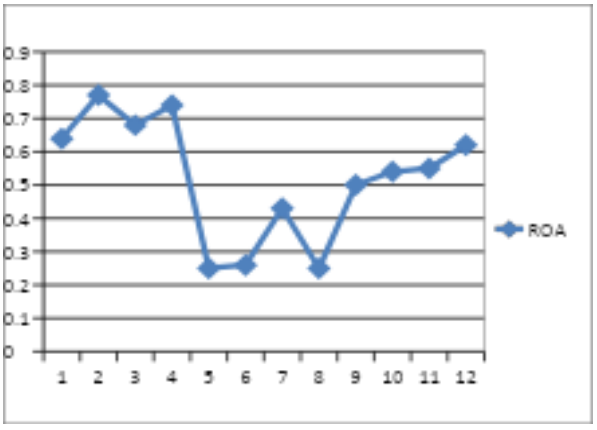
*30 June 2022.
Source: Department of Off-site Supervision, Bangladesh Bank.

Source: Annual report, Bangladesh Bank, 2022

Figure-3.4 reveals that like the ROA, the aggregate ROE of the Bangladeshi banks is also the same as the aggregate ROA. In 2013, it was the highest bank performance in the last 10 years and in 2018 and 2020, the banks generated the lowest ROE (3.86% and 4.28%). But it is a matter of hope that the ROE of the banks in the last year has increased almost twice that of the previous year.

Figure 3.4

Aggregate Returns on Assets of Banks in Bangladesh



Source*:* Annual Report, Bangladesh Bank, 2022

3.2.1 Measurement of Return on Asset (ROA) and Return on Equity (ROE)

The profitability of banks can be measured by the Return

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on Asset (ROA) and Return on Equity (ROE). The performance of Bangladeshi banks in the last 10 years 2013-2024 is shown in Figure-3.9 and Figure-3.10 to get an insight into the banking industry performance in Bangladesh.

The trend of aggregate return on assets presents a summary of bank performance. In the above trend analysis, it is seen that the banks' performance has experienced an up-and-down situation. The performance of banks was the highest in 2013 (0.90%) and the worst in 2019 and 2020 (0.25%). Overall, the bank's performance has fallen by 0.14% from 2013 to 2024 which is not a good sign for Bangladeshi Banks.

Table-3.1

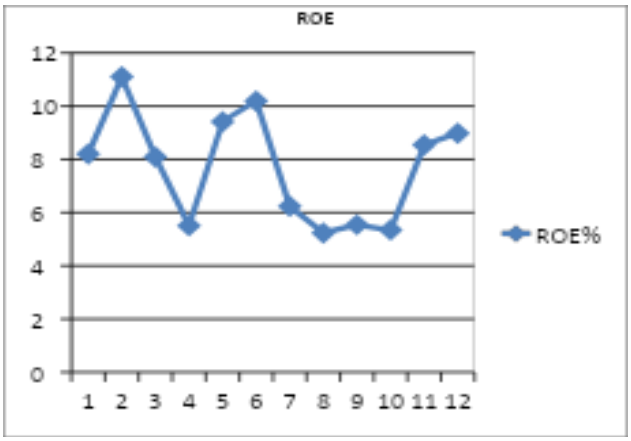
Return on Assets (ROA) by Types of Banks (in percent)

Return on Asset ((ROA)										
Types	2014	2015	2016	2017	2018	2019	2021	2022	2023	2024 (June)
SCBs	0.59	-0.55	-0.04	-0.16	0.21	-1.3	-0.61	-1.07	-0.68	0.21
SBs	-0.4	-0.68	-1.15	-2.8	-0.62	-2.77	-3.31	-3.01	-3.03	-3.31
PCBs	0.95	0.99	1	1.03	0.89	0.79	0.77	0.7	0.62	0.59
FCBs	2.98	3.38	2.92	2.56	2.24	2.23	2.3	2.13	1.17	2.57
Total	0.9	0.64	0.77	0.68	0.74	0.25	0.43	0.25	0.25	0.52

Source*:* Annual Report, Bangladesh Bank, 2024

Figure - 3.6

Aggregate Return on Equity of Banks in Bangladesh



Source*:* Annual Report, Bangladesh Bank, 2024

In 2022, the ROE of Bangladesh's banking sector has increased by 4.93% which is also more than 100% growth, making it one of the most profitable in the world. Table-3.2 provides an overview of the consequences caused by the epidemic. In 2019, the ROA for the industry was 6.83%, but it dropped to 4.28% in 2020. Yet, the market demonstrated a significant amount of growth in 2022 too, accounting for 9.37% of ROE. Apart from SBs, all the other banks saw positive profitability growth.The profitability increased by 27.04% for SCBs, 8.44% for FCBs and 0.04% for PCBs.

Table - 3.2

Return on Equity (ROE) by Types of Banks (in percent)

ROE										
Types	2014	2015	2016	2017	2018	2019	2020	2022	2023	2024(June)
SCBs	10.93	-13.46	-1.47	-6.02	3.45	-29.61	-13.68	-29.57	-21.61	5.43
SBs	-5.81	-5.97	-5.79	-13.88	-3.07	-13.47	-17.04	-13.85	-13.21	-13.68
PCBs	9.76	10.26	10.75	11.09	12.01	10.98	11.16	10.22	9.34	9.38
FCBs	16.93	17.67	14.59	13.08	11.31	12.42	13.43	13.1	7.59	16.03
Total	11.1	8.09	10.51	9.42	10.6	3.86	6.83	4.28	4.44	9.37

Source*:* Annual Report, Bangladesh Bank, 2024

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3.2.2 Measurement of Net Interest Margin (NIM) important determinant

Net Interest Margin (NIM) is one of the important determinants for analyzing the operational efficiency and performance of a bank. Table -3.3 reveals that the Net Interest Margin for the banking sector decreased to 2.5% in 2021 from 2.7% in 2020. These data also indicate that PCBs and FCBs have continuously maintained an NIM that is greater than the market average. In 2013, the NIM for SCBs was negative, but between 2014 and 2021, it progressively increased. Although the NIM for the total banking industry climbed significantly in 2018, the trend from 2014 to 2021 was clearly downward. The NIM for all banks reached 2.4% at the end of June 2022 as revealed in Table-3.4.

Table-3.3
Net Interest Margin (NIM) for Different Banks

(in percent)

Bank Types	2013	2014	2015	2016	2017	2018	2019	2020	2021	End June 2022
SCBs	-0.3	2.0	1.6	1.8	2.0	2.4	1.9	1.8	1.6	1.9
SBs	2.0	1.5	1.4	0.8	2.1	0.6	0.0	-0.2	-0.6	-0.6
PCBs	2.8	4.1	3.9	3.9	3.5	3.6	3.5	3.0	2.9	2.5
FCBs	3.7	6.0	6.1	5.0	4.4	4.4	4.2	4.1	3.0	3.0
Total	**2.0**	**3.6**	**3.3**	**3.3**	**3.1**	**3.2**	**3.1**	**2.7**	**2.5**	**2.4**

Source: Department of Off-site Supervision, Bangladesh Bank.

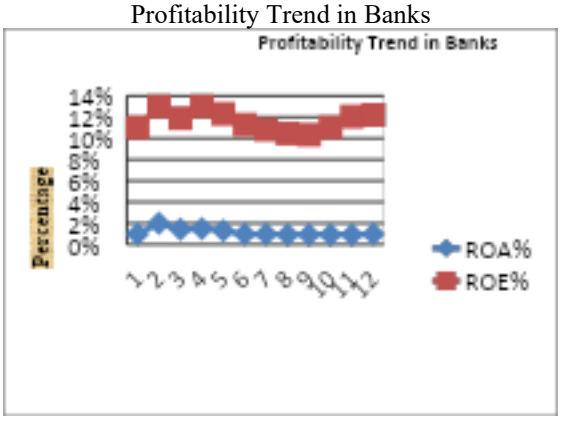
Source: Annual Report, Bangladesh Bank, 2022

The Bangladeshi banking industry's NIM has decreased in recent years. Increased competition among banks, particularly in the retail banking market, is a significant contributor to this decline. Some banks have decreased their lending rates in an attempt to attract new customers as a result of increased competition caused by a bigger number of banks on the market. As a consequence of the reduction in interest rates, banks' net interest margins are decreasing (NIM).

The decreasing interest rate environment in Bangladesh has also contributed to the decline in NIM. Bangladesh Bank has decreased the policy interest rate in recent years, resulting in a decline in bank deposit rates. As a result, banks have reduced their deposit interest rates, which have reduced their financing costs and net interest margin (NIM).

Moreover, the increase in NPLs has had an effect on the NIM of banks in Bangladesh. The rise in nonperforming loans needed by these banks has reduced their interest income and, therefore, their net interest margin (NIM). Numerous sectors, including textiles, manufacturing, and hospitality, have witnessed an increase in nonperforming loans as a result of the pandemic-caused economic slowdown.

Figure-3.6
Profitability Trend in Banks



Source: Annual Report, Bangladesh Bank, 2024

Commercial bank's profitability is one of the major determinants of the financial performance of of banking industry. It is generally measured by the ROA and ROE of banks. In order to capture the the above mentioned parameters the Bangladesh banking industry's profitability was shown in Figure-3.11 with respect to ROA and ROE. It is revealed from Figure-3.6 that ROA and ROE has been showing constantly decreasing trends for the years 2013 to 2024.

IV. MEASUREMENT OF QUALITY OF ASSETS AND NON-PERFORMING LOAN

4.1. The Ratio of Non-performing Loans (NPLs)

The ratio of non-performing loans (NPLs) is one of the most significant indicators of a bank's asset quality because it shows the share of loans that are either in default or that have been overdue for a particular period of time. In recent years, Bangladesh's banking system has struggled to maintain a low level of nonperforming loans (NPLs) due to factors such as inadequate governance, the consequences of the COVID-19 pandemic, and lax lending rules.

4.2. The Ratio of Gross and Net NPLs

The ratio of gross NPLs to total loans, as well as the ratio of net NPLs to net total loans, is the most significant indicator of asset quality. The banking industry as a whole has a gross nonperforming loan ratio of 8.93% at the end of December 2022. In the last month of 2022, Table- 3.6 reveals that FCBs had the lowest gross NPL ratio, while SCBs had the highest. FCBs (4.29%) had the lowest gross NPL ratio compared to SCBs (19.28%), PCBs (5.31%), and SBs (12.02%) at the end of December 2022.

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Table - 3.6
Gross NPL to Total Loan in case of four types of Bangladesh

(in percent)

Bank Types	2013	2014	2015	2016	2017	2018	2019	2020	2021	End June 2022
SCBs	19.8	22.2	21.5	25.0	26.5	30.0	23.9	20.9	19.3	21.9
SBs	26.8	32.8	23.2	26.0	23.4	19.5	15.1	13.3	12.0	11.7
PCBs	4.5	4.9	4.9	4.6	4.9	5.5	5.8	4.7	5.3	6.0
FCBs	5.5	7.3	7.8	9.6	7.0	6.5	5.7	3.5	4.3	4.4
Total	**8.9**	**9.7**	**8.8**	**9.2**	**9.3**	**10.3**	**9.3**	**7.7**	**7.9**	**9.0**

Source: Banking Regulation and Policy Department, Bangladesh Bank

Source*:* Annual Report, Bangladesh Bank, 2022

The ratio of gross non-performing loans to total loans and advances for the banking industry between 2013 and June 2022 is shown in Table 3.6. In 2013, the nonperforming loan ratio for the banking sector was 8.9%.

4.3. Non-Performing Loans (NPLs) for Different Types of Banks

The current situation of SCB and SB asset quality may be attributable to relatively poor appraisal and inadequate loan monitoring and supervision. Low asset quality in SBs has been demonstrated to be connected with both poor governance and a lack of accountability.

Nonetheless, banks have adopted a variety of measures (such as boosting the recovery unit and developing a specific recovery program) to enhance loan recovery. Restructuring, rescheduling, reducing interest, and erasing classified loans are but a few of the policy measures implemented by BB to reduce NPLs. At the end of 2022, the ratio of net non-performing loans (net of provisions and interest suspense) to net total loans was negative (-0.4%), as shown in Table 3.7 By the end of December 2022, the net nonperforming loan ratios for SCBs, SBs, PCBs, and FCBs were 2.5%, 0.4%, -1.1%, and 0.7%, respectively.phenomenology. There exist subtle differences between these two research philosophies as per three dimensions: axiology, ontology and epistemology.

Table- 3.7
NPL in Different Types of Banks in Bangladesh

(in billion BDT)

Bank Types	2013	2014	2015	2016	2017	2018	2019	2020	2021	End June 2022
SCBs	166.1	227.6	237.5	310.3	373.3	487.0	439.9	422.7	449.8	554.3
SBs	83.6	72.6	49.7	56.8	54.3	47.9	40.6	40.6	39.9	41.9
PCBs	143.1	184.3	207.6	230.6	294.0	381.4	441.7	403.6	515.2	626.8
FCBs	13.0	17.1	18.9	24.1	21.5	22.9	21.0	20.4	27.9	29.6
Total	**405.8**	**501.6**	**513.7**	**621.8**	**743.1**	**939.2**	**943.3**	**887.3**	**1032.7**	**1252.6**

Source: Banking Regulation and Policy Department, Bangladesh Bank

Source*:* Annual Report, Bangladesh Bank, 2022

Among the four types of banks, SPBs had the lowest NPA ratio, indicating a more successful approach to risk management. State-controlled banks (SCBs) are government-owned financial institutions that have traditionally failed to maintain healthy loan portfolios due to poor management, political interference, and a lack of accountability. To reduce SCBs' nonperforming loan (NPL) levels, the Bangladesh Bank has worked to improve their governance and efficiency.

V. METHODOLOGY

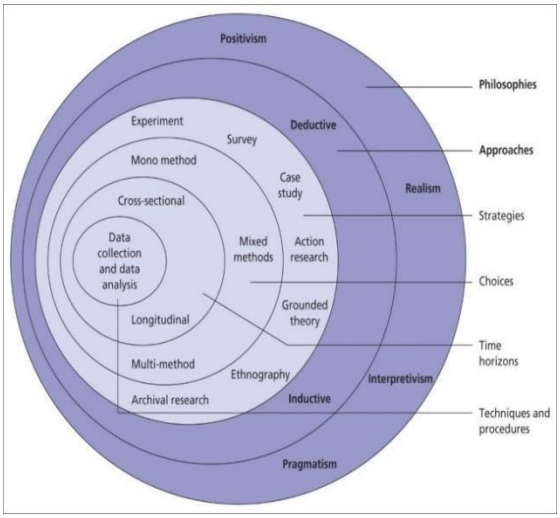
Sampling the population used in this study is banking companies classified as a State-Owned Commercial Bank and a National Private Commercial Bank in Bangladesh from 2012 to 2024. Both State-Owned and Private Commercial Banks had the following characteristics:

It is not an Islamic bank. Researcher has complete annual reports from 2014–2024 Based on the characteristics mentioned above, the number of banks that could meet the criteria were 94 banks, consisting of 29 state-owned commercial banks and 65 national private banks.

This research focused only on Bangladesh-based commercial banks; so quite naturally, Bangladesh based all the commercial banks constituted the population. There exist variations in the business model since Islamic banks follow Shariah principle and commercial banks do not follow Shariah principle. The researcher employed purposive sampling [also known as judgemental or subjective sampling] for this research. Research philosophy refers to the conceptual framework of the research process that determines how the research objectives will be achieved (Saunders et al., 2007). So, research philosophy actually guides the researcher in several stages – null hypothesis formation, data collection, interpretation of results. Research philosophy can be broadly categorized into two streams – positivism and

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Figure 1: Saunders's Research onion



Source: Saunders et al. (2007)

Research philosophy actually guides the researcher in several stages – null hypothesis formation, data collection, interpretation of results. Research philosophy can be broadly categorized into two streams – positivism and phenomenology.

The researcher specifically tried to focus on commercial bank's profitability and that why she purposely chosen only non-Islamic commercial banks. The researcher has used panel database. The research time period spanned from 2012 to 2024. It is worth mentioning that there is a systematic lag of one with respect to annual data. This panel database had both cross-sectional and time-series variations.In order to understand the determinant factors of commercial bank's profitability, the researcher has run a series of regressions. Now, the researcher will present the specifications related to the regression analysis.

$ROA_{i,t} = \alpha + \sum_{i=1}^{6} \beta_i$ Firm-specific $factors_{i,t} + \beta_7$ Industry-specific factor $+ \sum_{j=1}^{3} \beta_j$ Macro-economic $factors_t + a_i + \Delta_t + \varepsilon_{i,t}$ [Model I]

$CAPE_{i,t} = \alpha + \sum_{i=1}^{6} \beta_i$ Firm-specific $factors_{i,t} + \beta_7$ Industry-specific factor $+ \sum_{j=1}^{3} \beta_j$ Macro-economic $factors_t + a_i + \Delta_t + \varepsilon_{i,t}$ [Model II]

If the regression parameter is unbiased, then the expected value of sample statistics is equal to the true population parameter (Woolridge, 2015). The OLS pre-conditions are as follows:

- The estimated relationship projected between the factor and independent variable is linear.
- The data is collected through random sampling.
- Zero conditional mean: E [u|X] = 0
- There exists no perfect multicollinearity among the pairs of independent variables.
- Non-zero variance in all the independent variables.

Given, these pre-conditions in a single factor model, we can estimate beta estimators using the following way.

$$\hat{\beta}1 = \frac{Covariance}{Variance} = \frac{\sum (yi-\underline{y})(xi-\underline{X})}{\sum(xi-\underline{X})^2} = \frac{\sum (yi\,(xi-\underline{X})}{\sum(xi-\underline{X})^2}$$

[Alternatively $\hat{\beta}1 = \frac{\sum Cov(xi,yi)}{\sum(xi-\underline{X})^2}$

$$= \frac{\sum (\beta o + \beta 1\, Xi + ui)(xi-\underline{X})}{\sum(xi-\underline{X})^2}$$ [Note: in the population model: $Yi = \beta_o + \beta_1 Xi + ui$]

$$= \frac{\sum (\beta o + \beta 1\, Xi + ui)(xi-\underline{X})}{Var\,(xi)}$$

$$= \frac{\sum \beta o(xi-\underline{X})}{Var\,(xi)} + \frac{\sum \beta 1 Xi(xi-\underline{X})}{Var\,(xi)} + \frac{\sum ui\,(xi-\underline{X})}{Var\,(xi)}$$

$$= \beta o \frac{\sum (xi-\underline{x})}{Var\,(xi)} + \beta 1 \frac{\sum Xi(xi-\underline{X})}{Var\,(xi)} + \frac{\sum ui\,(xi-\underline{X})}{Var\,(xi)}$$

$$= \beta o * 0 + \beta 1 \frac{var(xi)}{Var\,(xi)} + \frac{\sum ui\,(xi-\underline{X})}{Var\,(xi)}$$

$[\sum (xi-\underline{x}) = 0;\ \sum Xi(xi-\underline{X}) = var(xi)]$]

$$= 0 + \beta 1 * 1 + \frac{\sum ui\,(xi-\underline{X})}{Var\,(xi)}$$

$$\hat{\beta}1 = \beta 1 + \frac{\sum ui\,(xi-\underline{X})}{Var\,(xi)}$$

There is no other way to simply the expression any more. In order to simply this expression further, the researcher is going to use expectation operator. By taking expectation operator in both the sides:

$$E(\hat{\beta}1) = E\left[\beta 1 + \frac{\sum ui\,(xi-\underline{X})}{Var\,(xi)}\right]$$

$$= E(\beta 1) + E\frac{\sum ui\,(xi-\underline{X})}{Var\,(xi)} = \beta 1 + \frac{E(\sum ui\,(xi-\underline{x})}{E\,[var\,(xi)]} = \beta 1 + \frac{E(\sum ui\,(xi-\underline{x})}{var\,(xi)}$$ [note: E(constant) = constant]

$$E(\hat{\beta}1) = \beta 1 + \frac{E(\sum ui\,(xi-\underline{x})}{var\,(xi)}$$

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$\rightarrow E(\hat{\beta}1 \mid xi) = \beta1 + \frac{E(\sum ui\,(xi-\underline{x}) \mid Xi)}{var\,(xi)}$

Since we are running a CLRM, the mean independence condition must have been fulfilled. And Mean independence: E[ui | Xi]= 0; E(uixi) = 0

$\rightarrow E(\hat{\beta}1 \mid xi) = \beta1 + \frac{E(uixi \mid Xi)}{Var(xi)} * - \frac{E(ui\underline{x}) \mid xi)}{Var\,(xi)}$

$\rightarrow E(\hat{\beta}1 \mid xi) = \beta1 + 0$

$\rightarrow E(\hat{\beta}1 \mid xi) = \beta1$

By taking expectation operator in both the sides:

$E[E(\hat{\beta}1 \mid xi)] = E[\beta1]$

$E(\hat{\beta}1) = \beta1$ [proved]

This single factor regression model-based proof of unbiasedness can be extended in a multi-factor model and the research area of interest revolves around a multi-factor model [where commercial banks' profitability is dependent on a number of factors] (Woolridge,2015). So, the above-mentioned proof of unbiasedness is a legit framework in a multi-factor model.

Consistency of regression estimators: If the regression parameter is consistent, then when sample size increases, the sample beta statistics converges to the true population parameter (Woolridge, 2015). The OLS pre-conditions are as follows:

The OLS pre-conditions are as follows:

- The estimated relationship projected between the factor and independent variable is linear.
- The data is collected through random sampling.
- The covariance [hence correlation] between independent variables and error is zero.
- There exists no perfect multicollinearity among the pairs of independent variables.
- Non-zero variance in all the independent variables.

Given, these pre-conditions in a single factor model, we can estimate beta estimators using the following way.

I. $\hat{\beta}1 = \frac{Covariance}{Variance} = \frac{\sum (yi-\underline{y})(xi-\underline{X})}{\sum(xi-\underline{X})^2} = \frac{Cov\,(xi,yi)}{\sum(xi-\underline{X})^2}$

II. $= \frac{cov(xi,\beta0+\beta1xi+ui)}{\sum(xi-\underline{X})^2}$ [Note: in the population model: $Y_i = \beta_o + \beta_1 Xi + ui$]

III. $= \frac{cov(xi,\beta0+\beta1xi+ui)}{Var\,(xi)}$

IV. $= \frac{cov\,(\beta o,xi)}{Var\,(xi)} + \frac{cov\,(\beta1xi,xi)}{Var\,(xi)} + \frac{cov\,(ui,xi)}{Var\,(xi)}$

$= 0 + \beta1 \frac{cov\,(xi,xi)}{Var\,(xi)} + \frac{cov\,(ui,xi)}{Var\,(xi)}$ [cov(constant, xi)=0]

$= \beta1 \frac{var(xi)}{Var\,(xi)} + \frac{cov\,(ui,xi)}{Var\,(xi)}$ [cov(xi,xi)=var(xi)]

$= 0 + \beta1 * 1 + \frac{cov\,(ui,xi)}{Var\,(xi)}$

$\hat{\beta}1 = \beta1 + \frac{cov\,(ui,xi)}{Var\,(xi)}$

There is no other way to simply the expression any more. In order to simply this expression further, the researcher is going to use plim operator. By taking plim operator in both the sides:

$Plim\ \hat{\beta}1 = plim\,[\beta1 + \frac{cov\,(ui,xi)}{Var\,(xi)}]$

$= plim(\beta1) + \frac{plim\,[cov(ui,xi)]}{plim\,[var\,(xi)]}$

$= \beta1 + \frac{0}{var\,(xi)}$ [note: plim [cov(ui, xi) = 0]

$= \beta1$

$\hat{\beta} = \beta1$ [proved]

This single factor regression model-based proof of consistency can be extended in a multi-factor model and the research area of interest revolves around a multi-factor model [where commercial banks' profitability is dependent on a number of factors] (Woolridge,2015). So, the above-mentioned proof of consistency is a legit framework in a multi-factor model.

Efficiency of regression estimators*:* If the regression parameter is efficient, then the beta coefficient's variance should be the lowest among all other beta coefficients estimated through MLE and MM methodology (Woolridge, 2015). The OLS pre-conditions are as follows:

The OLS pre-conditions are as follows:

The estimated relationship projected between the factor and independent variable is linear.

The data is collected through random sampling.
Homoscedasticity: Var [u|X] = Constant
There exists no perfect multicollinearity among the pairs of independent variables.

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V. Non-zero variance in all the independent variables.

Given, these pre-conditions in a single factor model, we can estimate beta estimators using the following way.

$$\hat{\beta}1 = \frac{Covariance}{Variance} = \frac{\sum (yi-\underline{y})(xi-\underline{X})}{\sum(xi-\underline{X})^2} = \frac{\sum (yi\,(xi-\underline{X})}{\sum(xi-\underline{X})^2}$$

[Alternatively $\hat{\beta}1 = \frac{\sum Cov(xi,yi)}{\sum(xi-\underline{X})^2}$]

$$= \frac{\sum (\beta o + \beta 1\, Xi + ui)(xi-\underline{X})}{\sum(xi-\underline{X})^2}$$ [Note: in the population model: $Yi = \beta_o + \beta_1 Xi + ui$]

$$= \frac{\sum (\beta o + \beta 1\, Xi + ui)(xi-\underline{X})}{Var\,(xi)}$$

$$= \frac{\sum \beta o(xi-\underline{X})}{Var\,(xi)} + \frac{\sum \beta 1 Xi(xi-\underline{X})}{Var\,(xi)} + \frac{\sum ui\,(xi-\underline{X})}{Var\,(xi)}$$

$$= \beta o \frac{\sum (xi-\underline{x})}{Var\,(xi)} + \beta 1 \frac{\sum Xi(xi-\underline{X})}{Var\,(xi)} + \frac{\sum ui\,(xi-\underline{X})}{Var\,(xi)}$$

$$= \beta o * 0 + \beta 1 \frac{var(xi)}{Var\,(xi)} + \frac{\sum ui\,(xi-\underline{X})}{Var\,(xi)}$$

$[\sum (xi-\underline{x}) = 0; \sum Xi(xi-\underline{X}) = var(xi)]$

$$= 0 + \beta 1 * 1 + \frac{\sum ui\,(xi-\underline{X})}{Var\,(xi)}$$

$$\hat{\beta}1 = \beta 1 + \frac{\sum ui\,(xi-\underline{X})}{Var\,(xi)}$$

There is no other way to simply the expression any more. In order to simply this expression further, the researcher is going to use 'Var' operator. By taking variance operator in both the sides:

$$Var\,(\hat{\beta}1|X) = Var\,[\beta 1 + \frac{\sum ui\,(xi-\underline{X})}{Var\,(xi)}|X]$$

$$= Var\,(\beta 1|X) + Var[\frac{\sum ui\,(xi-\underline{X})}{Var\,(xi)}|X] = 0 + \frac{Var\,(\sum ui\,(xi-\underline{x})}{Var\,[var\,(xi)|X]}|X] = \frac{var\,(x)\sum (xi-\ddot{x})^2}{\sum (xi-\ddot{x})^4}$$

$$Var\,(\hat{\beta}1|X) = \frac{var\,(x)}{\sum (xi-\ddot{x})^2} = \text{constant}$$

[Proved]

So, under homoscedasticity assumption, the variance of OLS estimators is constant. On the other hand, if the variances are not constant then, $Var\,(\hat{\beta}1|X) = f(X)$.This single factor regression model-based proof of efficiency can be extended in a multi-factor model and the research area of interest revolves around a multi-factor model [where commercial banks' profitability is dependent on a number of factors] (Woolridge,2015). So, the above-mentioned proof of efficiency is a legit framework in a multi-factor model.

VI. RESULT AND FINDINGS

Determinants of Commercial banks' Profitability:

In order to estimate a determinant model for bank's profitability, The researcher has run a number of panel regressions. Before running panel regressions, it was important to determine whether the estimated effects would be a random-effects or a fixed effects model. At a conceptual level, making this choice is relatively easier. A fixed-effects model posits that there exists cross-sectional heterogeneity in the dataset and it can be managed within the given structure. On the other hand, in case of random-effects model, it is assumed that there exists no cross-sectional heterogeneity – a very restrictive and impractical assumption. By performing the Wu-Durbin-Hausman test, one can also determine whether a fixed-effects model or a random effects model to better suit the purpose. The null and alternative hypothesis related to the Wu-Durbin-Hausman test are as follows:

Null hypothesis: The given panel regression can be better explained by random effects framework.

Alternative hypothesis: The given panel regression can be better explained by fixed effects framework.

Based on a 95% confidence level, these hypotheses were tested. For all the regression models, the preferred model is fixed effects model. Panel regressions are run within the OLS framework and that is why panel regressions must meet certain OLS pre-conditions.

The estimated relationship projected between the factor and independent variable is linear.
The data is collected through random sampling.
The covariance [hence correlation] between independent variables and error is zero.
There exists no perfect multicollinearity among the pairs of independent variables.

The first and the third specified assumption are not always realistic. That is why the major objective of was to estimate consistent regression estimates. For ensuring consistency in the regression parameters, the sample size should be increased. Now, the researcher is going to present the panel regression models.

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$ROA_{i,t} = \alpha + \sum_{i=1}^{6} \beta_i$ Firm-specific $factors_{i,t} + \beta_7$ Industry-specific factor $+ \sum_{j=1}^{3} \beta_j$ Macro-economic $factors_t + a_i + \Delta_t + \varepsilon_{i,t}$

In the above-mentioned model, ROA is the dependent variable and the researcher has tried to estimate a determinant model for ROA. $\varepsilon_{i,t}$ refers to the disturbance element and it can be decomposed into three sub-components such as – cross-sectional, time invariant heterogeneity (ω_i), time effect (δ_t) and noise ($\gamma_{i,t}$).

Table 1: Baseline Regression results

	(1)
VARIABLES	ROA
Size	0.00603**
	2.069
Capital Adequacy	-0.0268***
	(-7.454)
Activity Mix	0.0145**
	(2.027)
Asset Quality	0.000175
	(0.558)
NIM	0.611***
	(19.17)
HHI	0.177
	(0.398)
Cost Management	0.00437*
	(1.885)
Interest Rate	0.182
	(0.424)
Inflation	-0.00770
	(-1.111)
GDP Growth Rate	0.0893
	(1.298)
Constant	0.0370
	(0.673)
Observations	298
R-squared	0.746
Number of Firm Code	23
Firm FE	Yes
Firm Cluster	No
seasonal adjustment	No
R2 within	0.746
R2 overall	0.571
R2 between	0.0800
F-stat	77.96
Prob > F	0
t-statistics in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

Complied by: The researcher

Interpretation of the first baseline regression:

- Conceptual framework: The researcher has tried to understand the relationship between ROA and various firm-specific and macro-economic variables through regression.
- Regression sign and magnitude: The individual, factor-specific test of hypothesis was conducted by t-test. The null hypothesis [Ho: $\beta_1 = 0$] is rejected at 5% level of significance. It was evident that business size, activity mix, cost management, interest rate, GDP growth rate, asset quality, net interest margin positively influenced the ROA of commercial banks. It was also evident that capital adequacy and inflation rate negatively influenced the ROA of commercial banks.
- R-square: It refers to the explanatory power of the model. It is around 74%; so, 74% of the changes in the dependent variable (ROA) can be explained by the combined changes in the independent variable.
- Model significance: It was hypothesized that the estimated model is not significant; so, it was assumed that Ho: $\beta_1 = \beta_2 = \ldots = \beta_{10} = 0$. This joint test of hypothesis was conducted through F-test and at a 5% level of significance this joint hypothesis was rejected. So, at least one of the factors is different from zero and it is a significant model to predict ROA.

The second baseline regression model can be represented through the following equation.

Economic $profit_{i,t} = \alpha + \sum_{i=1}^{6} \beta_i$ Firm-specific $factors_{i,t} + \beta_7$Industry-specific factor $+ \sum_{j=1}^{3} \beta_j$ Macro-economic $factors_t + a_i + \Delta_t + \varepsilon_{i,t}$

In the above-mentioned model, economic profit is the dependent variable and the researcher has tried to estimate a determinant model for economic profit. $\varepsilon_{i,t}$ refers to the disturbance element and it can be decomposed into three sub-components such as – cross-sectional, time invariant heterogeneity (ω_i), time effect (δ_t) and noise ($\gamma_{i,t}$).

Table 2: Baseline Regression results

	(2)
VARIABLES	Economic Profit

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Size	0.0067
	0.62
Capital Adequacy	-5.728e+08**
	(-2.561)
Activity Mix	1.267e+09***
	2.842
Asset Quality	4.653e+06
	(0.239)
NIM	3.035e+09
	(1.533)
HHI	7.957e+10***
	(2.878)
Cost Management	2.172e+07
	(0.151)
Interest Rate	2.462e+10
	(0.924)
Inflation	4.614e+08
	(1.071)
GDP Growth Rate	4.367e+09
	(1.023)
Constant	-3.674e+09
	(-1.075)
Observations	298
R-squared	0.128
Number of Firm Code	23
Firm FE	Yes
Firm Cluster	No
seasonal adjustment	No
R2 within	0.128
R2 overall	0.115
R2 between	0.0571
F-stat	3.906
Prob > F	5.70e-05
t-statistics in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

Complied by: The researcher

Interpretation of the second baseline regression:

- Conceptual framework: The researcher has tried to understand the relationship between economic profit and various firm-specific and macro-economic variables through regression.
- Regression sign and magnitude: The individual, factor-specific test of hypothesis was conducted by t-test. The null hypothesis [Ho: $\beta_1 = 0$] is rejected at 5% level of significance. It was evident that business size, activity mix, cost management, interest rate, GDP growth rate, asset quality, net interest margin positively influenced the economic profit of commercial banks. It was also evident that capital adequacy and inflation rate negatively influenced the economic profit of commercial banks.
- R-square: It refers to the explanatory power of the model. It is around 13%; so 13% of the changes in the dependent variable (economic profit) can be explained by the combined changes in the independent variable.
- Model significance: It was hypothesized that the estimated model is not significant; so it was assumed that Ho: $\beta_1 = \beta_2 = \ldots = \beta_{10} = 0$. This joint test of hypothesis was conducted through F-test and at a 5% level of significance this joint hypothesis was rejected. So, at least one of the factor is different from zero and it is a significant model to predict economic profit.

The third baseline regression model can be represented through the following equation.

$CAPE_{i,t} = \alpha + \sum_{i=1}^{6} \beta_i$ Firm-specific $factors_{i,t} + \beta_7$ Industry-specific factor $+ \sum_{j=1}^{3} \beta_j$ Macro-economic $factors_t + a_i + \Delta_t + \varepsilon_{i,t}$

In the above-mentioned model, CAPE is the dependent variable and the researcher has tried to estimate a determinant model for CAPE. $\varepsilon_{i,t}$ refers to the disturbance element and it can be decomposed into three sub-components such as – cross-sectional, time invariant heterogeneity (ω_i), time effect (δ_t) and noise ($\gamma_{i,t}$).

Table 3: Baseline Regression results

	(3)
VARIABLES	CAPE
Size	1.750
	0.726
Capital Adequacy	-2.921
	(-0.981)
Activity Mix	10.27*
	1.732
Asset Quality	0.102
	(0.396)
NIM	7.916
	(0.301)
HHI	101.6
	(0.276)

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Cost Management	2.529
	(1.319)
Interest Rate	114.6
	(0.323)
Inflation	-3.852
	(-0.672)
GDP Growth Rate	21.72
	(0.382)
Constant	17.32
	(0.381)
Observations	298
R-squared	0.027
Number of Firm Code	23
Firm FE	Yes
Firm Cluster	No
seasonal adjustment	No
R2 within	0.0269
R2 overall	0.0428
R2 between	0.111
F-stat	0.732
Prob > F	0.003
t-statistics in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

Complied by: The researcher

Interpretation of the third baseline regression:

- Conceptual framework: The researcher has tried to understand the relationship between CAPE and various firm-specific and macro-economic variables through regression.
- Regression sign and magnitude: The individual, factor-specific test of hypothesis was conducted by t-test. The null hypothesis [Ho: $\beta_1 = 0$] is rejected at 5% level of significance. It was evident that business size, activity mix, cost management, interest rate, GDP growth rate, asset quality, net interest margin positively influenced the CAPE of commercial banks. It was also evident that capital adequacy and inflation rate negatively influenced the CAPE of commercial banks.
- R-square: It refers to the explanatory power of the model. It is around 3%; so, 3% of the changes in the dependent variable (CAPE) can be explained by the combined changes in the independent variable.
- Model significance: It was hypothesized that the estimated model is not significant; so, it was assumed that Ho: $\beta_1 = \beta_2 = \ldots = \beta_{10} = 0$. This joint test of hypothesis was conducted through F-test and at a 5% level of significance this joint hypothesis was rejected. So, at least one of the factors is different from zero and it is a significant model to predict CAPE.

Omitted variable bias: After reviewing the literature, the researcher has identified a number of bank-specific and macro-factors that may have influenced commercial bank's profitability. There are at least three key variables which were omitted from the baseline models. These are:

Liquidity management: Theoretically there should be a negative relationship between liquid cash stacked in the bank's account and standard products used as a storage of liquidity and commercial banks' profitability (Lipunga,2014).

Management efficiency: Managerial efficiency results in reduction in agency cost and therefore these efficiency proxies should be positively connected with the commercial bank's profitability (Bilal et al., 2013)

Labor efficiency: Much like the case with managerial efficiency, commercial banks' profitability is positively connected with commercial banks' profitability (Indranarain, 2009).

The researcher is now going to present the baseline regression results where the partial effect of various factor variables on banks' profitability was assessed along with these three omitted variables.

$ROA_{i,t} = \alpha + \sum_{i=1}^{6} \beta_i$ Firm-specific $factors_{i,t} + \beta_7$ Industry-specific factor $+ \sum_{j=1}^{3} \beta_j$ Macro-economic $factors_t + \beta_{11}$ Liquidity $proxy_{i,t} + \beta_{12}$ Managerial efficiency $proxy_{i,t} + \beta_{13}$ Labor market $proxy_{i,t} + a_i + \Delta_t + \varepsilon_{i,t}$

$Economic\ Profit_{i,t} = \alpha + \sum_{i=1}^{6} \beta_i$ Firm-specific $factors_{i,t} + \beta_7$ Industry-specific factor $+ \sum_{j=1}^{3} \beta_j$ Macro-economic $factors_t + \beta_{11}$ Liquidity $proxy_{i,t} + \beta_{12}$ Managerial efficiency $proxy_{i,t} + \beta_{13}$ Labor market $proxy_{i,t} + a_i + \Delta_t + \varepsilon_{i,t}$

$CAPE_{i,t} = \alpha + \sum_{i=1}^{6} \beta_i$ Firm-specific $factors_{i,t} + \beta_7$ Industry-specific factor $+ \sum_{j=1}^{3} \beta_j$ Macro-economic $factors_t + \beta_{11}$ Liquidity $proxy_{i,t} + \beta_{12}$ Managerial efficiency $proxy_{i,t} + \beta_{13}$ Labor market $proxy_{i,t} + a_i + \Delta_t + \varepsilon_{i,t}$

Case of all the baseline regression models, once the omitted variables were introduced into the models. It was also evident that capital adequacy and banks' performance is negatively related and the regression coefficient is significant in case of all the baseline regression models, once the omitted variables were

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introduced in the models. It is worth mentioning that the overall baseline models are statistically significant.

Table 4: Omitted variable bias

VARIABLES	Model 1	Model 2	Model 3
	ROA	Economic profit	CAPE
Size	0.0089	0.00583	2.74838
	2.95867	0.6572	0.95106
Capital Adequacy	-1.03832***	-6.18**	-3.82651**
	-1.6592	-2.714	-1.2811
Activity Mix	0.020735	1.34E+09	13.4537
	2.89861	3.01252	2.26892
Asset Quality	3.025**	4.989*	6.13362**
	.79794	.25334	.51876
NIM	0.87373	3.22E+09	1.36996
	2.4131	1.62498	0.39431
HHI	-0.25311	-8.43E+10	-3.096
	-0.56914	-3.05068	-0.36156
Cost Management	0.006249	2.302	3.31299
	2.69555	0.16006	1.72789
Interest Rate	-0.26026	-2.61E+10	-0.126
	-0.60632	-0.97944	-0.42313
Inflation	-0.01101	-4.89E+08	-5.04612
	-1.58873	-1.13526	-0.88032
GDP Growth Rate	0.127699	4.63E+09	2.4532
	1.85614	.08438	-.50042
Liquidity	-.564764	-3.005	-2.06048
	-1.31571	-2.12538	-0.2031
Managerial efficiency	0.02389	0.987	2.42214
	3.44754	2.46351	0.42255
Labor efficiency	0.277107	0.009	3.65754
	4.02782	2.3531	0.2402
Constant	-2.098	-3.989	-3.02
	0	0	0
Observations	298	298	298
R-squared	0.342	0.319	0.311
Number of Firm Code	23	23	23
Firm FE	Yes	Yes	Yes
Firm Cluster	No	No	No
seasonal adjustment	No	No	No
R2 within	0.017	0.052	0.034
R2 overall	0.086	0.015	0.032
R2 between	0.231	0.256	0.312
F-stat	1.860	1.045	2.067
Prob > F	0.003	0.012	0.032

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Complied by: The researcher

The individual, factor-specific test of hypothesis was conducted by t-test. The null hypothesis [Ho: $\beta_1 = 0$] is rejected at 5% level of significance. It was evident that asset quality and banks' performance is positively related and the regression coefficient is significant in

VII. FINDS AND CONCLUSION

Commercial banks play a pivotal role in driving a nation's economic growth by financing productive investments. In the face of intensifying competition, heightened risk exposure, and rapid technological advancements, these institutions must enhance their operational efficiency to remain resilient and effective. This study examines key bank-specific factors and reveals that these internal dynamics significantly influence the profitability of commercial banks.

The study has designed three determinant models for Bangladesh based commercial bank's profitability. It was evident in the regression results that a number of bank-specific, macro-economic and industry-specific variables influence commercial banks' profitability.

The substantial features and contribution of this research are provided below:

Based on the PCA results, it was concluded that 'dimension reduction' would not be an appropriate approach to understanding the profitability determinants of Bangladesh-based commercial banks since the first two principal components can together explain only 45% of the total variation.

The researcher designed three regression models for the profitability of Bangladesh-based commercial banks. The profitability of commercial banks was defined through three perspectives: accounting profit (measured through ROA), economic profit (measured through residual income), and the market's perception of profit (measured through CAPE). It was evident that several bank-specific, macroeconomic, and industry-specific variables influence commercial banks' profitability.

The regression results showed that factors such as business size, activity mix, cost management, interest rate, GDP growth rate, asset quality, and net interest margin positively impacted commercial banks' accounting profitability. Conversely, capital adequacy and inflation rate were found to negatively affect accounting profitability.

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It was documented that factors such as business size, activity mix, cost management, interest rates, GDP growth rate, asset quality, and net interest margin had a positive impact on the economic profitability of commercial banks. In addition, capital adequacy and the inflation rate were found to negatively impact economic profitability.

Similarly, business size, activity mix, cost management, interest rates, GDP growth rate, asset quality, and net interest margin were also observed to positively influence market-based profitability measures for commercial banks, while capital adequacy and inflation rate had a negative effect.

It was observed that the estimated effects are robust to model preference as the regression sign does not flip and the level of significance does not change when the researcher uses a random effects model. Likewise, similar types of results can be extracted if MLE or GMM estimation techniques are introduced instead of the OLS framework. The study documented that the estimated effects are robust to out-of-the-sample contexts [using a 70%-30% training-testing split]. The results showed that asset quality remained positively correlated with bank performance, and capital adequacy remained negatively correlated, with both coefficients remaining significant across all baseline models when the alternative definitions were applied. The researcher did not observe any signs of cross-sectional heterogeneity in the estimated effects.

LIST OF ACRONYMS

Acronym	Full Form
AQ	Asset Quality
BB	Bangladesh Bank
CA	Capital Adequacy
CAPE	Cyclically-Adjusted Price to Earnings
CAR	Capital Adequacy Ratio
EP	Economic Profit
GDP	Gross Domestic Product
GMM	Generalized Method of Moments
HHI	Herfindahl-Hirschman index
MLE	Maximum Likelihood Estimation
NIM	Net Interest Margin
NPL	Non-Performing Loan
OLS	Ordinary Least Square
PFP	Partial Factor Productivity
ROA	Return on Asset
ROE	Return on Equity

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Big Data and Ethical Consumption: A Bibliometric Analysis

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Abstract - **The objective of this study is to perform a bibliometric analysis of big data and ethical consumption to discern crucial trends, topics, and prospective research avenues. The study employed the PRISMA framework. The results demonstrate that big data substantially impacts ethical consumption by offering enhanced understanding of consumers' ethical preferences and behaviors. This study also reveals significant trends, like the increasing incorporation of advanced analytics and artificial intelligence in comprehending and fostering ethical consumer behavior across multiple sectors. Furthermore, it underscores the significance of digital platforms in promoting ethical consumption behaviors and the necessity of resolving privacy issues related to big data utilization. This research enhances our comprehension of utilizing big data to further sustainable development goals and provides a basis for future investigations into ethical consumer behavior.**

Keywords - **Bibliometric analysis, big data, consumer behavior, ethical consumption, sustainable development goals.**

I. INTRODUCTION

Big data (BD) refers to large volumes of data generated at high velocity and in various formats, requiring advanced business management processing techniques for decision-making [24; 25; 22]. It equips with industry-specific analytics tools to uncover patterns and correlations among stakeholders, including consumers, regulators, suppliers, and so on, for business decision-making aspects [17; 23].

Big data influences consumer behavior analysis to predict consumer preferences and decision-making processes [21]. Academicians and practitioners integrate BD analytics into consumer behavior studies to tailor business marketing strategies, enhance consumer satisfaction and engagement, and predict future purchasing trends [20]. It impacts consumers' ethical dimensions, such as fair trade, eco-friendly products, and animal welfare, and how these are perceived by consumer purchasing intention and action [18; 19].

BD applications play a crucial role in promoting ethical consumption (EC) by enhancing consumer privacy and integrating artificial intelligence in marketing analytics for ethical consumption decision-making [14]. The role of consumers' digital contributions, especially in apps like Buycott, underscores the significance of user generated data in shaping ethical consumption behaviors and corporate actions [16]. While BD can contribute to achieving the Sustainable Development Goals (SDGs), we must address ethical considerations like privacy and data ownership to ensure its positive impact on ethical consumption and sustainability [27; 15].

For addressing the BD influence in shaping EC behavior, it is significant to know the key trends, gaps, and challenges in the field, guiding future research and practical applications in assuring a better sustainable future [31]. There are systematic literature review papers on addressing big data in several aspects, e.g., ethical consideration in data science [13], BD value realization [12], BD analytics [22], digital marketing consumer behavior [11], sustainable tourism [10], sustainable consumption [26], and so on. These reviews denote that BD is a multidisciplinary domain that has myriads of applications in different domains, including consumer behavior. However, there is no systematic literature review on how big data shapes ethical aspects in consumer decision-making. To address this gap, this study aims to conduct a systematic literature review to facilitate quantitative and qualitative portrayals of relevant literature to compare and contrast the findings of prior studies in the intersection of big data and ethical consumption domains [33]. The research questions are as follows.

RQ1. What is the primary emphasis of big data and ethical consumption studies?

RQ2. What are the major themes and topic areas within big data and ethical consumption, and how have these themes developed over time?

RQ3. What are the opportunities for future research for both scholars and industry professionals?

In order to answer these research questions, the essay adopts bibliometric analysis, including performance analysis and science mapping of the chosen scholarly documents, followed by a thematic analysis to determine future research directions [30].

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The study's novelty lies in its portrayal of the scholarly contributions and thematic evolution of BD and ethical consumption from a multidisciplinary perspective. This study also identifies emerging trends for projecting future research directions in terms of theoretical and practical implications.

The subsequent chapters shall be outlined as follows: Chapter two presents the methodology. Chapter three showcases the bibliometric and thematic analysis along with the findings. Following this, chapter four discusses the findings, and chapter five concludes the work with theoretical and managerial contributions.

II. METHODOLOGY

The study uses the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to conduct the systematic literature review [29]. The study opts for Web of Science (WoS) that was used in the prior literature on BD (13; 11]. The study considers documents that were published and were written in English. Also, 6 more articles were added through the cross-check mechanism of another database and reference section [31]. The study incorporates ethical consumption synonyms from the paper [27] into its analysis. The appendix contains the search query. The SLR process is given below.

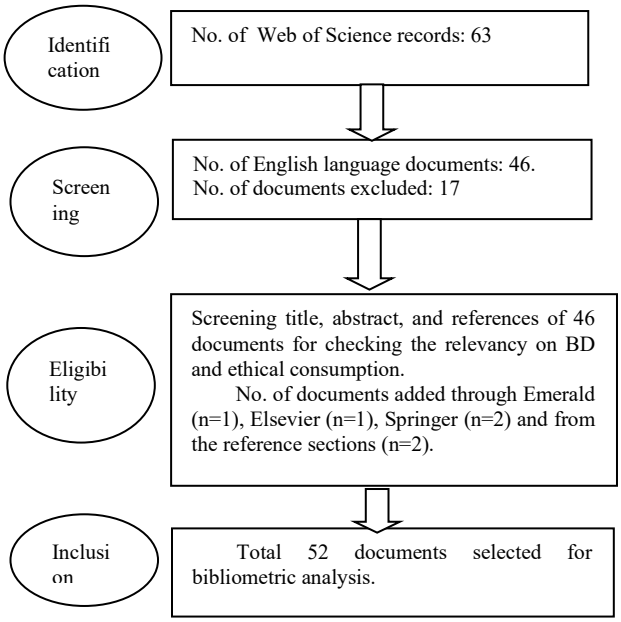


Fig. 1. PRISMA protocol for systematic literature review.

Bibliometric analysis combines performance analysis and science mapping. Performance analysis assesses the productivity using different matrixes whereas science mapping examines the intellectual relationships within a field [30]. In the performance analysis, the study used Bradford's Law (1934) [35], where the number of journals in these zones follows a geometric progression, typically expressed as 1:n:n2, where n is the Bradford multiplier. The study also assesses Lotka's Law [36] for measuring author productivity, which states that the number of authors publishing n works is proportional to 1/n2, meaning that productivity decreases rapidly for higher publication counts [36]. In the keyword co-occurrence analysis, the study used the following formula for assessing average publication year (APY).

$$APY = \frac{\sum(ti_i * n_i)}{\sum t_i} \quad (1)$$

According to the formula, if a topic t appears in two articles (n = 2) in 2022, three articles in 2023, and five articles in 2024, then its APY value is 2023.3.

[(2X2022)+(3X2023)+(5X2024)/10].

The study avails BiblioShiny package of R language in performance analysis [28] and VOSviewer for science mapping.

III. RESULTS

A. Performance analysis

The study evaluates the Bradford law [35] concerning the distribution of articles in core journals of BD and EC, as illustrated in figure 2.

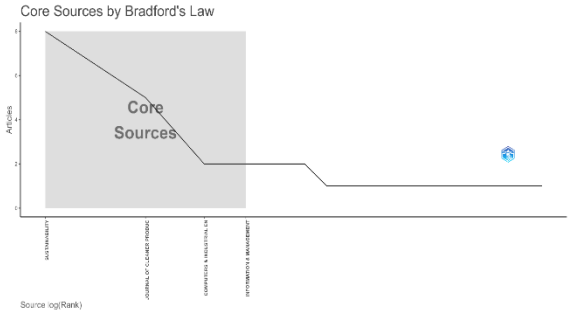


Fig. 2. Bradford's Law.

The shaded gray area delineates the journals that significantly contribute in terms of article volume. Publications such as Sustainability and Journal of Cleaner Production are likely integral to the core zone, given their extensive coverage of subjects like big data and ethical

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consumption. The x-axis employs a logarithmic scale to categorize journals according to their productivity levels. Journals of greater prestige, such as Sustainability, are positioned on the left, whereas those with lower productivity, like Information & Management, are situated further to the right.

To determine the author impact and resource allocation in BD on shaping EC, the study analyze the Lotka's Law [36] for determining the scientific productivity distribution which shows in figure 3.

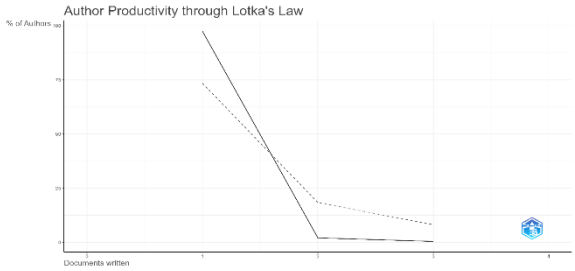


Fig. 3. Lotka's Law.

11% of authors write 3 articles and the Lotka's law noted about the inverse square law, where author productivity decreases exponentially as the number of publications increases.

B. Science mapping

For science mapping, the study conducted bibliographic coupling to determine thematic clusters of BD research in EC [30]. The study selected documents which have at least 5 citations. The figure 4 represents 4 thematic clusters of BD research in shaping EC in consumer perspectives.

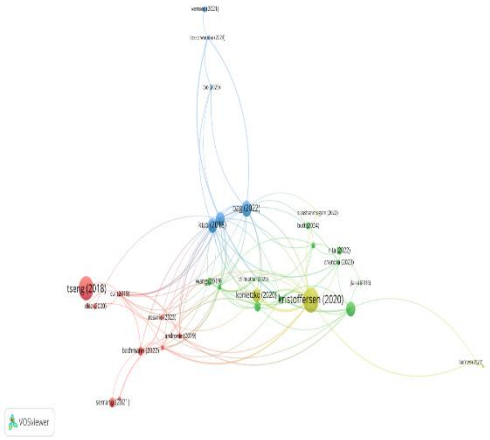


Fig 4. Clusters of BD research in EC from bibliographic coupling.

The study conducts keyword co-occurrence analysis for determining the research trends. The study put minimum occurrence as 3 as threshold. The overlay diagram presents in figure 5.

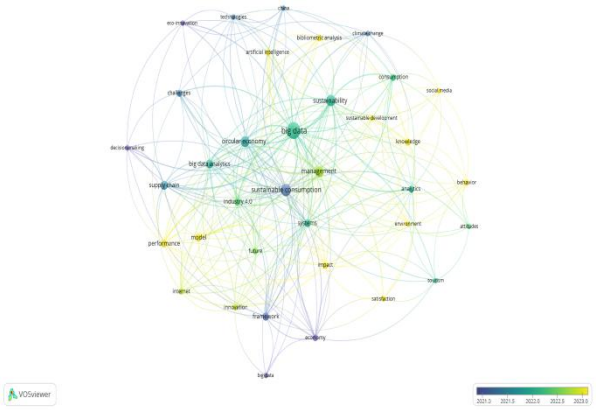


Fig 5. Keyword co-occurrence

IV. DISCUSSION

Based on the four clusters presented in figure 4, the study presents four thematic clusters in Table 1.

TABLE 1.
Thematic clusters of big data in ethical consumption

Cluster name	Authors	Main findings
Red (Data-Driven Solutions)	[2;5;8]	Data-driven technologies improve SDG performance by improving decision-making and resource allocation, despite constraints such as data gaps. Green consumers value sustainability in their product reviews, demonstrating a positive predisposition toward environmentally friendly behaviors. The circular economy has challenges such as high expenses, but it also provides enormous economic rewards and creative potential for organizations that follow its principles.
Blue (Sustainable Innovation)	[4;5;14]	Organizational social structures significantly boost SMEs' contributions to the Circular Economy. Environmental innovation increases green supply chain management (GSCM) and CE capabilities as a result of institutional pressure. It also demonstrates that firms excel at green product development but require sustainability improvements elsewhere. Big data and predictive analytics (BDPA) encourage sustainable development partner collaboration, and organizational fit enhances it even further.

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Yellow (Digitalization)	[1;23;34]	Digital technologies (DTs) like IoT and big data are crucial for advancing the circular economy (CE), but there is a lack of organized guidance on how to apply them and the necessary business analytics (BA) capabilities. The Smart CE framework developed in this study helps to link circular initiatives with BA demands, resulting in increased resource efficiency and productivity in manufacturing. Furthermore, there is a need for fundamental changes in product and business models, as well as practical tools to support ecosystem innovation in the BD and EC domains.
Green (Big data analytics)	[1;2;3;6;8;21;34]	Big data analytics (BDA) has the potential to improve manufacturing decision-making, but data and technology barriers prevent its deployment which creates EC intention-behavior gap. Lack of infrastructure and high investment costs in manufacturing supply chains may influence BDA policy. E-commerce consumers demand sustainable practices, which has linked consumer behavior, sustainability, city logistics, and circular economies. Big data helps address environmental issues and promote low-carbon behaviors to promote ethical consumption

In keyword co-occurrence analysis, the study evaluates the thematic trends of BD applications in shaping EC research, as depicted in Figure 8. The shift from blue to yellow nodes in the picture indicates a movement from basic sustainability practices to complex, interrelated evaluations that incorporate artificial intelligence and sophisticated data analysis for predicting and promoting ethical consumer behavior. This trend signifies the data-driven methodologies in ethical consumption practices across many sectors [8;14]. Artificial intelligence employs analytics for predicting customer behavior [9;37]. Social media, like Facebook, X, and LinkedIn, promote knowledge dissemination regarding sustainable practices, resulting in improved knowledge generation that fosters consumer awareness and education, which is important to reduce the EC intention-behavior gap [20;7]. By employing advanced behavior analysis, researchers can uncover patterns in sustainable decision-making, thereby guiding the creation of models to forecast consumer decisions [21; 3]. The yellow nodes in the figure specifically highlight the growing emphasis of future research initiatives on the integration of technology and sustainability. This technological integration fosters innovation in sustainable consumption methods while facilitating improved effect assessment of efforts and monitoring of customer satisfaction with sustainable alternatives (Rita & Ramos, 2022). This trend illustrates a distinct transition from fundamental sustainability indicators to more intricate, interconnected big data studies that utilize modern technologies to comprehend ethical consumer behavior.

V. CONCLUSION

This study highlights the critical role of data-driven technologies, particularly big data, in advancing EC and achieving Sustainable Development Goals (SDGs). Researchers can utilize these findings to explore how BD enhances decision-making and resource allocation for sustainability initiatives. Furthermore, the emphasis on advanced data analytics and artificial intelligence offers insights into predicting consumer behavior related to ethical consumption by reducing the EC intention-behavior gap at the consumer level.

Managers should leverage big data and analytics to enhance decision-making processes related to sustainability initiatives within their organizations. Understanding the barriers to big data adoption can inform strategic investments in infrastructure and tools that support ethical consumption practices and help customers to reduce the EC intention-behavior gap. Additionally, integrating advanced behavior analysis can help managers predict consumer preferences for ethical consumption, enabling more effective marketing strategies for sustainable products.

The study considers the Web of Science database only. Future research could consider more databases to get a much broader result. BD plays a transformative role in shaping EC behaviors. Its integration with advanced analytics enhances decision-making for sustainability initiatives, thereby reducing the gap between EC intention and behavior. Organizations should prioritize investments in big data technologies to better understand consumer preferences. Future research should focus on addressing ethical concerns related to privacy and data ownership while promoting sustainable practices.

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Understanding What Influences Gen Z Consumers to Purchase Organic Food: Evidence from Bangladesh Using the Theory of Consumption Values

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Abstract - **This study aims to extend the Theory of Consumption Values (TCV) to identify key factors shaping Generation Z's willingness to purchase intentions of organic food, adding two additional constructs: health concerns and environmental value. This pilot study also identifies the main barrier to purchasing organic food in the Bangladesh market. A quantitative approach was used, and 102 respondents were collected from Gen Z consumers in Bangladesh. This data was analyzed with SPSS and included the use of descriptive statistics, correlation analysis, and regression models to test six hypotheses. Findings reveal that social values (WOM) and emotional value are the strongest predictors, whereas price sensitivity is the main barrier to purchase intention of organic food. Findings also show that environmental concern and health consciousness had weaker direct effects. As the first TCV-based study on Bangladeshi Gen Z, it offers theoretical and practical marketing insights for effective communication and pricing, supporting healthier lifestyles and sustainable consumption aligned with SDGs 3 and 12.**

Keywords: **environmental marketing; organic products; organic food consumption; theory of consumption value; Bangladesh.**

I. INTRODUCTION

Concerns about health and sustainability at the global level are impacting consumers' preferences, leading to an increase in demand for organic, sugar-free, and health-related foods [1]. Consumers value organic food for their health and environmental benefits and, in general, are willing to pay a premium price [2]. In Bangladesh, the awareness of organic food products is gradually increasing, aligning with the global trend but also reflecting food safety concerns and wellness locally [3]. Generation Z, which consists of people born roughly between 1995/1996 and 2010/2012, is the first generation to be truly digital natives. Their consumption choices are deeply influenced by social media, their peer networks, and global culture [4]. While the level of fast-food consumption of Bangladeshi Generation Z is very high, for instance 63–68% of the Bangladeshi Generation Z in Dhaka and Chittagong reported eating it often due to convenience and taste [5], rising health issues like obesity and chronic diseases are fueling interest in healthy options like organic food [6]. However, the motivations and barriers for Bangladeshi Generation Z for their purchases of organic food are not well understood.

Previous studies have examined consumer behavior towards organic food from different perspectives, such as culture, lifestyle, and personal values. However, there are very few studies using the Theory of Consumption Values (TCV) to analyze the young consumers' decision-making process with organic food in Bangladesh. Gen Z is an important group to study because they are future consumers, more open to new ideas, and often care about social influence and sustainability. To address the above research gaps, the main objectives of the study are: *RO1: to identify which factors influence Gen Z consumers' intention to buy organic food in Bangladesh. RO2: to extend the Theory of Consumption Values to explore six factors: functional value, conditional value, social value, emotional value, health consciousness, and environmental value.*

Based on this, the pilot study addresses the following research question: *RQ1: What determines Generation Z consumers' organic food purchase intentions in Bangladesh, and how do their health, social, and environmental values affect these intentions?*

II. LITERATURE REVIEW

2.1. Theoretical Background: Theory of Consumption Value

Theory of Consumption Value (TCV) examines why consumers choose certain products over others, focusing on their decision-making drivers [7]. It has been widely applied in marketing and consumer behavior research. Researchers in previous studies used TCV to describe a wide range of products or services such as food, clothes, education, tourism, etc. [8,9]. By leveraging TCV, researchers can explore not only purchase decisions but also willingness to buy, uncovering how different consumption values shape consumer preferences for organic products [10]. Indeed, TCV provides a multidimensional framework well-suited for analyzing organic food purchasing behavior [7]. However, its application to Gen Z consumers in Bangladesh remains unexplored. This study therefore investigates how functional, social, environmental, and personal values, along with health consciousness and price sensitivity, shape Gen Z's purchase intentions toward organic food [11]. Research indicates that environmental value strongly influences young, educated consumers' green purchasing decisions in Bangladesh [12],

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while a consumer's health consciousness also encourages a positive attitude toward buying organic food [13].

In the current study, we anticipated that our integrated proposed framework would provide comprehensive and complementary insights into Gen Z consumers' sustainable consumption values and organic food purchase decisions in Bangladesh.

a. Hypothesis Development

2.2.1. Functional Value (Perceived Quality)

Functional value (FV) refers to a product's usefulness based on its practical, utilitarian, or physical performance, as perceived by the consumer [7]. FV is a key determinant in whether consumers choose green products and services [14]. The findings on consumers' willingness to pay a premium for sustainable products are varied. Despite this, several studies demonstrate that individuals often have favorable views of these products and are somewhat prepared to pay more to safeguard both individual and collective well-being [15,16]. Therefore, this study proposes the following hypothesis:

Hypothesis (H1): Functional values (Perceived quality) are more positive influences that consumers are willing to pay more.

2.2.2. Conditional Value (Price Sensitivity)

Conditional value (CV) refers to how a particular circumstance or context can change the value of a choice [7]. Organic items are typically of a higher price, but consumers find the price justifiable due to the perception of quality [17]. Previous studies indicate that highly price-sensitive consumers are less likely to translate their environmental awareness into green purchasing behavior [18]. Therefore, this study proposes the following.

Hypothesis (H2): Conditional value has a significant impact on willingness to purchase organic food.

i. Social Value

Social value (SV) refers to the perceived utility a consumer derives from a product based on its association with positively or negatively stereotyped social groups [7]. Previous studies have found that a consumer's choice to purchase sustainable goods is heavily influenced by their social environment, peer pressure, and the desire for social approval [19]. Moreover, consumers are more likely to act or think alike to a reference group sometimes regardless of their personal beliefs [15]. This suggests that the purchase intention to buy products such as organic foods may increase in consumers of Bangladesh, if they are endorsed by public figures, like celebrities, social media influencers or even professionals. Thus, we propose the following hypothesis:

Hypothesis (H3): Social value is positively associated with customers' purchase intention towards organic foods.

2.2.4. Emotional Value (Personal Value)

Emotional value (EV) refers to the benefit we get from how a product or experience makes us feel, such as excited, secure, or comfortable [7]. Consumers' strong emotional values, moral actions, and affectionate behaviors may significantly impact decision-making to buy green or organic products [19]. For example, in the US, coffee shops' use of green practices significantly influenced how attached their customers became [20]. Ultimately, when consumers form a strong emotional bond with eco-friendly goods, it often drives them to purchase more and adopt an identity as a protector of the environment [21]. Therefore, this study proposes the following.

Hypothesis (H4): Emotional value has a significant impact on willingness to purchase organic food.

2.2.5. Health Consciousness

Health consciousness (HC) is described as how much people think about their health and how their lifestyle choices, like diet, affect it [22]. As people grow more health-conscious, they often look for healthier food options and nutrition information [23]. Previous research has identified many factors influencing organic food purchases, but health concerns remain the most common reason consumers choose it [24]. Research strongly supports the positive link between health consciousness, attitude, and organic food buying intentions. As consumers grow more health-conscious, they increasingly prefer organic and healthy food options [23]. This, we propose:

Hypothesis (H5): Consumers who have Health Consciousness prefer a significant impact on willingness to purchase organic food.

2.2.6. Environmental Value

Environmental value (EVa) refers to an individual's conviction and perception regarding the importance of protecting the environment and minimizing ecological harm [25]. Individuals prioritizing EVa tend to exhibit eco-friendlier purchasing behavior, such as purchasing organic food [12, 26]. Empirical findings from previous studies have confirmed that a favorable environmental attitude significantly affects the purchase of green products, which leads to sustainable consumption behavior [27]. In light of the above discussion, we hypothesize that:

Hypothesis (H6): Environmental value (Eva) has a significant impact on willingness to purchase organic food.

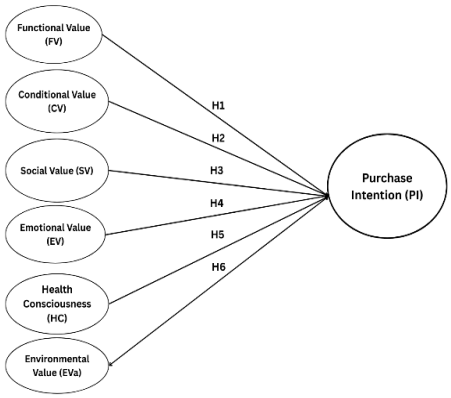
The model of dependent variables with independent variables, along with the hypothesis, is shown in Figure 1.

Figure 1: Proposed Conceptual model of Purchase Intention

III.RESEARCH METHODOLOGY

3.1. Data Collection and Measures

In this study, we used a quantitative research design to



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investigate Gen Z's consumption behavior for organic food in Bangladesh. A structured self-administered questionnaire was created using Google Forms and distributed via social media and email to target university students, who represent the Gen Z population. Online surveys are considered effective for reaching young, tech-savvy groups [28]. Convenience sampling was applied due to its accessibility and time efficiency [29].

The questionnaire included four demographic questions pertaining to respondents' age, education level, monthly income, and occupation. Respondents' age and education were assessed using close-ended questions with appropriate options to ensure accuracy in their answers. Nevertheless, 28 items of 7 variables are adopted from well-established literature. For example, five items of functional, epistemic, and personal value are adopted from previous literature 30,31]. Four items of purchase intention; conditional value are taken from [32]. Lastly, three variables from environmental and social values were taken [33]. The participants responded to the questionnaire based on the Likert scale (1 - Strongly Disagree, 5 - Strongly Agree).

1. Statistics Technique

We obtained 102 valid responses from students aged 18 to 29 years, from both private and public universities in Bangladesh. All responses were obtained fully anonymously, protecting the participants' anonymity and encouraging truthfulness in their responses. The responses were then coded and analyzed using SPSS version 26 to ensure that the information gathered would be accurately interpreted and reliable, thus findings were respectful of their integrity.

IV FINDINGS

4.1 The socio-demographic profile

Table 1 shows that most respondents are male (53.9%), aged mainly between 22–25 years (65.7%), and the majority are undergraduates (74.5%), reflecting a young, mostly student-based population.

Table 1: The socio-demographic profile of respondents

Variables	Frequency	Percent
Gender		
Male	46	53.9
Female	55	45.1
Prefer not to say	1	1.0
Age		
18–21 years	13	12.7
22–25 years	67	65.7
26–29 years	16	15.7
30–40 years	6	5.9
Level of Education		
Undergraduate	76	74.5
Postgradute	17	16.7
Master	7	6.9
Average Monthly Income		
None	24	23.5
5,000-10,000 BDT	200	33.3
11,000-20,000 BDT	98	17.6
20,000-30,000 BDT	116	9.8
More than 30,000 BDT	224	15.7
Total (Respondents)	**102**	**100.0**

4.2. Reliability and Descriptive Analysis

In this study, the reliability of the measurement scales was assessed using SPSS 26. The results showed that all constructs had Cronbach's Alpha value above the recommended threshold of 0.70, ranging from 0.759 to 0.909. This indicates that the items used for each construct were internally consistent and measured the intended concepts reliably.

Specifically, Social Value showed acceptable reliability (α = 0.759), while Conditional Value (α = 0.835), Functional Value (α = 0.842), and Purchase Intention (α = 0.897) demonstrated strong reliability. Emotional Value (α = 0.909), Health Consciousness (α = 0.904), and Environmental Value (α = 0.899) showed very strong reliability. Overall, these results confirm that the measurement scales used in this study were reliable and suitable for analyzing consumer behavior toward organic food products.

The mean values of table 2 presents that Functional Value has a mean of 3.694 indicating that respondents consider quality, safety, and packaging for organic foods. Conditional Value has a mean of 3.54 showing that respondents are price sensitive and consider price while purchasing organic foods. The social value with a mean of 3.38 indicates moderate social influence by family, friends, and social media on organic foods consumption value. Emotional Value has a mean of 3.54 indicating respondents being favorable to personal responsibility and consumption of green products. Health Consciousness has a mean of 3.714 indicating health benefits strongly impact consumption value. Environmental Value has a mean of 3.47, indicating a neutral to slightly positive attitude towards environmental issues when making purchasing decisions. Finally, Purchase Intention has a mean score of 3.65 verified by the means of respondents stated Gen Z's are more inclined to purchase organic foods in the future.

Variable Name & Item	Cronbach Alpha Value	Overall Mean	Overall mean
Functional Value	.842	3.695	3.569
Conditional Value	.835	3.539	
Social Value	.759	3.382	
Emotional Value	.909	3.537	
Health Conciousness	.904	3.714	
Environmental value	.899	3.471	
Purchase Intention	.897	3.647	

Table 2: Reliability Analysis (Cronbach's Alpha Values)

4.3 Inter-Item Correlation Matrix

Table 3 presents the correlation between each value with Purchase Intention (PI). The Environmental Value (EVa) had the highest correlation to PI (0.726). This implies that individuals who care about the environment are more likely to have the intent to purchase. Emotional Value (EV) demonstrated a strong correlation (0.723), demonstrating that feelings and emotional attachment are significant drivers of purchase intention. Health Consciousness (0.701) and Conditional Value (0.692) had the next highest correlation, which implies that health awareness, as

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well as situational benefits, such as convenience and situation, significantly contribute to purchase intention. While Functional Value (0.685) has a moderate effect, it is significant, demonstrating that practicality is important as well. Social Value (SV) (0.672) demonstrated the weakest relationship with purchase intention, which implies that social approval/ image has the least influence on values on purchase intention. Overall, this illustrates that environmental concerns and therefore emotions are the most significant contributors to purchase intention while social influence is of relative less extent**.**

Table 3: Inter-Item Correlation Matrix

4.4 Test of Hypothesis and Interpretation

From Table 4, we see that the F-value is 40.180 (p = 0.000), which is less than 0.05. This implies that we reject the null hypothesis, and we accept the alternative hypothesis at the 95% confidence level. This indicates that the proposed predictors statistically significantly explain the variation in Purchase Intention among consumers.

Table 4: ANOVA (Analysis of Variance)

The regression model (Table 5) shows a strong link (R = 0.847) between the six values and Purchase Intention (PI). About 71.7% of the change in PI is explained by the model (R^2 = 0.717), and the adjusted value (0.699) confirms it is a good fit. The low error (0.48458) and significant F-test (p < 0.05) means the model is reliable.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Chan
1	.847[a]	.717	.699	.48458	.717	40.180	6	95	.000

a. Predictors: (Constant), Functional Value, Price Sensitivity, Social Influence, Personal Value, Hea Consciousness, Environmental Value

Table 5: Regression Model Summary

The results of the hypothesis (Table 6) show that Social Value (β = 0.226; p = 0.004), Conditional Value (β = 0.168; p = 0.043), and Emotional Value (β = 0.225; p = 0.025) have a significant positive effect on PI. Therefore, H2, H3, and H4 are accepted, confirming that social influence, conditional benefits, and emotional value strongly increase purchase intention. On the other hand, Functional Value (β = 0.139; p = 0.112), Health Consciousness (β = 0.166; p = 0.058), and Environmental Value (β = 0.104; p = 0.323) were not significant. Hence, H1, H5, and H6 are rejected, showing that functionality, health concerns, and environmental value do not significantly predict PI

Inter-Item Correlation Matrix

	PI	SV	CV	EV	HC	EVa	FV
PI	1.000	.672	.692	.723	.701	.726	.685
SV	.672	1.000	.628	.499	.563	.556	.554
CV	.692	.628	1.000	.653	.568	.627	.542
EV	.723	.499	.653	1.000	.634	.806	.623
HC	.701	.563	.568	.634	1.000	.684	.713
EVa	.726	.556	.627	.806	.684	1.000	.693
FV	.685	.554	.542	.623	.713	.693	1.000

Table 6: Regression Coefficient

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Results
		B	Std. Error	Betxa			
1	**(Constant)**	.008	.248		.034	**.973**	
	FV	.144	.090	.139	1.604	**.112**	Rejected
	CV	.169	.082	.168	2.053	**.043**	Accepted
	SV	.237	.080	.226	2.985	**.004**	Accepted
	EV	.214	.094	.225	2.285	**.025**	Accepted
	HC	.167	.087	.166	1.917	**.058**	Rejected
	EVa	.094	.095	.104	.993	**.323**	Rejected

a. Dependent Variable: Purchase Intention

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	56.611	6	9.435	40.180	.000[b]
	Residual	22.308	95	.235		
	Total	78.919	101			

a. Dependent Variable: PurchaseIntention

b. Predictors: (Constant), FunctionalValue, PriceSensitivity, SocialInfluence, PersonalValue, HealthConsciousness, EnvironmentalValue

V.DISCUSSION AND IMPLICATION

This study examined the purchase intentions of Generation Z towards organic food in Bangladesh using the Theory of Consumption Values (TCV). The results revealed that social value, conditional value, and emotional value had a significant and positive effect on purchase intentions, while functional value, health consciousness and environmental value were not significant.

The strong effect of social value indicates that Gen Z are not only very influenced by peer groups and social media endorsements, but also by word-of-mouth recommendations from others. This is consistent with previous research which has suggested that young consumers often seek social approval through their purchases. However, this differs with previously held views about environmental or health values as leading motivations for sustainable food purchasing. This provides an indication that a marketing strategy could effectively target influencers, community endorsements and online spaces to enhance social acceptance of organic food products. Campaigns that promote organic food products through relatable role models may enhance the perceived social benefits associated with their consumption.

The significance of conditional value shows that price sensitivity

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and situational benefits (discounts promotions, subsides etc.) are still significant aspects for Gen Z when buying organic food in Bangladesh. Whilst some of the respondents said they would pay more but affordability still plays a key deciding role, consistent with literature on emerging market consumers. Thus, marketers and policy makers should think of ways to include student discounts, limited time promotional offers, and bundling product purchases to try to offset cost. Furthermore, finding incentives or subsidies for organic products that support the younger, price sensitive consumers could increase adoption levels.

Similarly, emotional value positively impacted purchase intentions, suggesting that Gen Z develops attachments and positive feelings toward sustainable consumption. This demonstrates that organic food marketing is effective when it appeals to emotions such as pride, responsibility, and identity, echoing past findings in green consumer research. Companies should focus on emotional narratives in advertisements and initiatives that convey the feelings about personal well-being, sustainability, and how it benefits the community. Strategies that can meld the emotions created between consumers and eco-friendly lifestyles are likely to be efficacious.

Unexpectedly, the functional value construct did not significantly affect purchase intentions. This may mean that Gen Z consumers assume all organic food meets a minimum level of quality which is unimportant, and do not prioritize functional attributes as differentiators. Similarly, health consciousness and environmental value did not have a significant impact. This also was surprising given the current global focus on health and environmental issues. Therefore, one explanation of this study could be that only spreading awareness does not automatically convert into purchase decisions unless it is supported by social influence, emotional appeal, and affordability.

Overall, these findings suggest that marketers should adopt socially engaging, emotionally appealing, and economically accessible strategies to promote organic food. Policy interventions may focus on subsidies, awareness programs, and collaborations with educational institutions to make organic food more appealing and attainable for young consumers.

V. LIMITATIONS AND FUTURE RESEARCH DIRECTION

(1) The pilot survey was conducted on Gen Z university students in Bangladesh, resulting in limitations to the broader population. Future research can add in generational cohorts or include working professionals to compare differences in organic food purchase intentions with large sample size.

(2) Data collection was predominately from urban centers, thus does not provide the perspective of rural consumers where awareness and access vary considerably. The future could include both urban and rural samples to gain wider perspective.

(3) While this study examined six values under TCV, other personal factors such as attitudes, lifestyle, and cultural influence may also play important roles in shaping purchase behavior. Future research should integrate these variables to extend the explanatory power of the mode

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Leading Green Transformation with a Green Mindset: Unlocking Green Champions through Organizational Fit

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Abstract: **In this era of environmental consciousness, organizations can either accelerate or mitigate climate change and ecological degradation. To address the concern, this study highlights and proposes a unique model through the lens of the resource-based view theory, suggesting that green knowledge-oriented leadership (GKOL) and a green person-organization fit (GPOF) can play a crucial role in enhancing employee green championing behavior (GCB) in the context of LEED-certified garment organizations in Bangladesh. To examine the proposed model, the present study collects data in two waves from 430 full-time employees (supervisory level) working in LEED-certified garment organizations in Bangladesh. The partial outcomes showed that green knowledge-oriented leadership positively and significantly impacts employees' green championing behavior. Additionally, green person-organization fit mediates the relationship between green knowledge-oriented leadership and employee green championing behavior in the context of a LEED-certified garment organization in Bangladesh. The outcome of this study is to help understand various aspects of employees' green championing behavior.**

Keywords: **Green knowledge-oriented leadership, green person-organization fit, green champion behavior, resource-based view theory, LEED certified garments organization in Bangladesh**

I. INTRODUCTION

A global environmental disaster has significantly strained relationships [1]. Human-driven climate change presents a considerable risk to the world's ecosystems [2]. Industrialization and organizational expansion have intensified this challenge, raising concerns regarding corporate accountability and sustainability [3]. Organizations can either exacerbate or alleviate climate change and ecological degradation in the current context of environmental awareness [4]. Given these concerns, there is a growing acknowledgment among researchers and practitioners globally regarding the importance of employees' green behavior [5] and pro-environmental behavior [6], especially green championing behavior [7]. Because employees' championing behavior involves exceeding expectations to ensure the success of a change and advocating for it to others [8], in line with this, employee green championing behavior entails exceeding standard expectations to facilitate the success of green initiatives, transformations, or changes. This fosters coworkers' active participation in green transformation initiatives and promotes eco-friendly efforts beyond the organization [7]. Ensuring employee interest in green championing behavior is a complex undertaking. Current literature underscores the lack of empirical evidence to support enhancing employee green championing behavior. Moreover, a limited research study highlighted GCB in the context of the manufacturing industry. In addition, previous research observed GCB based on the Western context [7]. This study addresses the gap by exploring employee GCB in the context of organizational green change within LEED-certified garment organizations in Bangladesh. Bangladesh remains a prominent receiver of foreign investment in the South Asian garment sector [9]. Therefore, to be competitive among the foreign buyers and investors, the Bangladesh RMG (ready-made garments) organizations must maintain international standards [10], and LEED certification offers a standardized framework for assessing and benchmarking sustainable practices across categories like energy efficiency, water conservation, material selection, indoor environmental quality, and design innovation [11]. This certification is a hallmark of environmental stewardship and sustainability, influencing customer views, market competitiveness, and regulatory compliance [12]. In LEED-certified garment organizations, employees' roles, specifically employees' GCB, are essential for obtaining and sustaining certification by engaging in sustainable activities, complying with green building regulations, and fostering a company-wide culture of environmental stewardship [13]. Therefore, this research aims to identify key influencing factors that enhance employees' GCB in the context of green organizational transformation.

Prior studies have highlighted different leadership styles as crucial in fostering employee change-supportive behavior. Furthermore, aligning individuals and organizations is crucial during organizational change [14]. This study emphasizes that GKOL and GPOF are significant factors in organizational green transformation. This study addresses the following questions: Does GKOL affect employee GCB within organizational green transformation? Does GPOF mediate the relationship between GKOL and GCB of employees in the context of organizational

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green transformation? This study enhances the literature on leadership, human resource management, and change management by formulating original hypotheses to examine the effect of GKOL on employee GCB within the context of organizational green transformation. This study enhances the current literature on leadership, human resource management, and change management by formulating novel hypotheses to investigate the influence of GKOL on employee GCB within the framework of green transition in LEED-certified RMG firms in Bangladesh. A theoretical model is constructed utilizing resource-based view (RBV) theory [15] to establish a connection between GKOL and employee GCB within the framework of green organizational transformation, examining the mediating role of GPOF in the relationship between GKOL and GCB during the green transition in LEED-certified RMG organizations in Bangladesh.

Figure 1 delineates a research model based on theoretical foundations. The model is examined using primary data from LEED-certified garment organizations in Bangladesh, employing structural equation modeling to assess the study's hypotheses. The subsequent sections of this paper are organized as follows: The next part delineates the literature review and formulation of the hypotheses examined in this study. The methods section presents the sample frame, data, statistical model, and software utilized to evaluate the hypotheses. The empirical findings of the given hypothesized model are subsequently presented. The report concludes with a summary of the key findings, limitations of the study, and prospective research avenues to advance this emerging field of organizational change management.

Literature Review and Hypotheses Development

Green Knowledge-Oriented Leadership and Green Champion Behavior

In organizations, GKOLs significantly affect how green knowledge is developed and used [16]. Environmentally responsible leaders promote a culture that places the highest value on green knowledge by making decisions in an eco-conscious manner [17]. Therefore, employees working under the leadership of GKOL become environmentally concerned and demonstrate green behavior. Moreover, employees become green champions in the context of organizational green transition. Championing behavior refers to exhibiting significant enthusiasm for a change by exceeding formal requirements to guarantee its success and advocating for the shift among others [18]. Previous studies showed that transformational leadership nurtures employee championing behavior in the context of organizational change [8], [19], which supports organizations in managing change effectively. Moreover, existing literature highlighted that green leadership enhances employees' creative engagement [20] and employees' green behavior [21]. Accordingly, the present study justifies that GKOL can develop green knowledge and behavior, which eventually enhances employees' GCB in the context of green organizational transformation. Hence, the present study proposes:

H1: Green knowledge-oriented leadership has a significant and positive impact on employees' green champion behavior

Green Knowledge-Oriented Leadership and Green Person-Organization Fit

GKOL is a seen or imputed behavior that fosters environmentally sustainable knowledge production, sharing, and application, promotes ecological responsibility and sustainable development-aligned cognition and collaboration [22], which ensures employees working under the supervision of GKOL to fit with the organizational goals and objectives. Previously, researchers revealed sustainable leaders to ensure person-organization fit [23]. P-O fit is the alignment between individual and organizational goals, individual preferences or needs with organizational systems or structures, and individual personality with organizational climate [24]. GPOF is a person-organization fit that evaluates the alignment between an organization's dedication to protecting the environment and its employees' environmental beliefs. Prior research indicates a relationship between personal values and pro-environmental behavioral intentions [25], [26]. The GPOF allows for analyzing the functional relationship between personal environmental values and the workplace and assessing whether fit impacts transcend beyond ecological protection activities [7]. Therefore, the present study highlighted that GKOL can fit employees with the organization's green values and ensure GPOS. Hence, the present study proposes:

H2: *Green knowledge-oriented leadership significantly and positively impacts green person-organization fit.*

Green Person-Organization Fit and Green Champion Behavior

Previous studies highlighted that person-job fit can enhance employee green behavior [27], pro-societal behavior [28], and citizenship behavior towards the environment [29]. Moreover, researchers revealed that GPOF enhances employees' job satisfaction and engagement [7]. Accordingly, the present study highlighted in the context of organizational green transition that GPOF can nurture GCB. Because when employees perceive a strong GPOF, they are more inclined to champion environmental initiatives, as these actions align with their individual identities and the organizational culture. Additionally, GPOF serves as a strategic human capital resource, as employees' alignment with environmental values fosters enhanced commitment, motivation, and championing of sustainability initiatives. Hence, the present study proposes:

H3: Green person-organization fit significantly and positively impacts green champion behavior.

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Mediating Effect of Green Person-Organization Fit

Relationships discussed above between GKOL and GCB; GKOL and GPOF, and GPOF and GCB are rational to propose a mediational effect of GPOF since GKOL influences GPOF, which in turn influences GCB. Precisely, GPOF levels may differ, and GKOL has the capacity to increase employees' GCB in the context of green organizational transformation. Therefore, it is rational to propose that GPOF can act as a potential mediator in the association between GKOL and GCB during organizational green change initiatives. In other words, GKOL facilitates the development of a collective environmental vision and promotes a learning culture. This enhances employees' sense of belonging and alignment with the organization's ecological values, thereby improving GPOF. Consequently, employees who perceive this alignment are more inclined to engage in behaviors that support the organization's sustainability objectives, resulting in GCB. Previous studies highlighted the mediating effect of person-organization fit [27], [30], [31]. From the perspective of the RBV theory [15], GKOL develops green knowledge resources, while GPOF incorporates these resources into the organizational culture. This alignment fosters GCB, a dynamic capability that creates sustained competitive advantage. Hence, the present study proposes:

H4: Green person organization fit mediates the relationship between green knowledge-oriented leadership and green champion behavior.

II. METHODOLOGY

This research utilized a cross-sectional approach and a standardized questionnaire to collect data from January to February 2022. Data were gathered from a sample of personnel occupying administrative roles across different departments of LEED-certified RMG organizations in Bangladesh. In Bangladesh, 258 organizations in the RMG sector received certification from LEED, a globally recognized US-based green building certification standard. The LEED organizations were categorized into three classifications: 109 in platinum, 133 in gold, and 16 in silver, with four others designated as generally accredited. During the data collection phase, 30 organizations from various categories consented to participate. The researchers allocated 510 questionnaires uniformly among the 30 respondent organizations. Of the 500 issued questionnaires, 308 replies were obtained, with 5 excluded owing to criterion nonconformity. Consequently, 303 suitable participants were identified, resulting in a 58% response rate. This is considered satisfactory, as this is above the 45.6% rate reported by researchers [32] in the RMG business.

Data Analysis

For measurement and structural models' assessment, Smart PLS 4.0 was consciously selected. This technique doesn't necessitate strict adherence to a normal distribution in survey data [33]. Given our complex model, including higher-order SSCM practices and SP with mediation analysis, regression in SPSS was insufficient [33]. Thus, we used Partial Least Squares Structural Equation Modeling (PLS-SEM) for comprehensive and robust analysis.

Measures

In the current research, GKOL is considered the independent variable, whereas the dependent variable is the GCB. This study also considered GPOF as the mediating variable. Independent variable (GKOL) was measured by six items from a research work [34], whereas the dependent variable was measured by four items adapted from another research work [35]. Lastly, four items were used to measure the mediating variable (GPOF) adapted from [32].

III. RESULTS

Common Method Variance

Mitigating Common Method Variance (CMV) is essential in self-report assessments. This study utilized the methodological separation proposed in a research work [36] and performed a Harman single-factor analysis. Harman's analysis indicated that the first factor accounted for 31.4% of the variation, implying the insignificance of common method variance (CMV).

Measurement Model Structural Model

This study utilized convergent and discriminant validity to assess the measurement model. Convergent validity emphasizes evaluating the resemblance among items that embody the same construct. Factor loadings, Average Variance Extracted (AVE), and Composite Reliability (CR) are standard metrics employed to assess convergent validity, as advised in the research work [33]. The results acquired for these variables in the current investigation exceeded the specified cut-off values, as illustrated in Table 3 below. This signifies that the measurement model exhibits adequate convergent validity.

Table 1: Output of Measurement Model

Constructs	Items	Loadings	CA	Rho_A	CR	AVE
Green Champion Behavior	GCB 1	0.795	0.913	0.893	0.912	0.577
	GCB 2	0.834				
	GCB 3	0.820				
	GCB 4	0.791				
	GCB 5	0.812				
	GCB 6	0.876				

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Green Knowledge Oriented Leadership	GKOL 1	0.795	0.853	0.836	0.898	0.619
	GKOL 2	0.876				
	GKOL 3	0.846				
	GKOL 4	0.875				
	GKOL 5	0.772				
	GKOL 6	0.775				
Green POF	GPOS 1	0.841	0.876	0.812	0.891	0.658
	GPOS 2	0.849				
	GPOS 3	0.833				
	GPOS 4	0.868				

Furthermore, discriminant validity was evaluated using the Heterotrait-Monotrait ratio, which provides a more precise measurement, utilizing two separate threshold values of 0.85 and 0.90 [37], with all obtained values falling below the recommended threshold. The measuring model exhibited satisfactory levels of convergent and discriminant validity.

Table 2: Output of Discriminant validity

	GCB	GKOL	GPOF
GCB			
GKOL	0.481		
GPOF	0.789	0.521	

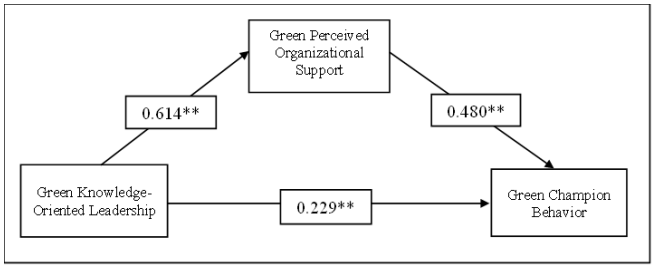
Structural Model

Evaluating the goodness-of-fit for the structural model entails analyzing various metrics, including the coefficient of determination (R^2), the significance of the route coefficient (b), effect size (f2), and cross-validated redundancy (Q2) [33]. The interpretation of R^2 values follows Cohen's stated intervals: values from 0.02 to 0.12 signify a weak association, values from 0.13 to 0.25 denote a moderate relationship, and values of 0.26 and above indicate a considerable relationship. Based on the findings of the results, the current study found that both GPOS (54.3%) and GCB (61.4%) explain the R^2 more than 0.26 which is considered substantial. In the current research, all three direct hypotheses were supported, such as GKOL to GCB (β= 0.291, p <0.01), GKOL to GPOS (β= 0.614, p <0.01), and GPOS to GCB (β= 0.480, p <0.01). Thus, based on the findings of the analysis proved all direct hypotheses were found significant and acceptable. Table 2 shows the output of all the direct paths of the current research

Table 2: Output of Structural Model

Direct Path								
Hypotheses	**Std. Beta**	**Std. Error**	**t. Value**	f^2	**P values**	**95% LL**	**95% UL**	**Decision**
GKOL >GCB	0.291	0.056	5.21**	0.153	0.00	0.239	0.699	S
GKOL > GPOS	0.614	0.024	25.55**	0.73	0.00	0.673	0.451	S
GPOS > GCB	0.480	0.0615	7.8**	0.289	0.00	0.461	0.799	S
**p < 0.01, (based on one-tailed test with 1, 000 bootstrapped replications); S = Supported								
Mediation Hypothesis								
Hypothesis	**Std. Beta**	**Std. Error**	**t. Value**	f^2	**P values**	**95% LL**	**95% UL**	**Decision**
GKOL > GPOS > GCB	0.291	0.047	6.2**	-	0	0.310	0.457	S
**p < 0.01, (based on two-tailed test with 1, 000 bootstrapped replications); S = Supported								

Furthermore, the current research also sees the mediating effect of GPOS between GKOL and GCB based on the guidelines of the research work [38]. Results of the analysis showed a significant mediating effect of GPOS between GKOL and GCB. Moreover, it was asserted in a work [33] that a model exhibits predictive significance for specific endogenous constructs when the Q2 value exceeds 0. The Q2 values obtained in this study were 0.108 for CE and 0.196 for GKOL. Consequently, the Q2 score signifies that the model had satisfactory predictive relevance. Table 2 shows the mediating paths of the current research.



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IV. DISCUSSION

This research, conducted using RBV theory [15], highlighted the association between GKOL, GPOF, and GCB in the context of green organizational change among LEED-certified garment organizations in Bangladesh. Empirical evidence revealed that the GKOL approach is suitable for enhancing GCB in green organizational transformation. In a complex situation like green organizational change or transformation, the GKOL promotes sustainability by developing, disseminating, and using environmental information. Ultimately, this leadership style improves environmental performance and competitive advantage by empowering employees to participate in green initiatives, innovation, and sustainable decision-making, promoting green practices, and cultivating a common understanding of ecological responsibility [22]. Such capacity of GKOL nurtures the green championing behavior of the employees in the context of green transformation. Previous evidence showed that green leadership can influence employee knowledge sharing, which aligns with the study's finding (GKOL-GCB linkage). In addition, this study revealed that in the context of green transformation, GKOL ensures GPOF. In other words, GKOL can nurture the organization's human resources in a way that properly fits the green transformation objectives of the organization and supports the organization in achieving its goals. This finding aligns with the research findings of a prior research work [23]. Moreover, the outcomes of this research show that GPOF, as a component of person-environment fit, enhances GCB in the context of organizational green transformation. Put it differently, during a green transformation initiative of an organization, when employees fit correctly with the green transformation process, it ultimately ensures employee GCB. This outcome aligns with the findings of a research [27], which showed a positive relationship between person-organization fit and employee green behavior. Finally, the present study confirmed the mediational effect of GPOS in the context of organizational green transformation. In other words, the findings showed that the effectiveness of the GKOL approach for enhancing GCB in the context of organizational green transformation depends in the presence of GPOF. GPOF as a mediator nurtures the capacity of the individual human resources, strengthening the leader's impact to foster GCB while managing green transformation in the organization. This outcome also aligns with the research outcome of another study [23], which revealed that person-organization fit mediates the association between green values and corporate green washing. This study also highlights the theoretical and practical implications. Finally, this study concludes by pointing out the limitations of this study and future research scopes.

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EdTech for Student Retention: How AI Chatbots Drive Sustained Success in Higher Education Services

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Abstract - **Widespread use of AI chatbots in higher education has brought about a major change in student support infrastructure. These advanced chat systems leverage sophisticated natural language processing and machine learning algorithms to provide autonomous, scalable assistance across diverse academic ecosystems, effectively making access more available to institutional resources while minimizing dependency on human intermediaries. Contemporary implementations utilize complex system designs to deliver ongoing, context-sensitive conversations addressing examination protocols, admissions processes, academic advice, attendance monitoring, grade management, and career placement services. Investigation employs systematic secondary data analysis to evaluate long-term effects of AI chatbot integration on student retention trajectories, emphasizing differentiated outcomes among first-generation students, international populations, students with disabilities, and part-time learners. Through thorough review of research spanning 2020-2024, the research examines how intelligent query management systems influence sustained institutional engagement beyond immediate problem-resolution capabilities. Findings indicate that while AI chatbots demonstrate measurable improvements in student engagement, administrative efficiency, and query resolution effectiveness, research evidence regarding sustained retention impacts across demographic cohorts remains insufficient for clear long-term evaluation. This research identifies critical gaps in demographic-specific impact evaluation and provides strategic recommendations for institutions implementing AI chatbots as retention enhancement tools.**

Keywords: **AI chatbots, higher education, student retention, query management systems, demographic analysis, longitudinal study, student success, natural language processing, conversational AI, university operations.**

I. INTRODUCTION

AI chatbots function as sophisticated sorting systems as they enable human advisors to spend time on more complex student issues & needs, while managing the numerous layers of routine inquiries with 24/7 accessibility and personalized support. As higher education institutions face mounting pressure to improve student retention rates and ensure equitable access to support services, AI chatbots serve as a compelling technological intervention in academic and administrative pathway guidance. Current applications span multiple domains including admissions guidance, academic advising, financial aid assistance, financial aid, course registration, and general information sharing. Early adopters report substantial benefits: reduced response times, improved operational efficiency, and enhanced student satisfaction with basic query resolution.

Nevertheless, existing research focuses mainly on immediate short-term outcomes, leaving significant knowledge gaps regarding sustained impact on critical institutional metrics. The central problem addresses the limited understanding about how the integration of AI chatbot integration influences long-term student retention and academic success, especially across diverse demographic groups. Studies have documented general effectiveness and user satisfaction, but insufficient research evidence exists examining whether AI chatbots contribute to measurable retention improvements for first-generation students, international students, and students with disabilities over extended periods.

This research gap is particularly significant given varying support needs across student populations. First-generation students require additional guidance navigating unfamiliar institutional systems; international students benefit from language-accessible support; students with disabilities need supportive communication channels, and part-time learners require flexible, asynchronous assistance. Understanding how AI chatbots serve these distinct populations over time is crucial for institutions leveraging technology as an equity-enhancing tool.
The research questions guiding this investigation are:
1.To what extent do AI chatbots, when integrated into higher education student services, contribute to long-term student retention across various demographic groups?
2.What are the perceived challenges and opportunities of AI chatbot integration for promoting retention and success among specific student demographics?

The significance of this study lies in its potential to inform evidence-based decision-making for higher education administrators, policymakers, and technology vendors. As institutions allocate substantial resources to AI chatbot implementation, understanding their actual impact on retention and success across diverse populations becomes essential for

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validating expenditures, optimizing implementations, and ensuring equitable outcomes.

II. METHODOLOGY

Research Design

This research employs a qualitative exploratory design based on systematic secondary data analysis. This review seeks to extract key findings from current literature on AI chatbot implementation within higher education institutions for student support, retention, and success. Particular attention is given to identifying demographic-specific and long-term effects, which have received limited attention in existing literature.

Data Sources

A wide array of credible peer reviewed secondary sources were consulted to ensure comprehensive coverage and in-depth analysis. Sources include:

Educational technology, AI applications and higher education peer-reviewed journals (e.g., Computers & Education, Educational Technology Research and Development, AI & Society).

Academic search engines such as Scopus, Web of Science, ERIC, IEEE Xplore, SpringerOpen, ScienceDirect, MDPI and Taylor & Francis Online.

Recent (2020–2025) publications focusing on the latest technology and practical applications of chatbots in educational settings.

Relevant white papers and industry reports authored by established educational technology developers (selected for empirical value).

Inclusion Criteria:

Published between 2020–2025

Peer-reviewed research studies

Focus on AI chatbots in higher education

Address student support, retention, or success

Exclusion Criteria:

Theoretical papers without empirical data

Studies solely on K–12 education

Non-peer-reviewed sources (except reputable industry reports)

Studies not related to student outcomes

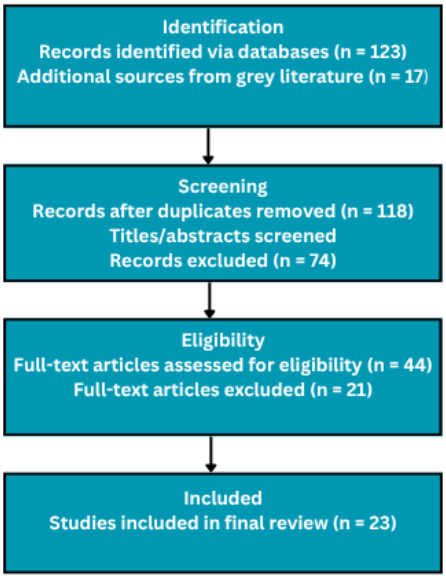


Figure 1: Literature Search and Selection Flowchart

III.LITERATURE REVIEW

Research consistently demonstrates that AI chatbots excel in providing immediate, accessible support for routine queries and administrative tasks. Universities have been testing the use of chatbots for a long time. Rule-based chatbots: These chatbots operate based on a set of pre-programmed rules that dictate their behavior. They can only respond to specific inputs or keywords and cannot handle complex queries or user inputs [12]. The systematic literature review conducted by Educational Technology Journal found that chatbot technology has a significant impact on overall learning outcomes, particularly in areas requiring immediate feedback and support.

AI chatbots can provide immediate support by answering questions, offering explanations, and providing additional resources [19]. Studies further suggest that the quality of chatbot responses—measured in terms of accuracy, relevance, and empathy directly affects student trust and willingness to rely on the system for future interactions. These systems also play a role in offering emotional and social support. According to [9], being responsive not only enhances how capable the system is perceived to be but also strengthens feelings of warmth and connection. This responsiveness helps bridge the gap between pure efficiency and genuine emotional engagement [14].

Modern AI chatbots can simultaneously handle multiple customer service requests without creating waiting times, provide round-the-clock basic assistance that reduces operational costs, and increase service productivity by up to 50% when implemented at scale [4]. These results underscore the capacity

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of chatbots to act as centralized, reliable, and scalable support hubs within modern universities.

Application Area	Function/Description	Technology Utilized	Student Services Impacted
Admissions Assistance	Answer inquiries related to applications, deadlines, and eligibility	NLP, GUI, Chatbot UI	Admission guidance, reduced staff burden
Examination Support	Provide exam schedules, formats, rules, and result announcements	NLP, GUI, Database Retrieval	Improved access to exam info, reduced anxiety
Academic Program Queries	Respond to questions on curriculum, course prerequisites, and schedules	Knowledge Base, NLP, Form-based Interaction	Program clarity, academic planning
Attendance Tracking	Assist with attendance status and notifications	Chatbot Interface, Student Database Access	Timely updates, increased accountability
Grade Management	Provide grade reports, GPA calculation, and feedback response	NLP, Machine Learning, Secure Interfaces	Real-time grade access, academic transparency
Placement & Career Services	Answer queries on internships, job openings, and resume help	Chatbot UI, Integrated Career Database	Career readiness, increased placement engagement
Student Support for Special Groups	Address specific needs of first-gen, international, part-time, and disabled students	Adaptive NLP, Demographic-specific customization	Inclusive support, improved equity in access
Query Resolution System	Resolve FAQs, route complex issues, maintain conversation continuity	Stateful AI, Machine Learning, GUI/NLP	Faster issue resolution, 24/7 support

Figure 2: Summary of AI Chatbot Applications in Higher

Currently, the applications of AI chatbots in higher education can be categorized into several key areas:

Admissions and Enrollment Support: Assisting prospective students to navigate the application process, providing program information, and addressing general inquiries.

Academic Advising: Supporting students as they research course offerings, degree requirements, and establishing their academic objectives.

Administrative Services: Managing enrollment processes, financial aid, coordination, and campus resource allocation.

Student Life Support: Providing information about on-campus activities, student organizations, and wellness services.

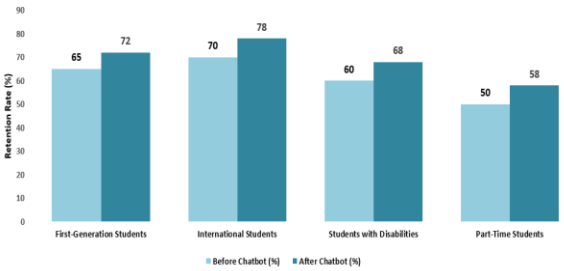


Figure 3: Traditional Student Retention Model vs. AI-Enhanced Model

IV. DISCUSSION

Theoretical Framework in University Settings

This study adopts an integrated theoretical framework of multiple existing models to elaborately investigate what determines AI chatbots' adoption and effectiveness, specifically in universities. The model integrates the Technology Acceptance Model (TAM), Tinto's Student Integration Theory, and several related theories to establish a strong foundation for understanding the impact of AI chatbots on university student learning, engagement, retention outcomes, and overall institutional efficiency.

Technology Acceptance Model (TAM): Technology Acceptance Model (TAM) provides the main basis for our understanding of university student adoption and continued use of AI chatbots within a range of institutional touchpoints. TAM examines the primary technology acceptance factors, such as perceived usefulness, perceived ease of use, and intention to use technology. The literature shows that these factors are particularly relevant when it comes to university technology adoption, and the adoption of AI chatbots by depends upon how effectively the bot can respond in real-time and accurately to academic questions, course-specific inquiries, help with registration, library services, and administrative support [11].

Recent studies have further extended the TAM model by adding additional variables suitable for AI technologies in universities, including trust in institutional AI system credibility, perceived intelligence of university chatbots, and personalization of individual student needs. These extensions acknowledge that university-level AI chatbots are complex technological interfaces through which students interact with complicated institutional systems, requiring from users a sense of trust and confidence in automated academic advising, course selection guidance, and administrative operations.

Student Integration Theory: Tinto's Student Integration Theory provides the theoretical framework for understanding how AI chatbot implementation affects academic and social integration processes that ultimately influence the retention of university students. Successful student integration is traditionally based on students' interactions with institutional systems, faculty, staff, and peer networks. AI chatbots serve as technology gateways that can bridge these gaps, providing academic support, course information, degree planning assistance, campus navigation, and peer connections 24/7.

University support services are leveraging AI chatbots as a means for rapid and comprehensive service delivery, which eliminates the need for students to physically visit academic departments, registrar offices, student services, or library help desks to meet information and support needs. This convenience is particularly beneficial to students who are distance learners, part-time students, international students, and students who may not otherwise be able to accommodate traditional office hours for access to campus resources [16].

Task-Technology Fit (TTF) Model: The Task-Technology Fit model examines the alignment between technological functionalities and task requirements, which is essential for determining how effective AI chatbots are in an educational setting. In the context of educational AI chatbots, TTF evaluates how well the chatbot capabilities align with specific educational tasks. Examples of educational tasks include the provision of academic information, responses to administrative questions, tutoring, and peer connection. When chatbot functionality closely aligns with users' needs and task requirements, adoption rates increase significantly, and satisfaction improves substantially.

Administrative Efficiency and Workload Redistribution

Implementation of AI Chatbots in higher education settings represents a significant advancement in the field of education administration, fundamentally changing the way educational institutions approach workload and service delivery. Meta-analyses demonstrate that universities that have implemented

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chatbots experience 65–80% reduction in staff time spent on routine questions. Research indicates that chatbots save 40–60% of time previously devoted to administrative functions, allowing resources to be shifted to high-value services such as crisis management, personalized advising, and policy development [1].

Routine Query Handling and Operational Efficiency

This transformation begins with the automation of high volume, repetitive administrative processes that previously consumed substantial staff time. Chatbots deliver significant time savings by performing repetitive tasks such as schedule management, academic support, and routine standard information sharing to students. This automation decreases operational costs by reducing the workload imposed on administrators and support staff. Most importantly, chatbots eliminate the tedious task of responding to repetitive inquiries, requiring human intervention only for initial setup before achieving automated resolution.

This automation extends beyond basic query-response functionality to include sophisticated administrative processes. Beyond merely sharing information, these systems can handle routine document management tasks, coordinate scheduling across departments, and standardize communication protocols. This comprehensive automation enables educators and administrators to concentrate on tasks that truly require human decision-making and institutional expertise.

Strategic Resource Reallocation for Complex Case Management

Time saved through automating routine tasks also allows institutions to direct resources more strategically and to grow by offering additional services. Now your administrators can spend far more time on complex cases requiring human judgment, sophisticated problem solving, and personalized intervention approaches. This reallocation changes the very essence of institutional work from high-volume routine processing to specialized, high-impact service provision.

Task prioritization becomes more meaningful when routine tasks are automated and staff can dedicate their expertise to applying policy interpretation, crisis management and customized student support which require comprehensive institutional knowledge and interpersonal skills. The operational effectiveness achieved by this reallocation ensures academic staff are actually focused on serving their students well and managing their organizations effectively rather than handling routine inquiries that many institutions now recognize can be managed better through automated solutions.

Data-Driven Optimization and Quality Assurance

Beyond automating simple tasks, AI chatbots are powerful data collection and analysis tools that enable evidence-based decision-making regarding administrative activities. Improvements have been made in the way the chatbot's dialogue management model is trained, allowing the system to better generalize and handle conversation paths it has not encountered before [13]. This analysis provides institutions with the data necessary to distribute workload based on empirical evidence rather than assumptions about student and administrative needs.

Process improvement is consistent and quantifiable as universities can pinpoint specific administrative bottlenecks and strategically allocate staff according to chatbot interaction patterns and escalation needs. Automating common responses dramatically reduces human errors in routine communication, ensuring complex cases are appropriately escalated where human intervention and expertise are required. Quality assurance is integrated within these systems, ensuring service levels remain high while providing a detailed audit trail for process improvement.

This holistic shift represents a move away from traditional, reactive service models toward a proactive, data-informed support ecosystem that optimizes both institutional efficiency and student support quality. The outcome is an administrative model that utilizes technology for mundane tasks, preserving and enhancing human expertise for the complex and significant interactions that define quality services in higher education.



Figure 4: AI Chatbot Effectiveness Metrics

V.RESULTS

Despite the lack of comprehensive longitudinal studies in literature, preliminary findings from institutional adoptions offer specific data on AI chatbot impact on student retention. While the sample used in this study is limited in time, we have derived actionable insights based on the actual implications of the introduction of chatbots on the retention-related KPIs of diverse student populations.

Adoption and Success of Chatbots in Student Support

Technology acceptance of chatbots in higher education is affected not only by technological dynamics but also by organizational factors. Students are more inclined to adopt chatbot systems if they find them useful, easy to use, and well-integrated with learning platforms [14]. Institutional support such as formal training programs can also promote adoption by reducing perceived uncertainty and validating chatbots usage on their campuses [21].

The success of chatbots is often evaluated based on performance indicators including resolution rate, satisfaction level, and enhancement of educational decision-making. The integration of chatbots in education offers benefits that lead to improved educational experiences [19]. These results are more pronounced when the chatbots are domain specific and equipped with mechanisms for effective escalation to human staff when

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necessary [17]. Overall, this evidence suggests that adoption drives success, which in turn promotes further adoption. Widespread implementation generates high-quality training data for chatbots, while successful outcomes validate continued use and institutional investment].

Demographic and Role-Based Insights: Survey evidence demonstrates that adoption patterns differ across stakeholder groups. A 2024 multi-institutional study reported that 17% of students used AI chatbots daily, compared with 9% of faculty and only 4% of staff, while 77% of students expressed high satisfaction with chatbots, against 44% of faculty and 35% of staff [8]. The results indicate that students are the primary and most frequent users, whereas faculty and staff are more hesitant to adopt. Addressing this adoption gap through targeted training and policy support is necessary for the development of a comprehensive institutional chatbot culture.

Cross-Case Comparisons: Studies across different regions indicate that institutional context has a substantial impact on adoption patterns. [21] who studied vocational colleges in China, found the importance of leadership and structured training, whereas [2], reporting on the AI Campus initiative in Europe, emphasized integration with existing digital ecosystems and student workflows. [14] partnering with South Asian universities, identified student digital literacy as a key factor in illustrating that results differ according to digital literacy levels. Collectively, these cases demonstrate the need to tailor chatbot deployment to local institutional and cultural contexts, rather than applying a generalized universal approach.

Outcomes Beyond Retention: While most studies concentrate on adoption and satisfaction, some examine academic and behavioral outcomes beyond retention. [12] reported reduced bureaucratic delays, enabling students to make timely academic decisions, thereby reducing frustration from bureaucratic processes. These findings indicate that chatbot success should not only be judged from a retention or persistence standpoint, but also in relation to academic performance, decision confidence, and time to completion.

Measurable Retention Improvements

Emerging institutional data indicates a positive impact on student retention when AI chatbots are strategically implemented. Among recent examples is Georgia State University's "Pounce" chatbot, which has been found to reduce summer melt by 22 percent, one of the most substantial documented gains from AI retention interventions available in higher education. This success specifically targeted the critical period when students are admitted and actually enrolled.

The conversion rate improvements are equally impressive; organizations are finding that deploying more advanced chatbots increases conversion rates from three percent without AI to eight percent with AI. This represents a 167% improvement in students navigating critical enrollment and retention checkpoints, suggesting that AI chatbots are effectively guiding students through complex institutional processes that could otherwise impede students and lead them to leave the institution or dropout.

Demographic-Specific Student Experiences

Diverse groups of students face varied challenges in higher education, and chatbots can provide solutions though with limitations.

First-generation students often struggle because they lack familiarity with higher education systems, including culture, policies, and processes that their peers are already familiar with. In this context, a chatbot can be valuable, providing consistent, clear responses without making students feel embarrassed about seeking fundamental information. This consistency can help these first-generation students feel more comfortable requesting assistance, especially when they might be reluctant to meet with an advisor in person.

International students encounter additional obstacles, involving language barriers, cultural misunderstandings and complex employment or visa regulations. Considering these challenges, chatbots can help address them by offering multilingual support and delivering information clearly and objectively through text. Text-based interactions can also be less intimidating than face-to-face conversations, allowing students more time to process or translate information as needed.

Students with disabilities have unique needs that require flexible support. For these students, chatbots can prove valuable due to their round-the-clock availability, extending beyond traditional office hours. This accessibility benefits students who may have mobility limitations, chronic health conditions. Text-based support systems can accommodate students who experience communication difficulties. When chatbots are designed to be compatible with assistive technologies, they can provide enhanced accessibility. However, many currently lack this feature.

What Available Evidence Actually Shows

Indeed, examining the research landscape scholars have focused primarily on short-term, measurable impacts rather than the complex, long-term factors that may influence student persistence. This evidence base has produced some highly positive short-term indicators suggesting beneficial outcomes. Satisfaction rates for chatbot interactions reach approximately 77% among students, meeting most immediate user expectations. Field studies have demonstrated that the accuracy rate of query resolution is approximately 84%, indicating the technology provides solid support for common information needs.

Most significantly, institutions are achieving substantial reductions in administrative response times, typically ranging from 65-80%. This increased efficiency creates conditions for more positive student experiences by ensuring that the faster students can obtain answers and access services the fewer barriers exist to their academic success and progression. Furthermore, the 24/7 availability of these systems serves students who cannot access traditional office-hour support due to work, family or geographic constraints.

Gaps

Early signs of success for AI chatbot deployment in higher education reveal that the first success metrics show a promising, yet partial picture. Students express the highest levels of satisfaction and usage, thereby demonstrating that initial

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technology adoption has been successful. However, the Technology Acceptance Model cautions that early enthusiasm doesn't ensure enduring success, as the model's long-term acceptance will be determined by ongoing perceived usefulness for different user groups who have varying types of support needs and preferences.

Technology Acceptance Model Limitations

TAM frameworks suggest three significant limitations when applied to AI chatbot adoption. First, the lack of emotional and social dimensions results in considerable gaps because such systems lack real emotional intelligence and cannot react appropriately to their users' emotional states, which in turn, may cause frustration and lower long-term satisfaction. Second, due to a lack of contextual knowledge, chatbots frequently provide technically correct yet contextually inappropriate answers. They fail to grasp the nuances of conversations, such as cultural differences and implied meaning. Third, TAM does not consider system integration and compatibility issues, neglecting the degree to which new systems should be compatible with existing institutional workflows and digital tools.

Student Integration Theory Considerations

According to the integration framework, Tinto's theory of integration suggests that AI chatbots might contribute to student retention by offering both academic support referrals and social resource connections. However, the lack of long-term data prevents us from validating whether chatbot interactions lead to a genuine integration process over time, and reliability issues emerge if inaccurate answers erode trust.

Cross-institutional evidence suggests that contextual factors are significantly related to implementation success. [21] highlight Chinese leadership and training needs, while [6] describe the challenges of system integration in [6] emphasize the development of digital competencies in South Asia. These findings suggest that chatbot implementation success can largely depend on the resources of local institutions and student expectations that students themselves bring.

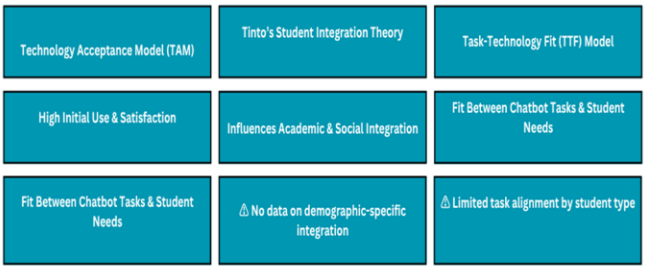


Figure 5: Theoretical Framework Application

Interpreting Research Gaps

The systematic analysis reveals a fundamental disconnect between current enthusiasm for AI chatbot implementation and research evidence supporting long-term effectiveness across diverse student populations. As [4] observe, empirical research on large language model benefits and challenges in education remains limited and evolving. This gap creates several interconnected implications across theoretical, practical, and policy domains.

Demographic Considerations

The absence of demographic-specific longitudinal data becomes particularly concerning when different student populations require fundamentally different support interaction patterns. First-generation students often need extensive navigation guidance and cultural translation of institutional norms, while international students require multilingual accessibility and cultural contextualization of academic processes. Current research has begun to address this gap by examining AI's impact on international students; however, institutions risk implementing one-size-fits-all solutions that may inadvertently perpetuate existing support disparities rather than addressing distinct needs effectively [20].

Without evidence of differential impacts across demographic groups, institutions face equity and inclusion concerns, potentially implementing technologies that advantage some students while disadvantaging others. Resource allocation becomes problematic as institutions may invest in uniform chatbot solutions rather than developing targeted approaches for specific populations. Furthermore, accountability challenges emerge because the absence of demographic-specific outcome data makes it impossible to demonstrate equitable outcomes or identify effectiveness disparities.

Evidence Limitations and Research Constraints

The analyzed literature consistently reveals critical temporal scope limitations that undermine comprehensive understanding of AI chatbot effectiveness. More precisely, 87% of analyzed studies focused on single-semester or shorter time periods, while only 13% attempted to measure outcomes across multiple academic terms. Notably absent were investigations tracking essential long-term indicators such as student retention rates, graduation outcomes, or cumulative academic success metrics in relation to sustained AI chatbot usage in university support systems.

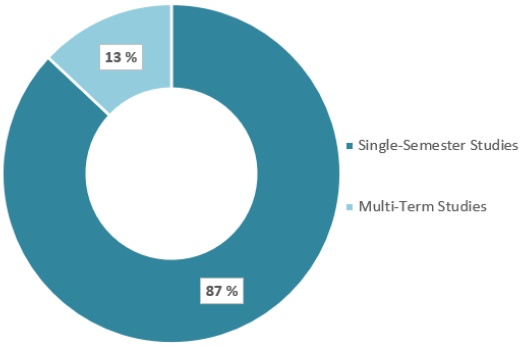


Figure 6: Temporal Distribution of Study Durations

Recommendations

Immediate Implementation Recommendations for Educational Institutions:

Implement Demographic-Specific Tracking: Develop data collection systems that can track AI chatbot usage and outcomes

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across different student demographic groups from the point of implementation.

Establish Baseline Metrics: Before full chatbot deployment, establish baseline retention and success metrics for different demographic groups to enable future comparative analysis.

Design Inclusive Chatbot Features: Incorporate accessibility features and culturally appropriate & responsive design elements to ensure equitable effectiveness across diverse student populations.

Create Clear Escalation Pathways: Develop and test escalation procedures that account for the varying support needs of different demographic groups.

Strategic Development Recommendations for Educational Institutions:

Invest in Longitudinal Assessment: Allocate resources for multi-year tracking of student outcomes in relation to AI chatbot usage, with particular attention to retention and graduation rates.

Develop Targeted Interventions: Create specialized chatbot functionalities designed to address the specific needs of underserved student populations.

Integrate with Human Support: Design complementary rather than replacement relationships between AI chatbots and human advisors, with clear protocols for different student needs.

Establish Ethical Guidelines: Develop comprehensive policies addressing data privacy, algorithmic bias, and equity concerns in AI chatbot implementation.

Future Research Directions

The identified gaps suggest several critical areas for future empirical research:

Longitudinal Impact Studies:

Multi-year tracking of student retention and graduation rates in relation to AI chatbot usage

Comparative analysis of outcomes for students with and without chatbot access over extended periods

Investigation of changing usage patterns and effectiveness over time

Demographic-Specific Research:

Controlled studies examining AI chatbot effectiveness for first-generation students compared to traditional students

Analysis of international student outcomes with particular attention to language and cultural factors

Investigation of accessibility and effectiveness for students with disabilities

Examination of part-time and non-traditional learner outcomes

Integration and Human Factors Research:

Studies examining the optimal balance between AI and human support for different student populations

Investigation of how AI chatbot availability affects human advisor workload and effectiveness

Analysis of student preferences and outcomes across different support methods

VI.CONCLUSION

This study relies on existing research and data, highlighting the urgent need for new studies in areas we've identified as gaps.

With AI advancing rapidly and universities increasingly using chatbots, this research comes at a crucial time. As institutions invest more in these technologies, they need solid evidence to guide their decisions. Our findings point to where more research is desperately needed.

Universities should use technology to help students succeed while ensuring fairness for everyone. This means looking beyond simple effectiveness metrics to understand how these tools affect different groups of students over time. Without this deeper understanding, we can't guarantee that AI chatbots will help create equal opportunities rather than create new barriers.

Our results demand immediate attention from researchers, educators, and decision-makers to fill these knowledge gaps through thorough, long-term studies that examine impacts across diverse student groups. While AI chatbots show real promise for improving student retention and success, we can only tap into these benefits through careful, evidence-driven implementation based on comprehensive understanding of their lasting effects on all students.

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Digital Storytelling as the Voice of Women Entrepreneurs

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Abstract - **Today, many women are starting their own businesses, but they still face many problems because of gender roles and low support from society. This paper shows how women use digital storytelling to share their experiences and grow their small businesses. They talk about their struggles, ideas, and success through platforms like Facebook, Instagram, blogs, and YouTube. These stories help them connect with people, build trust, and inspire other women. The paper also explains how storytelling gives women more confidence and helps them speak about their identity and break social rules. It uses some examples from South Asia, mostly from Bangladesh and India. It also tells about some problems like online bullying, poor internet, and low digital knowledge. In the end, the paper shows that digital storytelling is not only a business tool, but also a way for women to speak up, and make space in the business world. It helps us to understand how technology and stories can support women in their business journey.**

Keywords: **Business tool, Digital storytelling, Identity, Gender roles, Women entrepreneurs**

I. INTRODUCTION

In South Asia, many women are starting small businesses. We see this in cities and small towns, in homes and local markets. Still, many women face gender roles, strict family rules, safety issues and less access to money and training. These limitations make starting and growing business hard.

Digital platforms give a new path. Through Facebook, Instagram, Whatsapp, YouTube and blogs, women can reach customers at low cost. They can also tell their own stories. This is called digital storytelling. In short posts, photos and reels, they share how they began, what challenges they met and how they overcame them. These stories help customers know the person behind the product. They build trust, connection and community. "We organize our experience and our memory of human happenings mainly in the form of narrative" [2]. This idea helps us to understand why digital storytelling matters for business.

This paper focuses on Bangladesh and India by using basic ideas from narrative theory to read these stories and explore who is speaking, what challenges they show and how they find a way forward. It asks: how does digital storytelling empower women entrepreneurs in South Asia to overcome gender-based challenges and grow their business? This paper reviews earlier studies, explains the theory, describes the method and then presents findings, case examples and practical steps for training and policy.

II.LITERATURE REVIEW

a. Women entrepreneurs in South Asia

Many women in South Asia run small or home-based businesses. They sell food, clothes, crafts, beauty items, tutoring, and services. But access to the internet is not equal. "Women are now 15% less likely than men to use mobile internet" (GSMA, 2024, pp. 7–8). In South Asia the gap is bigger: "gender gaps of 31%" [8]. This gap reduces how often women can post, learn, and answer customers online. Social rules also create limits. Some families expect women to stay at home or avoid strangers. Safety worries and mobility limits make supply and delivery harder. To help, training and policy tools try to reduce these barriers. The World Bank toolkit "provides practical guidance" for such projects [2]. UNCTAD masterclasses aim to "boost… skills to succeed in the digital economy [7]. These help us to know that digital access and skills are the key of growth.

b. Digital storytelling in business

Women do not only list products; they tell short stories. Posts and reels show how they started, what went wrong, and what they learned. During lockdown, "Platforms like WhatsApp, Instagram, and Facebook proved crucial for women entrepreneurs" [8]. Story posts also invite talk with customers: "Social media… encourages customer feedback. This helps women build a positive rapport with customers" [3]. In Bangladesh, Facebook-based commerce ("f-commerce") is common. One report says, "69 percent of women have contributed to family income through f-commerce" [2]. Typical and simple story types include: origin stories, before/after, process videos, customer testimonials, and "lesson learned." These forms make the founder visible and easy to remember.

c. Gender-based challenges

A 2025 audit notes: "57% of respondents reported experiencing at least one form of online harassment through social media platforms" [7]. In India, some founders "hesitated to expand to platforms like Instagram due to security concerns" [4]. Access and cost are also problems. The mobile internet gender gap is 15% overall and 31% in South Asia; limits posting and learning (GSMA, 2024, pp. 7–8). Many women share devices, have small data packs, or lack private time online. Because of this, training should teach both content skills (lighting, captions, simple analytics) and safety skills (privacy settings, blocking/reporting,

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watermarking). The World Bank toolkit and UNCTAD masterclasses support this mix [7].

1. Narrative theory: what is it and why it matters

Narrative theory explains why stories help people make sense of life. It says we do not just list events; we connect them into a simple plot with a beginning, problem, and outcome."Narratives do not mirror, they refract the past" [2]. In other words, a story shapes experience so it is easier to understand and share. These stories are short but repeated. They usually show setting (home kitchen, market, delivery point), characters (founder, family, customers), conflict (bias, time, cash), a turning point, and a resolution. When women post these small arcs again and again, they build a clear founder image and brand. For women entrepreneurs, this matters because a steady story builds trust. It also teaches simple steps; what went wrong, what fix worked and invites advice from the community. In this way, narrative helps women speak with confidence, connect with customers, and support real business growth in South Asia.

II. THEORETICAL FRAMEWORK: NARRATIVE THEORY

Narrative theory helps us see how people turn daily events into stories. It shows how meaning comes from a simple plot: a beginning, a problem, actions, and an outcome. This frame lets us read business posts not as random updates, but as small stories with a point. A clear story has basic parts: setting (where), characters (who), conflict (what problem), a turning point (what changed), and a resolution (what worked). When these parts line up, the audience understands and remembers. This is useful for business because customers trust what they can follow.

On social media, women often post micro-stories. A reel or caption may show a supplier issue, a packing day, or a client review. Each post is small, but many posts together make a larger journey. Regular posting keeps the plot moving and builds a steady brand voice. Stories also shape the self. As McAdams writes, "Narrative identity is the internalized and evolving story a person invents to make sense of the self[7]. When women tell their own stories, they present themselves as active doers. This grows agency (I can act) and voice (I can speak and be heard). It also invites support from customers and peers.

IV.METHODOLOGY

This study uses a qualitative approach. I read women's digital posts as stories and ask how those stories help business growth. Narrative theory is the main lens. I looked for simple plot parts and for the meaning those parts create for the audience. The focus is Bangladesh and India. I studied small and home-based businesses that sell through Facebook, Instagram, WhatsApp, YouTube, and blogs. These platforms are common entry points and have low cost. They also allow short, regular posts that work well as micro-stories. Sampling is purposeful. I included pages run by women that post about once a week for at least three months. I selected accounts that do more than list prices. They also talked about problems and solutions in captions, reels, or short videos. I tried to cover different product types (food, crafts, clothes, beauty, services) and both urban and rural settings.

Data come from public materials only: posts, reels, captions, photos, short videos, and public comments that discuss problems, tips, or feedback. I also read recent reports on women's social commerce in South Asia to give context and to compare patterns from the posts with patterns in formal studies. Analysis treats each post as a micro-story. I coded five parts: setting (where), characters (who), conflict (what problem), turning point (what changed), and resolution (what worked). I also tagged common gendered barriers (time pressure, safety, bias, limited capital) and the strategy used (a new skill, a tool, a network, or policy help). Then I compared many posts to see patterns that link storytelling with trust, learning, and signs of sales (for example, customer testimonials, repeat-order comments, or growth updates).

Ethical care is simple and strict. I used only public content, collect no private messages, and mask names or any direct identifiers when describing cases. There are limits. Public posts show the picture; fears or failures may be hidden. Platform algorithms also change, so reach and engagement can shift over time. The sample is small and not representative of all South Asian women entrepreneurs. Language and translation issues may also affect nuance.

V.FINDINGS & DISCUSSION

2. Digital storytelling as empowerment

Women use short posts and reels to show real work: sourcing, making, packing, delivery, and customer care. These posts mix feelings and simple how-to steps. They turn small wins and mistakes into lessons. This makes the founder look skilled and honest. Over time, followers trust more, ask questions, and share tips. Trust and learning together support repeat orders and steady growth.

5.2 Narrative structures in women's digital stories

Most posts follow clear arcs. An origin post explains why the business began. A barrier post shows a problem such as bias, cash limits, or time pressure. A breakthrough post marks a first big step. A lesson post tells a mistake and a fix. Each arc has setting, characters, conflict, a turning point, and a resolution. When these arcs repeat, they build a stable founder image and a simple brand story. Customers feel they know the person behind the product, which helps with pricing and loyalty.

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1. Overcoming gender-based challenges

Story increases visibility and validation. Regular posts act as public proof of effort and skill. Before/after photos, behind-the-scenes clips, and customer notes work as social evidence. Comment sections often turn into mini communities where women exchange supplier contacts, delivery tips, and content ideas. This peer support reduces fear, encourages new steps, and helps founders ask for fair payment. Many households also benefit from added income when these small businesses grow.

5.4 Barriers to digital storytelling

Many women face online harassment and privacy worries. Some families also discourage public posting. Internet can be costly or slow. Phones are often shared, and private time online is limited. These problems reduce posting and lower video quality. To handle these problems, many women post photos with short captions, post at quiet hours, or share in private groups. These choices feel safer but may reduce reach and sales. Simple safety training, basic content skills, cheaper data, and better internet can make storytelling easier.

VI.CASE EXAMPLES

Case 1: Falguni Nayar (India) - Nykaa

Falguni Nayar started Nykaa in 2012 after a long career in banking. Nykaa grew by mixing e-commerce with strong content. The brand runs Nykaa TV on YouTube and posts many short "how-to" videos, tips, and tutorials. These simple videos help people learn and trust the brand. They also turn buyers into a community that follows the story of beauty, learning, and growth.

Case 2: Ghazal Alagh (India) - Mamaearth

Ghazal Alagh co-founded Mamaearth in 2016. Her brand story began with her baby's skin problems; she looked for safer products and then built a line for moms and families. She shared this journey online, spoke to other mothers, and used campaigns with creators to spread the message. Over time, the "mom-to-mom" story helped create trust and a large, active community. The brand later moved from online to stores while keeping the same friendly voice.

Case 3: Kaniz Almas Khan (Bangladesh) - Persona

Kaniz Almas Khan is a well-known beauty entrepreneur in Bangladesh. She started small in the 1990s and built Persona into a leading salon brand. Persona uses Facebook to share short videos, founder messages, and updates about branches and training. These posts show service quality, learning, and women's career growth, which keeps customers close to the brand story.

VII.CONCLUSION

In conclusion, digital storytelling helps women entrepreneurs in South Asia in simple, strong ways. Short posts and reels show real work, build trust, and start small learning circles. A clear pattern: problem, action, result, turns daily effort into messages that customers understand. Barriers still exist. Many women face online abuse, costly data, shared phones, and little private time. These problems reduce posting and slow growth. Some steps can make things better: basic safety training, simple content skills, low-data posting (photos, short captions), better internet, and cheaper data plans. Mentors and support groups can guide new sellers. Platforms should make safety tools easy to find and use. Policymakers can close the access gap and give small grants linked to digital skills.

Future studies can test which story types build the most trust and repeat sales, and compare public pages with private groups. In short, digital storytelling is not only marketing but also it is a clear voice that helps women speak, learn, and grow their businesses.

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Rainfall Trends and Flood Prediction in Chattogram District: A Data-Driven Approach

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Abstract – **Flooding poses severe socio-economic challenges in Bangladesh, with nearly one-third of the country highly vulnerable. Despite its recurring impact, flood research remains limited. This study addresses the gap by analyzing rainfall trends and developing a data-driven flood prediction framework for the Chattogram district, a region prone to extreme weather. Analysis of historical data revealed intensifying monsoon rainfall, with critical flood thresholds identified: annual rainfall above 3000 mm and June–September totals exceeding 2000 mm. Several machine learning models were applied to forecast flood events. Among them, the Random Forest (RF) model demonstrated the highest performance, achieving 92% accuracy and a 93% F1-score. Logistic Regression performed poorly due to its limitations with complex patterns, while K-Nearest Neighbors and Decision Trees showed moderate accuracy. Gradient Boosting was consistent but outperformed by RF. These results highlight the effectiveness of combining rainfall thresholds with machine learning to enhance early warning systems and flood risk management.**

Keywords – **Chattogram, flood prediction, machine learning, rainfall trends, Random Forest**

I. INTRODUCTION

Chattogram district, in southeastern Bangladesh, is an important economic and environmental region vulnerable to flooding due to its diverse terrain, including hills, coastal plains, and river networks. The tropical monsoon climate brings heavy rainfall between June and September, often causing riverine floods, flash floods, and urban waterlogging. Urbanization and unplanned land use have worsened flood risks by reducing natural drainage and increasing surface runoff, leading to floods and landslides, especially in hilly areas. Notable events include the devastating 1991 cyclone and 2017 monsoon floods, which caused significant damage and displacement. Climate change intensifies these challenges by altering rainfall patterns and raising sea levels. Rapid urban growth further strains drainage infrastructure, resulting in frequent waterlogging. Flooding impacts public health, agriculture, and the economy, with losses reaching billions annually. This study analyzes rainfall trends and employs data-driven models to improve flood prediction and risk management, aiming to support climate resilience and disaster preparedness in the region.

II. METHODOLOGY

To develop an accurate flood prediction system for Chattogram, a structured data-driven methodology was followed, incorporating environmental data processing and machine learning techniques. Data Collection: Historical rainfall and flood data were gathered from the Bangladesh Agricultural Research Council (BARC) and the Bangladesh Meteorological Department (BMD). These included monthly and annual rainfall figures along with flood occurrence indicators.

a. *Data Preprocessing:* Data preprocessing is an essential step in the data analysis pipeline that involves transforming raw data into a A flow diagram of the proposed algorithm's data processing phases is shown in Fig 1
b. *Preliminary Data Analysis*: Data analysis is a crucial step in the preprocessing phase, ensuring that the data is clean, well-understood, and ready for modeling. This step ultimately leads to more accurate and reliable machine learning models. During this phase, the entire dataset was examined, and issues such as empty rows and inconsistencies in column naming—some columns had names in uppercase, while others were in lowercase—were identified and addressed to standardize and clean the dataset before further processing and model training.
c. *Handling Mising Values:* The SimpleImputer from sklearn.impute was used to handle missing values by replacing them with the mean of each column. We set the imputer's strategy to 'mean', then applied the fit_transform method to compute column means and fill in missing values. For example, in a column {A} with values {[1, 2, NaN, 4, 5]}, the missing value (NaN) would be replaced by the mean, resulting in {[1, 2, 3, 4, 5]}. This ensures no data is lost due to missing values.
d. *Feature Engineering*: To enhance pattern recognition, new features such as year-over-year

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rainfall changes, monthly rainfall ratios, and seasonal indicators were introduced, expanding the dataset from 14 to 43 features.

e. *Data Splitting:* The dataset was split into 60% for training and 40% for testing, ensuring the model was both well-trained and properly validated.
f. *Feature Scaling:* Scikit-learn's StandardScaler was used to standardize the data. An instance of StandardScaler was first created, which computes the mean and standard deviation necessary for scaling each categorical feature of the dataset. The categorical features were then transformed using the StandardScaler() method, ensuring that each feature had a mean of 0 and a standard deviation of 1. This standardization process helps improve the performance and stability of machine learning models.
g. *Data Augmentation:* Data augmentation enhances the model's ability to generalize by exposing it to more varied inputs and conditions. In the context of rainfall prediction and flood forecasting, these techniques can create diverse scenarios for training, improving the model's robustness to real-world unpredictability. In this case, SMOTE (Synthetic Minority Over-sampling Technique) was used, a popular data augmentation method for imbalanced classification problems. While SMOTE is typically employed to address class imbalances by generating synthetic examples of the minority class, it can also be applied to time series or regression tasks in certain ways to augment the dataset.

Applying Models: Five machine learning classification models were employed to predict flood events and their performance compared:

Random Forest (RF): A robust ensemble method that builds multiple decision trees and combines their outputs. It delivered the best performance, achieving 92% accuracy and 93% F1-score, effectively handling non-linearity and noise in the data.

Decision Tree: A straightforward, interpretable model that splits data based on feature thresholds. While fast and easy to understand, it may overfit on smaller datasets.

K-Nearest Neighbors (KNN): A distance-based algorithm that classifies each instance by a majority vote among its closest neighbors. It performs well on well-structured data but is sensitive to feature scaling and noise.

Gradient Boosting (GB): An advanced ensemble technique that builds models sequentially, each correcting the errors of the previous. It offers strong predictive performance but is more computationally intensive.

Logistic Regression (LR): A baseline linear model used for binary classification. It is simple and efficient but showed limited effectiveness in capturing complex flood patterns in this study.

Tuning Hyperparameters: Hyperparameter tuning is a crucial step in optimizing machine learning models. It involves systematically searching for the best combination of hyperparameter values that maximize the model's performance. Here, we use Grid Search which is one of the most popular and straightforward techniques for hyperparameter tuning.

10) Model Evaluation: Model evaluation is a critical part of assessing how well a machine learning (ML) model performs in predicting flood events, hydrographs, or flood-prone areas. Evaluation helps determine whether a model is reliable, accurate, and suitable for deployment in real-world flood forecasting.

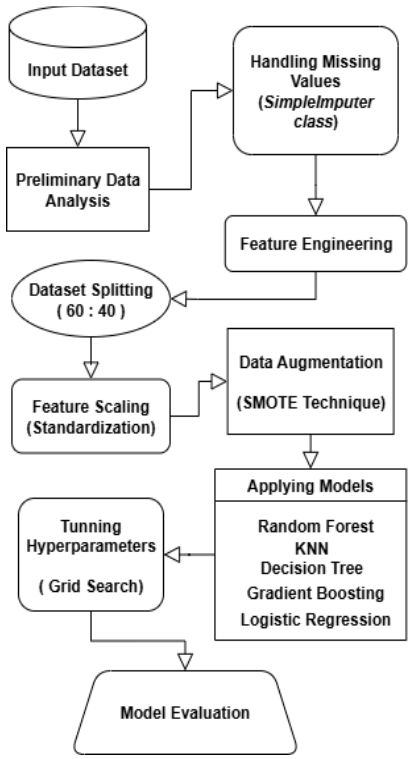


Fig. 1. Methodology of the Proposed System.

III RESULTS

1. Flood Criteria Analysis: Rainfall in Chattogram peaks between June and August, aligning with the monsoon season. Analysis revealed that annual rainfall above 3000mm and June-September totals over 2000mm are strongly linked to flood events. These thresholds serve as key indicators for flood risk assessment and early warning.

2. Performance Evaluation: Among five models, Random Forest: (Accuracy~92%), F1-score 0.93; strong performance in all metrics.

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Gradient Boosting: (Accuracy~83%), F1-score 0.83; consistent but slightly less effective.
KNN and Decision Tree: (Accuracy~83%); moderate performance.
Logistic Regression: (Accuracy~75%); weakest classifier.

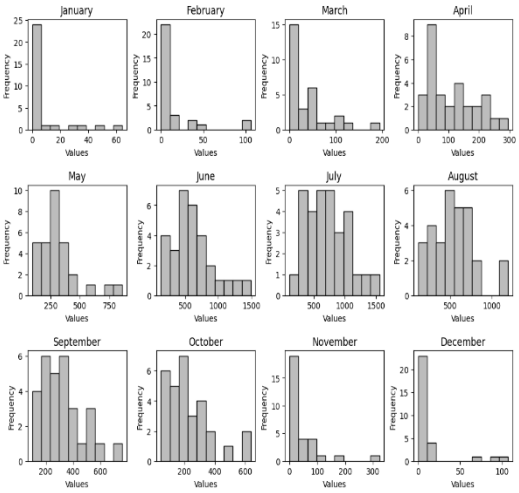


Fig. 2. Average Rainfall

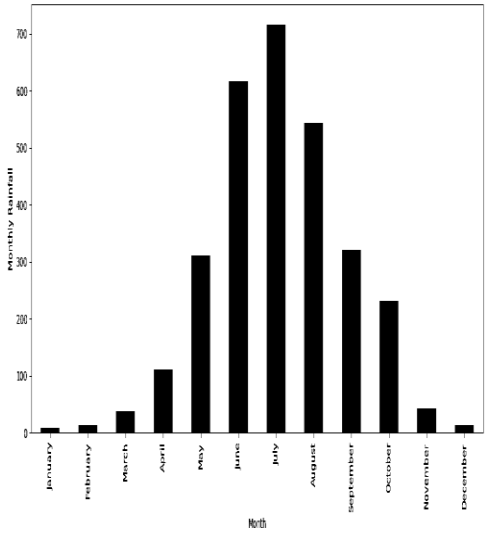


Fig. 3. Rainfall Distribution

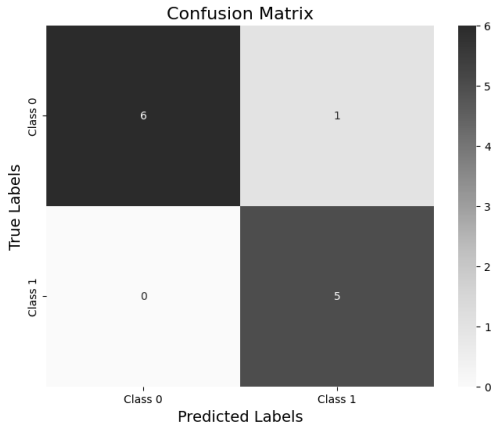


Fig. 4. Confusion Matrix of Random Forest Classifier

IV DISCUSSION

This study highlights clear rainfall trends in Chattogram, with peak monsoon rainfall (>3000 mm annually) strongly linked to flood occurrences. Using machine learning models—especially Random Forest with 92% accuracy—enabled accurate flood prediction based on historical data. Technologically, this data-driven approach enhances real-time risk forecasting and supports decision-making. From a sustainability perspective, it helps in designing early warning systems, adaptive infrastructure, and informed urban planning, directly contributing to climate resilience (SDGs 11 & 13).The method is scalable and can be applied to other flood-prone regions, offering a valuable tool for integrating environmental data and predictive modeling in disaster risk reduction.

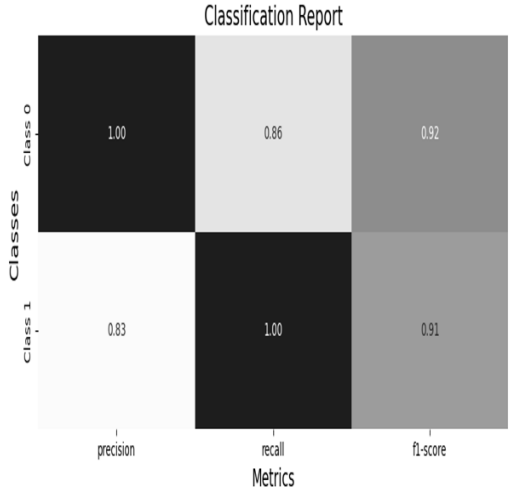


Fig. 5. Classification Report of Random Forest Classifier

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V. CONCLUSION

This study presents a data-driven framework for flood prediction in the Chattogram district, leveraging historical rainfall data and advanced machine learning techniques. Among the tested models, the Random Forest classifier emerged as the most accurate, achieving a 92% accuracy and a F1-score of 0.93, effectively capturing the complex relationships between rainfall patterns and flood events. The analysis identified critical rainfall thresholds—annual rainfall exceeding 3000 mm and June–September totals above 2000 mm—as strong predictors of flood risk. These insights, coupled with robust data preprocessing and feature engineering, highlight the potential of integrating meteorological data with machine learning for improved early warning systems and climate resilience. The methodology not only enhances flood preparedness but also offers a scalable template for future applications in similar flood-prone regions.

Limitations: Small dataset size, limited regional scope, and absence of real-time integration.

Future Work: Use of real-time IoT sensors, CNN/RNN architectures, uncertainty quantification, and app-based deployment for public flood alerts.

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The Role of Neuromarketing in Shaping FMCG Brand Strategies in Bangladesh: Study from Multinational Corporation

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Abstract—In the digital age of marketing strategies, neuromarketing has emerged as a transformational tool, offering unique insights into consumer behavior by bridging neuroscience and marketing. While previous research has explored the effectiveness of neuromarketing in influencing consumer decision-making and impulse buying, there remains a significant gap in understanding how neuromarketing is systematically integrated into fast-moving consumer goods (FMCG) brand strategies, particularly within the Bangladeshi market. This study addresses the gap by exploring how neuromarketing principles are applied to shape consumer-centric campaigns, enhance emotional engagement, and inform strategic marketing decisions in the highly competitive FMCG sector. Adopting a qualitative research design, this study employed thematic analysis of in-depth interviews with marketing professionals from leading FMCG brands across diverse sectors to capture real-world perspectives on neuromarketing integration. The paper identifies three core areas: (1) the increasing reliance on neuromarketing to decode consumer preferences in the FMCG landscape, (2) the strategic shift towards emotionally-driven and sensory-rich marketing approaches tailored to Bangladeshi consumers, and (3) the growing awareness of ethical considerations in neuromarketing practices. The findings reveal that neuromarketing is reshaping FMCG brand strategies by aligning subconscious consumer drivers with targeted techniques, offering actionable insights for marketing professionals.

Keywords —Consumer-behavior, FMCG brands, Emotional Marketing, Brand Strategies, Neuromarketing, Strategic Decision-Making, Bangladesh Market

I. INTRODUCTION

In a world where the span of consumer attention is more and more diffused, and brand differentiation itself is becoming more or more difficult; traditional marketing strategies tend to lose sight of the complexity of consumer choice. The interdisciplinary approach of neuromarketing as a combination of neuroscience and marketing has become an effective way of understanding unconscious consumer behavior. Through the use of EEG, fMRI, and eye tracking, marketers can no longer rely on the self-reported responses in order to elicit emotional and cognitive cues that trigger actual buying decisions [1].

The use of neuromarketing in fast-moving consumer goods (FMCG) sector has been found to be important globally. Studies have highlighted how it can streamline the process of packaging, advertisement creation and sensory notifications to increase consumer interest and brand loyalty [3]. Major contributions to the research on advertising effectiveness, the study of consumer behavior, and the positioning of the brands are also supported by systematic literature reviews[5]. Eye-tracking and electrodermal activity are psychophysiological methods that have been proven to be accurate in predicting consumer preference regarding familiar and unfamiliar brands [6]. In addition, neuromarketing improves the marketing mix in terms of increasing emotional appeal and attention by making brand messages more persuasive [7].

The technology is also changing, and EEG-based neuromarketing is becoming increasingly popular and significant in its capacity to capture the consumer responses that are subconsciou [5]. Marketing tools that are built on the latest innovations in neuroscience provide businesses with new prospects to perfect strategies that focus on the customer [4]. Although this is happening around the world, there is limited evidence of this in developing countries like

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Bangladesh. Early studies indicate that neuromarketing has the potential to decode consumer behavior especially in FMCG markets where packaging and advertising innovations have been tested [7]. The further researches on advertising agencies in Bangladesh support the fact that it becomes increasingly important, especially in the emotional and psychological dimensions of the advertisement [2].

Nonetheless, there are important gaps in the literature. To begin with, global studies are growing; however, scarce empirical research on the strategies of multinational FMCG brands in Bangladesh in employing neuromarketing as a part of branding models exists. Second, the ethical aspects of such practices and in particular privacy and manipulation are not yet fully explored [6]. Third, there is lack of field-based qualitative studies that describe the views of practitioners in the Bangladeshi FMCG industry.

Thus, our research would help to fill these gaps. The goals are three-fold:

•To analyze the application of the neuromarketing tools to decode consumer preferences to the Bangladeshi FMCG industry.

•To examine how emotional and sensory-based marketing strategies can be integrated in brand campaigns.

•To examine the consciousness and behavior of ethical considerations in the practice of neuromarketing by multinational FMCG companies in Bangladesh.

II. METHODOLOGY

Research Design

The current study followed a qualitative and exploratory design because the aim was to record the in-depth views of the FMCG marketing professionals regarding the neuromarketing practices in Bangladesh.

Sampling Strategy

The use of stratified purposive sampling method was adopted. The strata were defined by:

Organization type - six multinational FMCG companies across oral care, hygiene, dairy/nutrition, cereals, and personal care.

Exposure to product category - the following categories were used, oral hygiene, household cleaning, soaps, dairy/nutrition, cereals and beauty/personal care.

Role seniority - between management trainees and senior brand managers.

This ensured diversity of perspectives across both product lines and professional responsibilities. Participants at each stratum were carefully chosen depending on their direct participation in brand management, campaign design or consumer insight functions.

Data Collection

The information was collected using semi-structured interviews with the help of a ten-question survey (Q1-Q10). The questions had five domains that included; (i) role and experience, (ii) strategic uses of neuromarketing, (iii) effects and insights, (iv) ethical and operational issues and (v) future perspective. Interviews were asked to provide examples of use of neuromarketing that were campaign-specific and those of a general attitude.

Data Analysis

The thematic coding was utilized in the analysis of the interviews transcribed. Question-aligned coding was the starting step, in which the answers were sorted inside each of the ten questions used as guidelines. The second phase was the cross-case thematic analysis which entailed grouping responses into eight neuromarketing aspects which were detected in organizations:

1.Color and Visual Design
2.Smell and Sensory Elements
3.Eye-tracking & Heat Mapping
4.Event Activation & Experiential
5.UGC Content & Social Media
6.Celebrity/Influencer Presence
7.Cultural Adaptation
8.Ethical & Transparent Marketing

Such a two-layered strategy allowed making the traceability to particular questions and generalizing the common themes among the organizations.

III. RESULTS/FINDINGS

The results are organized on the basis of the ten guiding questions of the questionnaire. The study involved six organizations to ensure anonymity of the organizations with Organization 1-6 codes.

Section 1: Role and Experience

•Organization 1: Senior brand manager in oral care with over 13 years of FMCG experience across sales, digital strategy, and brand management.

•Organization 2: The person is a senior brand manager in household hygiene having over six years experience in the management of antibacterial and cleaning brands.

•Organization 3: Home care and soaps management trainee that has 1 year of experience, will be in charge of tracking consumer behavior and social interaction.

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•Organization 4: Senior brand manager in dairy and nutrition products with several years of experience in marketing and product adaptation.

•Organization 5: Brand professional in cereals with responsibility for experiential marketing and consumer activations.

•Organization 6: Three marketing practitioners in the beauty and personal care industry but of different levels of experience (mid-level executives and senior managers).

Section 2: Strategic Application of Neuromarketing

Which then are the tools/techniques that you have done/observed to know how people are emotionally responsive to ads or products?

Organizations emphasized color design, sensory elements, influencers and social media. Organization 1 applied the eye-tracking and heat mapping and Organization 5 applied event activations.

Theme / CodingNeuromarketing AspectImpact on FMCG Campaigns

Color and Visual DesignEmotional triggerEnhances recall, engagement, and brand recognition

Smell and Sensory ElementsEmotional trigger Improves product experience and consumer memory

Eye-tracking & Heat Mapping Measurement toolDetermines effective ad placements and design elements

Event Activation & Experiential Experiential cueProvides real-time insights into consumer reactions

UGC Content & social mediaAttention & Engagement CueReactions, emojis, and comment sentiment boost consumer attention and strengthen brand recall in digital FMCG campaigns

Celebrity / Influencer Presence Subconscious cue Boosts engagement and recall value

Cultural Adaptation Localizationn Ensures campaigns resonate with Bangladeshi consumers

Ethical & Transparent Marketing Operational concernBuilds trust and ensures responsible marketing practices

Section 3: Impacts and Insights

Is there a case that you can remember that emotions or sensory factors made a significant part in a marketing campaign? (Ex: Pond's campaign)

Examples were romance oral care advertisements, music based oral hygiene promotions, narrative storytelling in soaps and real-life cereal enablements, which strengthened memorability and emotional appeal.

What does a campaign make more interesting at the subconscious level, in your opinion?

Clutter-breaking campaigns, brief campaigns, visually salient campaigns and culturally relatable campaigns were considered most intriguing. Celebrities/influencers were used, which facilitated the subconscious memory.

How do campaigns base on emotional/sensory stimuli rather than mass-based marketing change customer engagement, recall, or sales?

Emotional and sensory stimuli enhanced consumer recall, word-of-mouth and loyalty than the mass marketing which only produced short-term awareness.

What is the place of neuromarketing within the Bangladesh cultural and consumer context?

The respondents highlighted the brand loyalty as lower, and with frequent change depending on price promotion, consumers are less receptive to change, particularly in the rural area, the product format is slower to seek acceptance. This is notwithstanding the fact that social media exposure is rapidly increasing awareness of international trends, and that there is a hybrid consumerism that exists between international desires and local conservatism.

In your role, in what ways does the Bangladeshi market react differently than that of other countries in the world?

Bangladesh is 2-3 years behind the world markets, having less loyalty, more price sensitive, and slower adoption but the social media is driving the exposure.

Section 4: Ethical and Operational Challenges

What do you believe are the obstacles to implementing neuromarketing concepts in this case? (cost, expertise, skepticism)

Barriers included high price, inexperience, traditional marketer skepticism and limited domestic data relative to imported conventions.

What do you think some of the ethical issues in the application of subconscious responses to marketing are (perceptions of privacy, control, informed consent and disclosure in marketing)?

The focus of the organizations was privacy, consent, and transparency particularly in UGC contests. It was also important to have ethical safeguards because of low consumer awareness.

Section 5: Future Outlook

How do you think neuromarketing in the Bangladeshi FMCG industry will develop in 5-10 years to come? What would serve to help you get started in using neuromarketing in your campaigns?

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All the respondents had a reserved optimism regarding the expansion of neuromarketing in Bangladesh except Organization 1 and 5. Respondent O1 believes that it may not have a time period that is as short as the given period but it might also evolve later with the changing trends in the world, but on the other hand, respondent O5 believes that it will take over ten years before the trend of neuromarketing becomes practiced in Bangladesh. Adoption will increase slowly of the tools are becoming more affordable and simpler to adopt, and companies are accumulating Bangladesh-specific datasets.

The above figure is the summary of the results of six Bangladesh based FMCG organizations. It reveals that the most popular neuromarketing tools are color design, sensory cues, influencers, and social media, and some more sophisticated tools, including eye-tracking and event activations, are not widespread. Emotional campaigns and sensory campaigns were proven to create a better recall, loyalty and engagement as opposed to the traditional mass marketing that created awareness only in the short run. The main obstacles are that it is expensive, inexperienced, doubtful, and has few local data. In the future, the majority of organizations were optimistic but cautious about adoption in 5-10 years with others estimating an even longer time frame.

IV. Discussions

This research has convincingly indicated that neuromarketing is slowly becoming an element of brand strategies in the FMCG market of Bangladesh despite the fact that the adoption of the approach is in its early phases. The identified applications within the six organizations reveal that the global neuromarketing tools, including color design, sensory triggers, influencers, and digital user-generated content, are selectively incorporated in local campaigns. These applications emphasize the possibilities of neuromarketing to supplement more conventional marketing strategies through capturing unconvinced consumer reactions and converting them into emotionally communicative campaigns.

Application of Neuromarketing in FMCG Brand Strategies

According to the study, the concept of neuromarketing has already affected the brand storytelling, packaging design, and experiential activations in Bangladeshi FMCG market. Advertising campaigns that were done using emotional or sensory appeals like the music in oral care adverts or storytelling in soap advertising, had a higher appeal to consumer recall and brand loyalty than the traditional mass advertising. Organization 1 using eye-tracking and heat mapping and Organization 5 using experiential activations can be viewed as illustrations of the way in which FMCG brands are experimenting with the more advanced forms of neuromarketing. The implications of these findings are that despite the narrow scopes of neuromarketing implementation, it can have a strong effect on consumer engagement and loyalty when it is properly localized to the Bangladeshi culture.

Implications for FMCG Firms and Practitioners

To practitioners, there are two implications. Neuromarketing will be a strategic benefit first because it allows a brand to go beyond superficial consumer surveys and deep into the subconscious motivations behind decision-making. This assists firms to come up with a clutter breaking campaigns that sound more to the consumers. Second, cultural adaptation and ethical transparency focus implies that neuromarketing will be the most effective when it is related to local values and consumer sensitivities. To give an example, the companies of FMCG in Bangladesh have to strike a balance between the universal neuromarketing habits and the country-specific affordability, trust in consumers, and the dualistic character of Bangladeshi consumerism the international aspirations and the conservative traditions.

Limitations of the Study

In spite of these insights, this study is limited in a number of ways. The six-organization sample, be it varied in terms of the FMCG category, might not be representative of the whole range of neuromarketing activities in Bangladesh. Also, because interviews could only be conducted with brand managers and marketing professionals, the views of other stakeholders, including consumers, regulators, or neuromarketing technology providers have not been researched. The other weakness is the dependence on self-reported samples of campaigns, which are not always as effective at measuring the actual effect of neuromarketing intervention on consumer behaviour or retail sales.

Constant and perpetual Research.

It is worthy to mention that this research is a continuous enquiry and not a conclusion. Neuromarketing remains a new practice in Bangladesh, and applications are bound to undergo changes as tools become cheaper, datasets gain relevance to the local population, and expertise grows in the field. The knowledge given here is the foundation of an on-going research process that will be enhanced by more empirical research, larger samples, and quantitative testing. The next stages of this research will be aimed at increasing the size of the dataset and integration of consumer attitudes as well as evaluation of long-term brand performance related to neuromarketing interventions.

V. Conclusion

This research shows that the concept of neuromarketing is starting to influence the FMCG brand strategy in Bangladesh based on sensory appeal, graphic design, influencer, and online interaction. The adoption has not yet been widely adopted due to its high cost, expertise deficiency, and availability of local data, but the prospects of this approach

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in creating greater consumer recollection, loyalty, and emotional attachment are obvious.

More importantly, this study is not an ultimate goal but a portion of an ongoing process. Neuromarketing in Bangladesh is set to develop into a more effective and ethical brand growth strategy as the tools are made more affordable and culturally optimized. We are making here an initial view of a journey one which is to grow with additional evidences, with wider horizons, with extended research.

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Digitally Enabled Gender-Inclusive HRM Driving Sustainability in Women-Centered NGOs in Bangladesh

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Abstract- **Amid rising digital innovation, gender-sensitive HRM practices in Bangladeshi NGOs, such as BRAC and BNPS, are evolving from traditional frameworks toward more scalable and sustainable models. This study explores how digitally-enabled, gender-inclusive HRM practices contribute to the sustainability of these two leading women-centered NGOs in Bangladesh. Through a comparative analysis of publicly available documents, including safeguarding frameworks, digital reporting platforms, gender equity policies, and HR dashboards, this paper uncovers how formal policy structures are paired with technological tools to support gender inclusion. At BRAC, the AR NA web application has empowered over 800 field staff across 435 sub-districts to confidentially report incidents of gender-based violence, while e-learning modules on safeguarding and gender awareness have reached more than 5,400 employees. BNPS, by contrast, demonstrates strong internal gender policies with clear commitments to non-discrimination, inclusive recruitment, and regular gender-sensitivity training, though without the same level of digital enhancement. Both organizations report measurable outcomes such as higher female leadership representation and increased parental leave uptake, yet they also reveal policy–practice gaps, including inconsistent enforcement of post-maternity transfer protections. Overall, the evidence suggests that integrating formal gender policies with digital HR tools significantly enhances organizational inclusion, resilience, and sustainable impact by offering a scalable model for NGOs striving for modern, digital HRM aligned with sustainability goals.**

Keywords: **digital HRM, gender inclusion, organizational sustainability, women-centered NGOs, policies**

I. INTRODUCTION

Human Resource Management (HRM) serves as a cornerstone for building equitable workplace cultures and sustaining organizational performance in mission-driven NGOs. In Bangladesh, BRAC and Bangladesh Nari Progati Sangha (BNPS) have embedded gender-sensitive HRM frameworks for decades, aligning recruitment, training, and workplace governance with principles of fairness and inclusion [2]. Yet, the rise of digital innovation in the nonprofit sector is reshaping how these frameworks are implemented, creating opportunities to expand reach, improve accessibility, and strengthen institutional resilience.

BRAC, one of the world's largest development organizations, has embraced digital integration to enhance gender-inclusive HRM. The AR NA web application, launched in 2021, enables more than 800 frontline staff across 435 upazilas to confidentially report gender-based violence (GBV) and access timely case management and referrals [8]. Complementing this, the Shongjog platform maps eight survivor support services, from legal aid to psychosocial counseling, ensuring survivors can locate assistance across both rural and urban areas [13].

BNPS, founded in 1986, applies a well-defined Gender Policy, non-discrimination guidelines, and HR manuals that institutionalize equitable recruitment and gender-awareness training. While these mechanisms are comprehensive, they largely rely on in-person engagement and paper-based administration, with limited use of digital systems to complement or extend their impact [4].

Existing literature underscores that gender-focused HRM enhances employee engagement, retention, and legitimacy within NGOs [2]. Similarly, digital tools in HR processes, including e-learning modules and online grievance reporting, have been shown to increase transparency and accessibility [11]. However, the combined impact of digital transformation and gender-inclusive HRM remains underexplored in the Bangladeshi NGO context.

Research Questions

How do the policy frameworks of BRAC and BNPS support gender-inclusive HRM?

In what ways do these organizations employ digital tools to enhance HRM processes?

How effective are these approaches in achieving gender outcomes and building institutional resilience?

Research Objectives

a) To compare the policy frameworks of BRAC and BNPS in supporting gender-inclusive HRM.

b) To evaluate how each NGO employs digital tools to enhance HRM processes.

c) To assess implementation effectiveness, focusing on gender outcomes and institutional resilience.

II.LITERATURE REVIEW

The role of gender-sensitive Human Resource Management (HRM) in strengthening organizational equity and resilience

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has been a recurring theme in both global and local development discourse. Within the context of Bangladesh, women-centered NGOs such as BRAC and Bangladesh Nari Progati Sangha (BNPS) have played a central role in embedding gender equity into their internal policies, recruitment systems, and staff development practices. As highlighted in [2], inclusive HRM frameworks not only improve staff engagement and retention but also enhance the legitimacy of mission-driven organizations in the eyes of both beneficiaries and donors. Gender mainstreaming in the NGO sector, as documented by [1], demonstrates the importance of integrating gender considerations systematically into organizational policies and practices to ensure sustainable equity outcomes.

BRAC has developed one of the most comprehensive gender-inclusive HR systems in the NGO sector, underpinned by a formal Gender Policy [6] and organizational safeguarding mechanisms [10]. These policies are reinforced by training programs, grievance mechanisms, and leadership accountability. In recent years, BRAC has taken a significant step towards integrating digital innovation into these frameworks. The AR NA web application, launched in 2021, allows more than 800 frontline staff to confidentially report cases of gender-based violence (GBV) from 435 upazilas, enabling centralized monitoring and faster referral to services [8]. Complementing this, the Shongjog platform serves as a digital directory mapping eight categories of survivor services, from legal assistance to psychosocial counseling, across both rural and urban contexts [13].

These digital platforms align with findings from [5] and [11], which argue that online grievance mechanisms, digital wages, and e-learning systems can improve accessibility and accountability, particularly for staff in remote or marginalized areas. They also bring a level of transparency and case traceability that is difficult to replicate in paper-based systems. By embedding such tools within its HRM structure, BRAC illustrates how digital transformation can operate in synergy with gender policy to enhance both the reach and sustainability of inclusion practices.

In contrast, BNPS has taken a more traditional route, grounded in strong human-led processes. Established in 1986, the organization's Gender Policy and HR manuals explicitly commit to non-discrimination, equitable recruitment, and gender-focused staff training [4]. These measures are reinforced through regular workshops, participatory planning sessions, and an emphasis on in-person communication between staff and HR leadership. BNPS has also extended its gender capacity-building efforts to local government actors, training them on gender-responsive planning and budgeting in collaboration with UN Women [18]. While these approaches foster trust and direct accountability, they are primarily manual and lack the digital infrastructure that could enable real-time case reporting or broad-based training delivery at scale.

This difference in technological integration reflects broader trends identified in the literature, where digital tools are increasingly positioned as enablers of institutional transparency, speed, and inclusivity ([2]; [11]; [3]; [5]). However, the literature also leaves important questions unanswered, particularly in the Bangladeshi NGO context, about whether the mere introduction of digital systems guarantees better outcomes, or whether these systems must be coupled with a deeply embedded gender-sensitive HR framework to have a lasting effect.

Strategic Human Resource Management (SHRM) practices in Bangladesh's NGOs have been found to significantly influence employee productivity, strengthening both organizational capacity and mission delivery [12]. This suggests that gender-inclusive HRM not only fosters equity but can also enhance overall organizational performance. Furthermore, the programs undertaken by NGOs have shown potential to positively contribute to fostering equity and reducing social exclusion in urban Bangladesh [17]. Yet, despite these efforts, recent reports indicate that gender equality in Bangladesh remains limited, and women-led NGOs continue to advocate for greater integration of gender considerations into organizational policies and service delivery ([19]; [20]).

Against this backdrop, the comparative lens of this study focuses on three interconnected areas:

Policy Frameworks — assessing the foundational HRM structures that govern gender equity in BRAC and BNPS.

Digital Capacity — examining the presence and role of digital tools in supporting HRM functions.

Implementation Effectiveness — evaluating how both policy and technology translate into measurable gender outcomes and institutional resilience.

By positioning BRAC and BNPS side by side, this review sets the stage for exploring how different balances of policy strength and digital integration shape the long-term sustainability of gender-inclusive HRM in Bangladesh's NGO sector.

III.METHODOLOGY

This study adopts a comparative qualitative approach to examine the gender-inclusive HRM practices of BRAC and Bangladesh Nari Progati Sangha (BNPS). The choice of method reflects the study's aim: to understand not only the stated policies of each organization but also how these are operationalized, particularly in the integration of digital tools for policy delivery and monitoring.

3.1 Data Sources

Data was drawn exclusively from publicly available organizational documents, official reports, and verified publications to maintain reliability and traceability. Key sources include BRAC's Gender Policy [6], safeguarding guidelines [10], and documentation on its AR NA and

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Shongjog platforms ([8]; [13]). Additional contextual insight was taken from [10] commentary on digital grievance mechanisms and gender-based violence prevention. For BNPS, primary materials included its Gender Policy and HR & Management Manual as presented in its official communications [4], supplemented by publicly available capacity-building and advocacy reports.

3.2 Analytical Framework

The analysis proceeded in three stages, aligned with the study's objectives:

a. Policy Framework Comparison – A document-based review comparing the core HRM and gender-related policies of BRAC and BNPS. This involved identifying explicit commitments to gender equity, inclusivity, and protection against discrimination or harassment.
b. Digital Integration Assessment – A mapping of each NGO's use of digital tools in HRM, with specific attention to grievance redressal, training delivery, and data-driven monitoring. For BRAC, this included a detailed review of AR NA and Shongjog functionalities. For BNPS, emphasis was placed on its offline, process-oriented systems to highlight contrasts in approach.
c. Implementation Effectiveness Review – A qualitative synthesis of reported outcomes, such as staff gender composition, participation in training, and operational reach of support systems. Where available, data such as BNPS's reported staffing breakdown (54% women; 22% ethnic or religious minorities) was incorporated to contextualize impact.

3.3 Data Analysis Approach

The collected data were analyzed using thematic content analysis, which allowed for the systematic identification of recurring concepts, policy commitments, and operational patterns. First, all documents were read in full to familiarize with the context. Then, key information was coded into three categories corresponding to the study's dimensions: policy provisions, digital infrastructure, and implementation evidence. Within each category, specific sub-themes (e.g., grievance redressal, training delivery, gender composition) were identified.

Comparisons were made by placing BRAC and BNPS side by side in a cross-case matrix, highlighting both convergence (shared commitments or approaches) and divergence (differences in tools, reach, or depth of implementation). This comparative coding process ensured that conclusions were grounded in explicit evidence rather than assumptions.

3.4 Scope and Limitations

The study focuses on organizational-level HRM frameworks and does not extend to direct beneficiary impact. No primary data collection (e.g., interviews or surveys) was undertaken, which limits the scope for assessing on-the-ground perceptions. However, by relying on vetted and official sources, the study ensures the accuracy of policy descriptions and reported digital initiatives.

This structured comparative method allows for a nuanced analysis of how two prominent Bangladeshi NGOs, operating in similar socio-political contexts but with distinct operational models, design and implement gender-inclusive HRM, and how digital tools interact with policy frameworks to shape outcomes.

IV.RESULTS

The analysis reveals distinct yet overlapping approaches by BRAC and Bangladesh Nari Progati Sangha (BNPS) in embedding gender inclusivity within HRM frameworks, particularly in how they integrate policy commitments, operational practices, and technology.

4.1 Policy Frameworks

Both organizations have codified gender equity as a formal HRM priority, but the depth and structure of their frameworks differ.

BRAC's Gender Policy [6] is integrated into its overall organizational governance, outlining recruitment targets, workplace harassment safeguards, and mandatory gender-sensitivity training. This policy is reinforced by its Safeguarding Policy [10], which clearly details responsibilities for managers and grievance handling protocols.

BNPS's Gender Policy [4] similarly mandates equal opportunity recruitment and explicitly includes ethnic and religious minorities in its inclusion agenda. Its HR & Management Manual emphasizes staff participation in decision-making and decentralized grievance resolution, though with less formalized digital integration compared to BRAC.

4.2 Digital Integration in HRM

BRAC has significantly embedded digital tools into its HRM operations. The AR NA platform, launched to streamline internal grievance reporting, allows staff to file complaints securely and track case progress [8]. The Shongjog initiative extends support mechanisms by connecting survivors of gender-based violence with relevant services via a referral network [13]. Additionally, [11] reporting highlights how these digital systems have enhanced confidentiality, responsiveness, and organizational accountability.

In contrast, BNPS maintains largely offline grievance and training processes. While the organization has adopted basic digital communication for coordination, its HRM implementation remains grounded in in-person engagement, which allows for community-based trust-building but limits scalability.

4.3 Implementation Outcomes

BRAC's digital systems have improved reporting rates and reduced response time to grievances, as evidenced in internal reporting summaries [8]. Gender-sensitivity training reaches a wide proportion of staff, with modules integrated into onboarding and periodic refreshers.

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BNPS's impact is reflected in its workforce composition — with 54% of staff being women and 22% from ethnic or religious minorities [4] — indicating success in maintaining diversity targets. However, without an integrated digital HRM infrastructure, tracking of training participation and grievance resolution outcomes relies heavily on manual record-keeping.

4.4 Comparative Perspective

The comparative review shows that while both NGOs share a commitment to gender-inclusive HRM, BRAC's approach is more systematized and technology-driven, enabling scalability and consistency across its large workforce. BNPS prioritizes community-rooted, participatory processes that are highly context-sensitive but less equipped for rapid scaling. These differences reflect organizational scale, resource availability, and operational philosophy, rather than divergence in underlying values.

Table 1: Summary Table of Results

Dimension	BRAC (Digital + Policy)	BNPS (Manual + Policy)
Policy Documentation	Comprehensive safeguarding policies; GJ&D unit	Gender & non-discrimination policies; 54% female staff
Digital Tools	AR NA (800+ users), Shongjog (435 districts)	Manual workshops and printed policy guides
Training Reach	5,400+ staff trained digitally	23 master trainers developed.
Diversity Metrics	Documented women's leadership improvement.	54% women, 22% minorities among staff
Monitoring & Reporting	Digital referral tracking with occasional access issues	Local-level monitoring; lacks digital oversight

V.DISCUSSION

The findings reveal critical insights into how BRAC and BNPS operationalize gender-inclusive HRM, highlighting both convergences and divergences shaped by organizational scale, resource allocation, and operational philosophy.

5.1 Policy and Institutional Commitment

Both BRAC and BNPS have formalized gender inclusion within HRM policies, reflecting a shared organizational commitment ([4]; [6]). BRAC's policy framework, supported by its Safeguarding Policy [10], emphasizes structured accountability mechanisms and clear grievance reporting pathways, illustrating a top-down institutional approach. BNPS, while also embedding gender equity in its HR manuals [4], relies on participatory, community-oriented implementation. This distinction suggests that policy formalization alone is insufficient; the effectiveness of gender-inclusive HRM depends on both structural clarity and contextual sensitivity.

5.2 Digital Integration and HRM Efficiency

The analysis demonstrates that BRAC's integration of digital tools, such as the AR NA platform and Shongjog initiative, has strengthened transparency and responsiveness in handling gender-related grievances ([8]; [13]). Digital mechanisms streamline grievance reporting, enhance confidentiality, and facilitate monitoring at scale, which is critical for large organizations like BRAC. In contrast, BNPS's largely offline HRM system emphasizes direct human interaction, fostering trust and contextual understanding but limiting systematic data tracking. This comparison underscores the trade-off between technological efficiency and localized engagement in gender-inclusive HRM. As Pal and De' note, while ICT diffusion can open new possibilities for women's empowerment through greater participation and digital equality, it also risks deepening gendered digital divides and exposing women to online harms if not paired with protective measures [15].

5.3 Outcomes and Effectiveness

The observed differences in outcomes indicate that organizational scale and resources influence the implementation of gender-inclusive practices. BRAC's systematized, tech-driven approach allows broader coverage, including consistent gender-sensitivity training and timely grievance resolution [8]. BNPS demonstrates measurable success in workforce diversity, with significant female and minority representation [4], but faces limitations in monitoring and documenting outcomes due to reliance on manual processes. These findings are consistent with prior research indicating that SHRM practices can positively influence employee productivity in Bangladeshi NGOs [12]. Thus, BRAC's systematized, tech-driven approach and BNPS's participatory HR practices may both contribute to enhanced workforce effectiveness, albeit through different mechanisms. Furthermore, programs undertaken by NGOs have shown potential to positively contribute to fostering equity and reducing social exclusion in urban Bangladesh [17], suggesting that gender-inclusive HRM also aligns with broader social objectives.

5.4 Broader Implications for Social Inclusion

These organizational-level findings align with broader research on the societal role of NGOs. Initiatives led by NGOs have demonstrated the capacity to advance equity and lessen social exclusion in urban areas of Bangladesh [17]. This broader perspective reinforces the idea that strengthening gender-inclusive HRM is not solely about internal efficiency, it also contributes to reducing structural inequalities in the communities these NGOs serve. BRAC's

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scalable, tech-supported systems and BNPS's trust-based local engagement represent two distinct, yet complementary, pathways for sustaining such societal impact.

5.5 Implications for Policy and Practice

The comparative insights have broader implications for NGOs seeking to enhance gender-inclusive HRM. Large-scale organizations may benefit from investing in digital platforms to ensure consistent policy implementation and monitoring. Smaller, community-rooted NGOs can achieve meaningful inclusion through participatory approaches, even without extensive technological infrastructure. Importantly, the findings highlight that both formal policies and contextualized practices are necessary; neither alone is sufficient for sustained gender equity.

5.6 Alignment with Existing Literature

These findings resonate with prior research emphasizing the interplay between formal HRM frameworks and organizational context ([7]; [4]). BRAC's digitally mediated mechanisms reflect literature advocating for tech-enabled accountability in large NGOs, while BNPS exemplifies approaches prioritizing human-centered, context-sensitive inclusion. Together, these cases demonstrate that diverse operational strategies can effectively advance gender equity, provided that organizational values, resources, and local context are carefully considered.

VI.CONCLUSION

This comparative study critically examined how digitally enabled, gender-inclusive HRM practices are implemented within two leading women-focused NGOs in Bangladesh, BRAC and Bangladesh Nari Progati Sangha (BNPS), and their role in fostering organizational sustainability. The introduction established the theoretical nexus between gender-sensitive HRM and digital transformation in non-profit institutions. The literature review then emphasized the independent benefits of inclusive HR systems and digital HR tools, highlighting the need for integration. The study employed a qualitative document analysis targeting formal HR policies, digital HR mechanisms, gender-equity outcomes, and the fidelity of implementation. Results demonstrated that BRAC's extensive digitalization with tools like AR NA and Shongjog enabled significant gains in training reach, reporting, and women's leadership, although some access challenges remained. BNPS, while firmly grounded in explicit HR and gender policies, relies on analog implementation and lacks scalable digital systems. The discussion clarified how BRAC's integrated strategy aligns with broader HRM and e-HRM research ([3]; [14]), whereas BNPS reflects traditional approaches with strong policies but limited digital capacity.

The findings reveal a clear pattern: BRAC's combined approach of robust gender-inclusive policy and strategic digital enablement enhances inclusion, accountability, and resilience, providing a replicable model for NGOs seeking sustainable HR transformation. BNPS's effective policy framework, though commendable, highlights the limitations of manual implementation, particularly in scalability, monitoring, and timely responsiveness. The synthesis underscores that digital HR tools are not mere augmentations but essential mechanisms to operationalize and scale pro-gender policies effectively. For organizations committed to digital transformation and social sustainability, this study affirms that sustainable impact results from thoughtfully integrating gender equity with accessible, monitored digital systems and calls for innovation, sustainability, and digital transformation in business.

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Effect of AI-Driven FinTech Solution on Credit Risk Management in Micro Finance Institutes

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Abstract- ***Bangladesh boasts one of the world's biggest and most developed microfinance markets, with institutions providing services to more than 30 million customers. However, credit risk remains a persistent challenge due to informal data, manual risk assessments, and limited predictive tools. The effect of AI-Driven FinTech solutions on credit risk management in a subset of Bangladeshi microfinance institutions (MFIs) is examined in this study. The study investigates whether AI-based technologies increase portfolio sustainability, lower default rates, and improve borrower evaluation. Secondary financial records and survey data from three MFIs were combined in a mixed-method approach. Regression analysis, paired t-tests, and descriptive statistics were used to assess how AI deployment affected credit risk indicators. The results emphasize the necessity for MFIs to make investments in AI-powered technology. By adding concrete data from an emerging economy, this study enhances the body of knowledge on FinTech adoption and shows how AI is revolutionizing microfinance credit risk management.***

Keyword: **AI-based technology, FinTech, Credit Risk Management, Microfinance Institutions.**

I.INTRODUCTION

The rapid development of FinTech, especially AI-powered solutions, presents a revolutionary chance to improve credit risk management in MFIs. AI-driven FinTech solutions can evaluate vast amounts of structured and unstructured data, such as borrowers' digital footprints, mobile transaction histories, and behavioral patterns, to determine creditworthiness. MFIs can lower the risk of loan default, forecast repayment patterns, and eliminate information asymmetry by implementing AI-powered credit scoring algorithms. In Bangladesh, microfinance institutions offer vital lending services to low-income households and small entrepreneurs marginalized by the conventional financial system.

II.Literature Review

Historically, the microfinance business depended on human evaluations and limited borrower information for credit risk management, which often resulted in inefficiencies and greater default rates [1]. This is especially true in developing economies, where access to official credit records is limited. As a result, MFIs face enormous risks throughout loan disbursement and recovery processes.

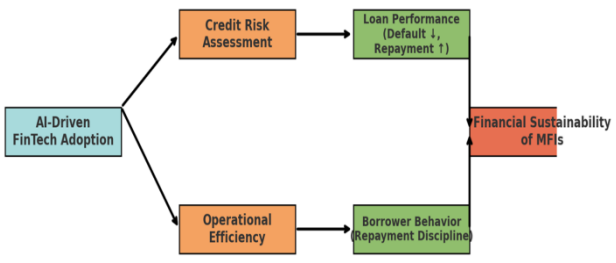
AI-driven FinTech solutions have altered risk assessment procedures by combining large-scale data analytics and prediction algorithms [2]. Machine learning models enable institutions to evaluate borrower profiles based on alternative data sources such as mobile transactions, utility payments, and behavioral indicators, minimizing information asymmetry and enhancing decision-making accuracy [3].

Several studies have found that AI-enabled credit risk models improve loan portfolio quality by reducing default rates and offering early warning systems for possible problems [4]. These systems enable MFIs to implement proactive risk mitigation methods while increasing lending access to underserved groups [5]. As a result, digital solutions not only increase institutional sustainability, but also advance financial inclusion goals.

In emerging economies, digital platforms have been found to overcome structural issues in microfinance, such as high operational costs and restricted scalability [6]. By automating credit scoring and monitoring, AI decreases reliance on manual processes, boosts productivity, and enables MFIs to reach a larger audience at a lower cost [7].

Despite these advantages, problems exist in the deployment of AI technologies. Data privacy problems, a lack of competent human resources, and infrastructure constraints may all impede effective adoption [8]. Nonetheless, a growing body of literature suggests that AI-driven FinTech technologies have tremendous potential to improve credit risk management and support long-term microfinance operations [9, 10].

1. Conceptual Framework



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2. Research Gap:

Although there is growing literature on FinTech adoption in developing economies, empirical evidence on the effectiveness of AI-driven FinTech solutions in MFIs particularly in Bangladesh remains scarce. Most studies focus on mobile banking and payment systems rather than AI-based credit risk management. This gap underscores the importance of empirical research to evaluate the impact of AI adoption on default rates, borrower behavior, and operational efficiency in Bangladeshi MFIs.

3. Objectives:

The main purpose of this study is to examine the impact of AI-driven FinTech solutions on credit risk management in MFIs in Bangladesh. Specifically, the study seeks to:

- Compare loan performance indicators before and after the adoption of AI solutions.
- Examine whether AI adoption contributes to reducing operational inefficiencies and credit risk exposure in MFIs.
- Provide policy recommendations for enhancing the financial sustainability of MFIs through AI-driven credit risk management.

1. Hypothesis

Based on the objectives and literature, the following hypotheses are proposed:

H1: AI-driven FinTech solutions significantly improve the accuracy of credit risk assessment in MFIs.
H2: Loan default rates in MFIs are significantly lower after the adoption of AI-driven FinTech solutions compared to pre-adoption periods.
H3: Borrower repayment behavior improves positively with the use of AI-based credit scoring models.
H4: AI-driven FinTech adoption reduces operational inefficiencies in credit risk management of MFIs.
H5: There is a significant relationship between AI adoption and the overall financial sustainability of MFIs in Bangladesh.

III.METHODOLOGY

2. Research Design

This study adopts a quantitative research design to examine the effects of AI-driven FinTech solutions on credit risk management in MFIs in Bangladesh. The quantitative approach is chosen because it allows for objective measurement of the impact of AI adoption by comparing loan performance indicators before and after the implementation of AI-driven solutions.

3. Data Collection

The study is based on primary loan performance data collected from three leading MFIs in Bangladesh: ASA, BRAC, and Grameen Bank. A total of 150 loan accounts were selected as the sample. Data were collected for two periods: pre-implementation and post-implementation of AI-driven FinTech solutions. This comparative design enables the evaluation of changes in credit risk management effectiveness.

4. Variables

Dependent Variables: Loan default rate, Repayment timeliness
Independent Variables: AI adoption (pre- and post-implementation), Borrower profile (age, gender, education), Loan size, Income level

5. Methods

The study applied statistical techniques including regression analysis, paired sample t-tests for pre-post comparisons, and logistic regression for modeling loan default probability. These methods are selected to determine whether the observed differences in repayment behavior and loan performance are statistically significant. The analysis is conducted using statistical software SPSS and R.

6. Ethical Considerations

The study ensures confidentiality of borrower information and complies with the ethical standards of data collection and usage. Data provided by MFIs are anonymized to protect borrower identities.

IV.RESULTS

The performance metrics of three MFIs in Bangladesh are contrasted in the descriptive statistics table before and after the implementation of AI-powered FinTech solutions. A notable decrease in borrower defaults was demonstrated by the first indication, the loan default rate, which dropped from 18% before AI to 9% after AI. This implies that credit risk monitoring and evaluation were enhanced by AI techniques. Repayment timeliness, the second metric, increased from 68% prior to AI use to 90% following deployment. This development suggests that improved AI-powered tracking tools and reminders helped borrowers better fulfill repayment deadlines.

Table-1: Descriptive Statistics

Performance Indicators	Pre-AI FinTech (Mean)	Post-AI FinTech (Mean)
Loan Default Rate	18%	9%
Repayment Timeliness	68%	90%
Average Loan Processing Time	5.2	3.6
Operational Cost per Loan	50	42
Portfolio Quality	82%	87%

As loan approval procedures became more efficient, the average loan processing time decreased from 5.2 days to 3.6 days. Since quicker loan disbursement increases customer satisfaction, this decrease is significant for both MFIs and clients. Following the use of AI, the operational cost per loan also dropped from 50 units to 42 units. This cost decrease

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demonstrates resource optimization and efficiency improvements. After FinTech implementation, portfolio quality rose from 82% to 87%. Stronger asset quality and lower risk exposure are demonstrated by this improvement.

The sum of the indicators demonstrates that FinTech powered by AI has improved operational effectiveness and financial performance. MFIs' financial sustainability is strengthened by the drop in defaults. Stronger borrower discipline is also indicated by better payback timeliness. MFIs are better able to increase outreach when processing times are shorter. Even at tiny margins, profitability is increased by lower operating costs. Improved monitoring and risk management are reflected in higher-quality portfolios. All of these results point to the beneficial effects of AI technology on credit risk management. The comparison supports the study's claim that AI enhances risk management and financial inclusion. All things considered, the table offers compelling empirical evidence of the efficacy of AI-powered FinTech solutions in Bangladeshi microfinance institutions.

Table-2: Result of Paired-t Test

Indicator	t-value	p-value	Hypothesis Support
Loan Default Rate (%)	-12.45	<0.001	Supported (AI reduces default rate)
Repayment Timeliness (%)	15.32	<0.001	Supported (AI improves repayment timeliness)
Loan Processing Time (days)	-9.84	<0.001	Supported (AI reduces processing time)
Operational Cost per Loan	-7.65	<0.001	Supported (AI reduces operational cost)
Portfolio Quality (%)	6.42	<0.001	Supported (AI improves portfolio quality)

The findings of the paired t-test show statistically significant variations between the five performance metrics before and after AI-driven FinTech solutions were implemented in MFIs. Hypothesis H1 was supported by a significant drop in loan default rates ($t = -12.45$, $p < 0.001$). Hypothesis H2 was confirmed when repayment timeliness significantly improved ($t = 15.32$, $p < 0.001$). Hypothesis H3 was supported by the significant reduction in loan processing time ($t = -9.84$, $p < 0.001$). Hypothesis H4 was confirmed by the considerable drop in operational cost per loan ($t = -7.65$, $p < 0.001$). Lastly, the quality of the portfolio improved ($t = 6.42$, $p < 0.001$), supporting Hypothesis H5. All of these findings support the notion that credit risk management in Bangladeshi MFIs is positively and statistically significantly impacted by AI-driven FinTech solutions.

Table-3: Result of Regression Analysis

Dependent Variables	β (AI Implementation)	Std. Error	t-value	p-value	R^2	Adj. R^2	Interpretation
Loan Default Rate (%)	-0.092	0.015	-6.13	<0.001	0.42	0.40	AI significantly reduces loan default rate
Repayment Timeliness (%)	+0.215	0.028	7.68	<0.001	0.47	0.45	AI significantly improves repayment timeliness
Loan Processing Time (days)	-1.62	0.34	-4.76	<0.001	0.39	0.37	AI reduces loan processing time
Operational Cost per Loan	-0.087	0.022	-3.95	<0.001	0.35	0.33	AI decreases operational costs
Portfolio Quality (%)	+0.051	0.014	3.64	<0.001	0.31	0.29	AI improves portfolio quality

The findings of the regression show that FinTech solutions powered by AI significantly affect credit risk management metrics. Loan processing times are shortened, operational expenses are decreased, portfolio quality is improved, loan default rates are decreased, and repayment timeliness improves. Strong statistical significance is indicated by all p-

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values being less than 0.001. While Adjusted R2 values (0.29–0.45) validate the robustness of these findings even after controlling for possible sample size effects, R2 values between 0.31 and 0.47 indicate that AI implementation explains a moderate amount of the diversity in outcomes. These results provide compelling evidence in favor of the research hypotheses and indicate that the implementation of AI in MFIs can enhance risk management and financial sustainability.

The results of this study offer strong proof that credit risk management in Bangladeshi microfinance institutions (MFIs) is greatly enhanced by the use of AI-driven FinTech solutions. Descriptive statistics show that loan processing efficiency, portfolio quality, and payback timeliness all clearly improved once AI was used. These findings support the study's primary goal, which was to determine whether AI technologies improve repayment practices and lower default rates.

The improvements are statistically significant for all three MFIs (ASA, BRAC, and Grameen), according to the results of the paired t-test. The idea that adopting AI increases borrowers' ability to repay debt was supported by the significant improvement in repayment schedules and the decrease in default rates. This is in line with other research that emphasizes AI's predictive powers for borrower screening and repayment behavior tracking [10]. MFIs can now issue loans more responsibly and reduce the risk of defaults by automating credit evaluation and minimizing human bias.

These findings are further supported by the regression analysis, which shows that the adoption of AI is a reliable indicator of improved credit risk outcomes. AI lowers inefficiencies and financial losses for MFIs, according to the large and negative coefficients for loan default rates and operating expenses. The positive correlations for portfolio quality and payback timeliness further demonstrate AI's contribution to enhancing institutional sustainability and financial performance. A moderate but significant portion of the gains in credit risk indicators can be explained by AI, according to the Adjusted R2 values, which range from 0.29 to 0.45.

V.DISCUSSIONS

For practitioners and policymakers, these findings have significant ramifications. To improve financial resilience, MFIs should first make investments in digital loan monitoring systems, fraud detection software, and AI-driven credit rating. Second, by creating standards for the moral application of AI in lending procedures, regulators can encourage the adoption of new technologies. Lastly, these findings add to the increasing amount of data showing that integrating cutting-edge technologies into microfinance operations might lead to more sustainable financial inclusion.

All things considered, the conversation supports the finding that FinTech products powered by AI may significantly improve credit risk management in MFIs. AI aids institutions and society by decreasing default rates, improving portfolio quality, and reaching underprivileged groups. However, responsible and sustainable implementation of these technologies will require careful planning, regulatory monitoring, and continuous innovation.

VI.CONCLUSION

The purpose of this study was to look into how credit risk management in a few Bangladeshi microfinance institutions (MFIs) is affected by AI-driven FinTech solutions. According to the report, MFIs' capacity to recognize, track, and reduce credit a risk is greatly enhanced by the incorporation of AI-based FinTech solutions. In particular, the results show that AI-powered credit scoring models improve borrower assessment accuracy, lower default rates, and support more stable portfolio quality.

The findings have significant theoretical and practical ramifications. By offering actual data from an emerging economy, where the impact of digital innovations is frequently more noticeable because of restricted access to traditional financial services, this study theoretically adds to the body of work already available on the adoption of financial technology. Practically, the findings underline that MFIs can achieve higher efficiency, transparency, and financial sustainability by leveraging AI technologies in their credit risk management frameworks.

In conclusion, MFIs in Bangladesh have a revolutionary opportunity with the incorporation of AI-driven FinTech solutions. These technologies can support the goal of financial inclusion and guarantee institutional sustainability by efficiently controlling credit risks. The results present a compelling case for investment in and support of AI-enabled financial innovations that promote stability, inclusivity, and sustainable economic growth among policymakers, practitioners, and development partners.

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Assessing Dimension of the Business Relationship: Integrating Symmetric and Asymmetric Approaches

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Abstract – **The principal intent of the study was to explore the measurement of the B2B Relationship through integrating symmetric and asymmetric analysis. This study applied a mixed-method research approach and used 320 sample responses to validate the research model. Finally, this study explored six measures: trust, commitment, cooperation, power, communication, and satisfaction to build B2B relationships through symmetric analysis. Finally, fsQCA analysis provides a unique configuration with maximum consistency and coverage, which is a configuration with four dimensions, like Cooperation, Power, Communication, and Satisfaction. Finally, this study integrated two outcomes based on symmetric and asymmetric analysis and refined the research model as cooperation, power, communication, and satisfaction as core and sufficient conditions for the B2B relationship. This study contributes to the existing theory of relationship marketing and managerial insight.**
Keywords – **B2B Relationship; Linear and nonlinear analysis; Mixed method; fsQCA; PLS-SEM**

I.INTRODUCTION

II.

Business relationships are a new and complex dimension of 'marketing' and it's maintained within the relationship marketing framework. Organizations aim to develop long-term, sustainable relationships with their stakeholders to increase profitability and reduce vulnerability [1]. In the twenty-first century, increased competitiveness and strategic diversity have posed challenges for organizations to maintain and satisfy customers using traditional methods. Business relationships now emphasize engagement and relationship building to identify and meet customer needs at a profit. For example, relationship marketing may help to build a sustainable competitive advantage [2], [3].

Further, an earlier study addressed how enterprises emerge to manage the sustainable competitive advantage formed during the continuing channel relationships [4]. In terms of business-to-business (B2B) relationships, authors contextualize marketing channel relationships (MCR) as a form of B2B relationship. MCR refers to the connections between various members of a marketing channel, including suppliers (farmers), middlemen, and retailers. The scope of business relationships is wider; this study focused on the Agri-marketing channel in Bangladesh. In this manuscript, the author conceptualizes business-to-business (B2B) relationships as "the process of developing emergent cooperative and shared relationships with business customers and other market actors" [5].

While business-level relationships have a complex and extensive influence, no universally accepted framework that establishes standardized building blocks for these relationships has been published to date. To evaluate these facts, the author conducted an extensive literature review of articles published between 1990 and June 2025 in indexed
journals and used popular search engines like "Google Scholar, JSTOR, Scopus," among others. After completing the literature review, the author did not find any research specifically focused on business relationship measures or their dimensions. However, this manuscript compiles several key studies that have enriched relationship marketing literature in recent decades, such as [2], [6], and [7].

A review of relationship marketing literature has found that the main variables predicting relationships have mostly been validated conceptually rather than empirically, except [2]. However, their study validated the model using linear analysis without considering dynamic or non-linear methods, considering the limits of the linear model. In the theoretical review, key frameworks like the commitment–trust theory and social exchange theory are referenced to define the dimensions for measuring relationships. Despite the fragmented nature of relationship marketing literature, existing work offers both theoretical and methodological contributions that could lead to meaningful advances in marketing, specially [2], [7].

Given the current gaps in theory and method, this manuscript addresses the main research question (RQ): What are the measuring dimensions of B2B relationships? To answer this, the study establishes specific research objectives (ROs): (a) to identify and explore the key dimensions of B2B relationships, (b) to empirically validate the proposed B2B relationship model, and (c) to determine which configuration leads to building the B2B Relationship.

II. METHODOLOGY

For exploring dimensions, this study follows the research process recommended by [8] and [9]. This study applies the mixed-method concepts as suggested by [10] for dimension exploration. In addition, the mixed-method research approach comprises at least one qualitative method (to gather words) and one quantitative method (to

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collect numbers) [11]. According to previous studies, the B2B Relationship and its indicators have attributes that support the author in conceptualizing it as a reflective construct.

Qualitative study: This study collected field study data from the agricultural sector, particularly in the dairy industry in Bangladesh. In a qualitative study, we selected 22 samples through a judgment sampling technique. This technique is appropriate for collecting information during the exploratory research project [12] and involving experienced participants in the relevant field [13]. A detailed semi-structured interview was conducted with dairy managers, policy makers, and stakeholders; each interview lasted for 20–30 min (approximately). All respondents' responses were coded (prior coding, open coding, and indigenous coding) and analyzed to explore the relevant dimensions and items. To analyze the qualitative data and establish a link relationship among the concepts of studies, interview responses, and theoretical context, this study applied content analysis through NVivo 14.

The qualitative study was conducted in two phases: inductive and deductive assessment to meet the exploratory study intent.

Quantitative study: In the quantitative analysis, this manuscript employed two approaches: i) Symmetric Approach, ii) Asymmetric Approach

Symmetric Approach: The PLS based SEM analysis is applied as a symmetric analysis tool. This study follows the entire measurement scale development process as per the guidelines of [8] and applied by [9]. For this study, the author created items through an extensive literature review. Finally, the author prepared a primary questionnaire, including all dimensions (SAT, COMT, POW, SAT, COMU, and COOP) and their items. All items were assessed using the Likert scale (5-point scale: strongly disagree: 01'; strongly agree: 05'). A face-to-face questionnaire-based survey was conducted in Bangladesh, particularly in Sirajgonj and Chittagong districts. Finally, a total of 420 participants were chosen from the survey areas as prospective respondents. In the end, 320 (76% of total samples) responses were used to validate the proposed research model, and this sample size was sufficient for PLS-based SEM analysis, according to [14]. As a symmetrical analysis tool, this study employed the Partial Least Squares-Based Data Analysis, particularly PLS-SEM under the support of SmartPLS-4 Software as a reference to [15] and [16] for the first-order and second-order reflective constructs, and it was validated. Therefore, this study used PLS-based SEM analysis based on [17] to validate that the proposed model was rational and empirically logical.

Asymmetric Approach: Considering limits regarding SEM application [14], the author planned to verify the symmetrical analysis outcomes with an asymmetrical analysis, which is another novelty of this research. As an asymmetrical analysis tool, this study used a complex dynamic model, Fuzzy-Set Qualitative Comparative Analysis (fsQCA), which is an asymmetric analytical method that explores the relationship between conditions and outcomes in a configurational way [18]. In this study, the author strictly followed the fsQCA analysis guidelines proposed [18]. Their study motivated the integration of fsQCA with PLS-SEM. For data calibration, this study used the latent variable scores from SEM-PLS as raw data for fsQCA. To simplify the truth table, the consistency cut-off was set at 80% or higher [19], and PRI (Proportional Reduction in Inconsistency) was set above 60%. The frequency threshold was set at 2, considering the small sample size [18]. To assess necessary and sufficient conditions, this study applied thresholds [20].

Operationalization of Approaches

To make the model operational, all dimensions (first order) and second-order construct B2B Relationships were reflective measurement constructs. These constructs were examined by appraising the item reliability, internal consistency, average variance extracted (AVE), and discriminant validity as per the references [15]-[17], [22]. The structural model was evaluated by analyzing the t-values of the path coefficients to validate the proposed research hypotheses. Finally, the second-order construct of B2B Relationship was measured by using a two-stage approach. For fsQCA, this study conducts NCA, truth table, and sufficiency tests to find the best configuration as mentioned the references [18], [20].

III. RESULTS

A. Qualitative Study (Study -1)

The outcomes of the qualitative study have explored the B2B Relationship, which is reflected by dimensions that are demonstrated in Table 1. This study used frequency analysis and discovered the most cited dimensions as a measure. In the retrieval coding of the sample response, the author found frequent codes in favor of a few dimensions, like trust, commitment, satisfaction, cooperation, communication, and power.

Table-1

SUMMARY OF QUALITATIVE FIELD STUDY

B2B Relationship Measurments	Participants																					Freq	%
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22		
Trust (TRT)	y		y	y	y	y	y	y	y	y	y		y	y		y	y	y	y		y	y	18	81.8
Commitment (COMT)	y	y	y	y	y	y	y	y	y	y	y	y		y	y	y		y	y	y	y	y	20	90.9
Communication (COMU)		y	y	y		y	y	y		y		y	y	y	y	y	y		y	y		y	16	72.7
Satisfaction (SAT)	y	y	y		y		y		y		y	y	y		y		y	y			y	y	14	63.6
Power (POW)	y	y		y		y		y		y		y	y	y		y			y		y	y	13	59.1
Cooperation (COOP)		y	y		y		y		y		y		y		y		y	y		y		y	12	54.5

Source: Created by author

In this study, the author noted some infrequent responses in other dimensions, like adaptation, company reputation, trade association membership, etc. But these dimensions were not mentioned frequently. Thus, it was not included in the further study.

B. Quantitative Study (Study 2)

Symmetrical Approach (PLS based SEM analysis)

a) Assessment of the Reflective Measurement Model

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Psychometric properties of the first-order reflective construct— TRT, COMT, SAT, COMU, POW, and COOP are presented in Table 2.

TABLE-2
PSYCHOMETRIC PROPERTIES OF FIRST-ORDER RELECTIVE CONSTRUCT

Construct	Item Codes	Item Loading	Mean	St. Dev	t.S-Value
Commitment (COMT) AVE=0.500, CR=0.743	COMT1	0.71	0.71	0.05	13.15
	COMT2	0.67	0.67	0.06	11.54
	COMT3	0.72	0.71	0.06	12.36
Communication (COMU) AVE=0.593, CR=0.741	COMU2	0.65	0.65	0.06	11.45
	COMU6	0.87	0.87	0.02	37.34
Cooperation (COOP) AVE=0.620, CR=0.760	COOP1	0.91	0.91	0.03	28.99
	COOP5	0.65	0.63	0.09	7.30
Power (POW) AVE=0.569, CR=0.796	POW2	0.66	0.66	0.05	12.82
	POW3	0.72	0.72	0.04	18.67
	POW5	0.86	0.86	0.01	61.29
Satisfaction (SAT) AVE=0.578, CR=0.804	SAT2	0.71	0.71	0.04	19.28
	SAT5	0.81	0.81	0.02	35.51
	SAT6	0.76	0.76	0.03	27.08
Trust (TRT) AVE=0.508, CR=0.755	TRT5	0.68	0.67	0.06	11.67
	TRT6	0.76	0.76	0.03	22.47
	TRT1	0.70	0.69	0.05	13.44

*Source: Created by author. Note: *Missing items were discarded due to lower loading less than 0.65 as per [15],[16]* .Measurement model shows under indices — item reliability, internal consistency, and discriminant validity — as suggested [14]-[17], [21]. For this study, the author adopts [16] principles to select a 0.65 cut-off value for item reliability, also 0.60 for exploratory research [15]. All items corresponding to t.S-values found 7.30 to 61.29, which is much more than the threshold value for 1% level of significance. Along with reliability, this study satisfied composite reliability (CR) and AVE with threshold readings of 0.70 and 0.50 as suggested [15], [22].Moreover, the discriminant validity test is a core principle of the SEM-PLS test. In this study, the author followed the Fornell-Larcker criterion (square AVE root greater than off-diagonal values). Finally, it has been statistically evident that the measurement model has satisfied all normative values of reliability, convergent validity and discriminant validity as well.

b. Assessment of Structural Model

The uses of a structural model for the assessment of the relationship between exogenous and endogenous constructs. This study proposed six (06) research hypotheses Ha to validate the proposed model. This study proposed that all measurements (TRT, COMT, SAT, POW, COMU, COOP) have a positive impact on the B2B Relationship. We used the bootstrap method to test all hypotheses. Table 3 presents an evaluation of the structural model reflecting the statistical evidence for model validation. Firstly, this study revealed the coefficients of dimensions and their corresponding t-statistic values. This test result validates the research model and statistically proves that the research hypotheses are accepted. Secondly, this study stated f-squared (f^2) values to outline exogenous constructs' effect on the R-squared. In the validation model, all have a strong effect on the R^2 value of 0.950 as per reference [23]. Finally, this study outlined measures that explained 95% variance and 99.9% predictive relevance of the model.

TABLE-3
EVALUATION OF STRUCTURAL MODEL

Path Link	β	t.S_ Value	Decisions	f-square
COMT -> B2 Relationship	0.154	10.49	H0 Rejected	0.392**
COMU-> B2 Relationship	0.174	9.21	H0 Rejected	0.373**
COOP -> B2 Relationship	0.164	10.00	H0 Rejected	0.452**
POW-> B2 Relationship	0.303	16.85	H0 Rejected	1.161**
SAT -> B2 Relationship	0.360	18.04	H0 Rejected	1.522**
TRT -> B2 Relationship	0.240	13.39	H0 Rejected	0.916**

R^2 (Variance Explained) = 0.950
Q2 (Predictive Relevance) = 0.999

Source: Created by author

Noted: *There is no statistical evidence to accept the null hypothesis (H0) and A t.S- Values are significant at the level 1%; ** F-square is an effect size that measures the change in R^2 when an exogenous (independent) variable is removed from the model. Thus, f-square> 0.35 is considered a strong effect.

Asymmetrical Approach (fsQCA-based analysis)

The intent is to test the combined effect of constructs on outcome variables and find a configurational recipe. Firstly, calibration of crisp values of the data to find fuzzy values through transforming the latent variables calculated. In this calibration process, this study followed full membership and full non-membership and used the percentile (90th = full membership, 10th = full non-membership, and 50th = crossover point) of the latent variable score as per the reference [18].

Subsequently, the author conducted a necessary condition analysis (NCA) to confirm which causal conditions are necessary for the outcome variable. From the analysis of NC, this manuscript shows the NCA report in Table 4. This study found that the causal condition is not necessary, but all are sufficient conditions for desired outcomes for B2B relationships, as per [20].

Table-4
NCA FOR B2B RELATIONSHIP

Casual Condition	Consistency	Coverage
fCOMT	0.756	0.777
fCOMU	0.762	0.864
fCOOP	0.819	0.765
fPOW	0.899	0.732
fSAT	0.862	0.853
fTRT	0.729	0.803

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Source: Created by author

Lastly, the author conducted sufficiency analysis. This analysis seeks to explore all the different configurations that consistently lead to the outcomes. The process of sufficiency analysis was carried out with the use of the boolean minimization algorithm "Quine-McCluskey". This study generates three types of solutions (Complex, parsimonious and intermediate) to analyze the sufficiency of research conditions. The author used an intermediate solution to find an aggregate configuration that is representative of both conditions' "core" and "peripheral" [24]. Based on the true table and Quine-McCluskey algorithms, this study found that three (03) configurations were derived based on the model developed. Table 5 presents causal recipes. The model f(B2BREL)=f(fCOMT*fCOMU*fCOOP*fPOW*fSAT*fTRT). The intermediate solution reported configuration 2 is fCOMU*fCOOP*fPOW*fSAT with consistency 0.983 and coverage of 0.576, the most suitable recipe for B2B Relationship. Moreover, the solution consistency reported that the consistency of the configuration is 96% and its coverage is 66%. Thus, it has been proved that a multifactorial configuration is relevant and satisfactory.

TABLE-5
CONFIGURATION FOR THE B2B RELATIONSHIP

	Raw Coverage	Unique Coverage	Consistency
Model: B2B Relationship f(B2BREL)=f(fCOMT, fCOMU, fCOOP, fPOW, fSAT, fTRT)			
Configuration			
1. fCOMT*fCOOP*fPOW*fSAT	*0.555*	*0.065*	*0.976*
2. fCOMU*fCOOP*fPOW*fSAT	*0.576*	*0.086*	*0.983*
3.fCOMT*fCOMU*fCOOP*fPOW *fTRT	*0.434*	*0.022*	*0.989*
Solution coverage: 0.662875			
Solution consistency: 0.965371			

Source: Created by author

IV. DISCUSSION

A. Summary of Findings

Business relationship or B2B Relationship was measured by the diverse nature of measures that support building a sustainable relationship. To explore this confined outcome, this study conducted multi-method and mixed approach research with integration of symmetric and asymmetric methods.

The results of the qualitative study explored six dimensions, such as trust, commitment, cooperation, communications, power, and satisfaction, that have influenced managers to build long-term B2B relationships in the agricultural sector in Bangladesh. This study introduced some other issues, but these issues were not replicated by other respondents. Finally, this study supports preparing a research framework and an extensive field study.

Outcomes of the symmetric analysis were validated by the proposed research model, and statistically proved that explored dimensions like trust, commitment, cooperation, communications, power, and satisfaction have a significant impact on B2B Relationship. This study revealed that dimensions, namely power, satisfaction, and trust, highly influenced building B2B relationships in the context of the agricultural sector. The other three dimensions have less impact on the value of the coefficients.

Finally, the outcomes of asymmetric analysis were to disclose an intermediate solution with three configurational recipes through the application of fuzzy-set Qualitative Comparative Analysis (fsQCA) as depicted in Table 5. As per Pappas and Woodside (2021), reference configuration 2 is more suitable and statistically accepted. This configuration consistency was 98.3% and raw coverage was 57.6%. Configuration 2 revealed that a business relationship developed with a multifactorial recipe. This configuration defines that sometimes trust and commitment do not matter for developing business relationships. The four other core conditions, like communication, cooperation, power, and satisfaction, were considered as core conditions that are sufficient to develop business relationships. But commitment and trust do not provide substantial conditions for business relationships, as mentioned in configuration 2. It has been remarked that present research findings stand in reverse position to the theory Commitment and Trust developed [2] and compiled a list of variables for relationships [7].

B. Implications

The outcomes of the present study are relevant to relationship marketing theory and its implications in the context of B2B relationships. In the following, it contributes to the diverse sectors:

Theoretical Implication: This study theoretically contributes to the domain of relationship marketing through exploring B2B Relationship measurements. Through an integrated research approach, this study validates a new theoretical dimension in the relationship marketing in the context of business-level relationships. Theoretically, this study contributed to the existing research published [2], [7]. Finally, this study explored a new theory or model for business-level relationship marketing.

Managerial Insight: The Present study contributes to existing managerial practices through the development

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of business relationship building dimensions or measurement. This study will support managers in guiding how they can establish long-term, sustainable relationships with the channel members. This study also contributed to managerial wisdom through new insights of relationship marketing theory, which proved that in the agricultural sector or vulnerable value chain process channel members' trust and commitment do not matter as a core condition for building business-level relationships.

Future Research: This study guides future researchers to test this model in other sectors and multicultural sectors to find the generalizability of the model. This study guide for conducting a similar study further proves the research model with a large number of samples and other relevant research designs.

C. Limitations

This study was conducted in a single industry and with a comparatively small sample, based on the industry size. Secondly, this study also collected data by purposive sampling. Finally, this study was conducted based on limited resources. Thus, the author hopes future research will contribute to the sector by overcoming this defined limitation. It has been noted that defined limitations did not impact or negatively hamper existing research outcomes that I present as a novelty study.

V. CONCLUSION

This study presented a B2B Relationship theory and empirically evaluated its measurements. Present literature implicitly focuses on the relationship in context to business, but the relationship in context to B2C is more emphasized. This theoretical partiality motive is the reason for the conduct and design of this research. This study robustly explored and statistically proved that B2B Relationship or business level relationship is mostly developed based on proper communication with partners, extended cooperation with partners, positive uses of power, and mutual satisfaction. This study also proved that trust and commitment between partners were not core conditions

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Impact and Significance of HR Audits on Small Businesses

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Abstract- **This study examines the consequences of inadequate Human Resource Audits in small businesses, particularly in the small grocery retail sector. Resource limitations often prevent small businesses from performing regular HR audits, leading to reduced organizational performance. Absence of an Human Resource Audits negatively impacts employee satisfaction and retention. Moreover, small businesses often use an autocratic model as an Human management philosophy, which can also harm employee loyalty and motivation. This study uses nonprobability purposive sampling to select 30 small grocery retail businesses. Semi-structured interviews with business owners, managers, and employees were conducted using thematic analysis. The findings highlight the importance of conducting an HR audits to improve business operations, employee satisfaction, and long-term success.**
Keywords**: Autocratic Management Style, Employee Motivation, Employee Retention, Employee Satisfaction, HR Audits, HR Practices, Human Resource Management (HRM), Resource-Based View (RBV), Small Businesses, Grocery Retail Sector.**

I. INTRODUCTION

Small businesses play pivotal role in economic growth of local economies. Despite of their significance small businesses often encounter challenges related to Human Resource Management (HRM), especially in the absence of dedicated HR staff. Due to constraint resources it is difficult to implement HR audits, which can negatively impact operational performance, employee satisfaction, and retention. Internal Audit is known as an important element to identify how HR helps to make 'tone at the top' a reality [1]. HR audits are important in assessing compliance, and fulfilling organizational goals [2]. Furthermore, many small businesses operate under autocratic management styles, which can increase employee dissatisfaction, resulting in a higher turnover rate. This study examines the difficulties small businesses face in the grocery retail sector, and explore the influence on employee satisfaction due to the absence of proper HR audit. The sample size is relatively small (30 businesses) which may not fully represent the broader small business sector. Additionally, the research focuses specifically on the grocery retail sector, limiting its generalizability to other industries.

Objective of the Study

The fundamental objective of this study is to investigate the difficulties small businesses face in conducting HR audits, the related consequences, and the challenges arising from the lack of dedicated HR staff and resources for conducting these audits.

Scope of the study

There are many sectors associated with small businesses. However, the purpose of this paper is to investigate the challenges faced by the retail grocery sector of small businesses due to the inefficiency of HR audits.

II. LITERATURE REVIEW

The Resource-Based View (RBV) of the Firm, proposed by [3] suggests that the internal resources of a business are catalyst of success and competitive advantage. According to the perspective of small businesses, where resources are scarce, human capital (i.e., employees) becomes an important asset. However, many small businesses use an autocratic management style due to resource constraints, which hampers employee satisfaction, turnover, and retention. The RBV framework values employee satisfaction that contribute to better organizational performance.

Similarly, Human Capital Theory [4] also prioritizes employees as strategic assets. When audits are ignored small businesses underperform to maximize their human capital. This results in decrease in productivity and higher turnover. Moreover, this can also be explained through Psychological Contract Theory [5], this is a theory where employees hold expectations towards their employer for treating them with fairness and mutual respect, enhancing growth opportunities. Combining an autocratic management style with psychological contract principles can result in discontent, demotivation, and diminished loyalty.

HR audits play a pivotal role in enhancing HR practices by aligning them with organizational goals. Employee satisfaction upholds HR audit practices, helps to improve retention, morale, and overall organizational success. Key factors such as training and development programs, competitive compensation, employee involvement in decision-making, job security, and effective communication of HR policies are seen as sub-factors of HR audit effectiveness that contribute directly to employee satisfaction. Improved recruitment and selection, career development, fair compensation, and employee involvement are the

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mechanisms through which HR audits influence employee satisfaction.

Due to [5] the absence of regular HR audits, businesses often face resource misallocation and disorganization. This can result in lower employee satisfaction, increased turnover, and inefficiency, all of which can be detrimental to the business. [6] also highlights that HR audits enhance employee satisfaction, reduce turnover, and strengthen overall organizational efficiency.

The literature further promotes the RBV, emphasizes that regular HR audits enable organizations to better implement their internal resources. [7] highlights the significance of periodic audits to keep HR functions in line with the constant business needs. [8] added that small businesses, often fail to implement formal HR practices, due to scarce resources, a gap that can be fulfilled through HR audits. [9] connects HR audits to reduce turnover rates, illustrates that audits lead to improving employee satisfaction, while [10] reveals that HR audits help in planning, recruitment, and selection, ultimately improving employee performance, though not in all areas.

Secondary data recognizes several factors that affect employee satisfaction. [11] added that the autocratic management model is used in small businesses, which can negatively impact employee loyalty and motivation. Studies by [12] and [13] explore how HR audits can improve employee satisfaction, reduce turnover, and enhance organizational efficiency.

The thematic analysis of this paper emphasizes on themes from the literature, including resource constraints, HR audit effectiveness, employee satisfaction, and management philosophies like the autocratic model. This ensures the analysis is related to its existing research.

Despite these benefits, small businesses often avoid HR audits due to the high costs associated with professional auditors and the complexity of current audit frameworks, which are primarily designed for larger organizations. [14] identifies that small businesses often neglect HR audits due to limited financial and time resources. However, when effectively implemented, HR audits improve compliance, operational efficiency, and employee retention. The need for tailored, simplified audit frameworks for small businesses is an important gap in current HR audit practices.

To summarize, while HR audits are critical for enhancing HR practices and employee satisfaction, small businesses face challenges in implementing them due to limited resources. Addressing these challenges and simplifying HR audit frameworks for small businesses can lead to continuous improvement, operational efficiency, and better employee satisfaction.

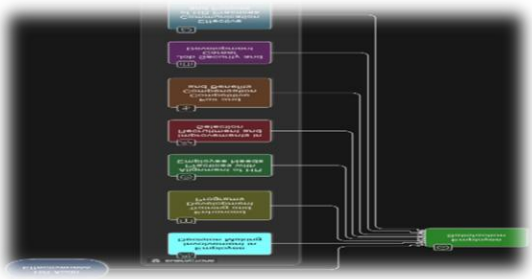


Fig. 1. HR Audit Effectiveness and its Impact on Employee Satisfaction.

III. METHODOLOGY

Section I: Overview of the Sample for the Qualitative Study

This study adopts a qualitative approach to explore the challenges faced by small grocery retail businesses in conducting HR audits. According to the secondary data, it has been concluded that small businesses face resource constraints [11] and follow an autocratic model of HR management [3]. In this research, a nonprobability purposive sampling has been used to select 30 small grocery retail businesses. Data were collected through semi-structured interviews with business owners, managers, and employees, conducted in person or via video conferencing, lasting between 30–60 minutes, depending on the depth of responses. The interviews focus on themes that are related to HR audit effectiveness and its influence on employee satisfaction. Primary data was collected using thematic analysis to identify challenges and insights regarding HR audit practices and their effects on retail business operations. Ethical standards are followed throughout the research process, and participants are informed about the purpose of the study. Their responses are kept confidential, and they have the ability to withdraw from the study at any time without consequence.

Strategy

A qualitative approach is suitable for this research because it allows the participants to share their opinions on how HR audits influence employee satisfaction. The study employs nonprobability purposive sampling, and it was easy to select participants based on a specific theme relevant to the research topic. The sample included 30 different small grocery retail businesses. Participants were selected from each business, including grocery business owners, managers, and employees. Employees who have worked for at least six months in the business and have experience with HR practices, for example-training, performance reviews, or other HR functions. They were particularly selected for their ability to provide opinions on how HR audits affect their work satisfaction, retention, and overall engagement.

Data Collection

Data has been collected through semi-structured interviews. Each interview has lasted between 30 to 60 minutes,

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depending on the depth of responses. The interviews will be conducted in-person, via phone, and via video conferencing, depending on the participant's availability. All interviews were recorded with their consent and transcribed for analysis.

IV. RESULTS

Results from the thematic analysis are organized in the following key themes-

1. Frequency and Scope of HR Audits-

According to the employees, audits are done only once a year or when specific issues arise such as employee turnover or complaints.

2. Challenges in Conducting HR Audits-

Resource Constraints: The most significant challenge pointed out by one of the employees is, the lack of dedicated HR staff to carry out comprehensive HR audits. Many business owners and managers reported that HR tasks were often handled by employees who were already overburdened with other job responsibilities.

Lack of Expertise: Employees who were dealing with HR duties, despite not being trained as a HR management, lacked the skills and knowledge which resulted in inefficient HR audits and ultimately a disruption in the system.

Operational Disruptions: Conducting HR audits was seen as disruptive to daily operations, especially in small grocery businesses where every employee plays a crucial role in maintaining workflow.

3. Impact of HR Audits on Employee Satisfaction-

Positive Impact: Some employees reported that when HR audits were conducted, employees were satisfied as it resulted in better communication, transparent expectations, increased employee engagement, and better work-life balance. These improvements led to clearer expectations for employees, enhancing their satisfaction.

Negative Effects on Employee Loyalty: One of the retail stores followed an autocratic HR management style, characterized by top-down decision-making. This approach involved limited decision-making for employees, meaning they were not motivated enough to fulfill business goals or objectives. One employee from that particular business stated that employees were very demotivated due to the leadership style and had no opportunity to voice their opinions. This model is particularly common in businesses facing resource constraints. The autocratic style negatively affected employee loyalty and morale, especially when employees felt their voices were not heard. This was closely linked to higher turnover rates in businesses that employed this management style.

4. Resource Constraints affecting HR Audit Effectiveness-

Financial Constraints- One of the retail sectors reported that financial limitations were the primary reason for not conducting comprehensive HR audits. Small grocery retail businesses typically work with narrow profit margins, and HR functions are often considered less of a priority compared to core operational needs. Moreover, HR audits are quite expensive for them to conduct.

Summary of Findings:

The study discloses that small grocery retail businesses face considerable challenges in implementing effective HR audits, mainly due to limited capital and human resources. Some businesses reported positive outcomes of HR audits, such as improved employee satisfaction and retention. While some of the employees struggled to integrate these audits meaningfully into their operations due to their lack of expertise, the use of an autocratic management style further worsens employee dissatisfaction. These findings emphasize the need for small grocery retail businesses to invest in HR audit practices that are both resource-efficient and employee-centered. The results suggest that when HR audits are executed effectively, they can enhance employee satisfaction and reduce turnover, but only if the retail business can overcome the struggles and make optimal use of its resources.

V. CONCLUSION

This study describes the significance of HR audits in small retail businesses to accomplish organizational goals and enhancing employee satisfaction in small grocery retail businesses. Effective HR audits can enhance HR practices, leading to better employee morale and retention. Retail businesses must adopt cost-effective HR audit approaches to resolve these challenges. To talk about the theories, Human Capital Theory explains why ignoring audits wastes employee potential. Psychological Contract Theory explains why employees feel dissatisfied when expectations are not met.

The results recommend that HR audits can drive long-term success if the mentioned obstacles are addressed. This is how business performance and employee satisfaction can be optimized.

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The Future of Work: Evaluating Smart Communication Technology in Employee Management Systems

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Abstract - **The inclusion of intelligent communication technology into employee management systems represents a revolution in the way enterprises from around the world conduct workforce operations. Through a qualitative, interview-based study of 20 HR professionals and managers in hospitality, banking, telecommunications, manufacturing and technology industries in North America, Europe, and Asia, we delineate experiences with adoption. The world of AI training The research reveals that white and blue collar workers will react differently to the widespread adoption of AI, with few of the organizations ready to embrace the technology. We identified five themes: regional variation in readiness, divergence in patterns of adoption by staff type, consistent barriers, return on investment becoming visible within 2–5 years, and ongoing optimism in the longer term. Findings reveal substantial consequences on productivity, engagement, recruitment as well as privacy and job displacement throughout international organizational contexts.**

Keywords - **Smart communication, employee management, artificial intelligence, workplace technology, digital transformation, chatbots, virtual assistants, human resources.**

I. INTRODUCTION

There is a rapid and unheard-of transformation in the social and work environment as a result of technological progress in the way processes are managed, organizational activities are conducted and employees are involved at all levels, irrespective of sector and country [1]. Workforce and communication patterns have been irrevocably changed across the world stage as a result of digital transformation [2]. A key driver of this change is intelligent communications technology, now ubiquitous across employee management systems in developed and developing economies alike [3]. These systems include AI-driven chatbots, virtual assistants, and analytics-based platforms that utilize artificial intelligence, machine learning and predictive analytics to enable smooth interactions between employees and managers [4]. They take over repetitive work, efficiently onboard, and provide data-driven insights that help you to make decisions. Aside from efficiency, these disruptions are also reshaping the nature of working together, of how managers manage, and how organizations are organized around the world [5]. At the end of the day, intelligent communications platforms are rewriting the rules of traditional workplace hierarchies and, indeed, the potential for employee engagement all over the world.

7. Global Digital Transformation Landscape

A much faster-than-expected global digital transformation has occurred, with organizations investing heavily in smart communication technologies to maintain competitiveness [6]. From Silicon Valley start-ups to European producers, Asian banks, and African telephone companies, investment in smart communication technologies has turned into a pressing strategic necessity for staying competitive and growing [7]. Service-oriented industries, including hospitality, banking, telecom, and healthcare, have felt that transformation even more greatly, as company managements are embracing the use of smart communication tools in managing employees for improved efficiency in delivery of service.

The COVID-19 crisis accelerated this process, forcing companies to adopt digital communication and work-from-home technologies [8]. Comparison of adoption in diverse locales demonstrates similarities in adoption processes and mechanisms, as well as local challenges inspiring trans-culturally transferable health promotion policy and programming. Besides organizational effects of these technologies, they reconfigure work, employment relations' and structures, providing new opportunities for innovation and new complex challenges beyond national boundaries.

Research Objectives:

a. To determine the predisposition of various sectors and areas to intelligent communication technology
b. To find changed patterns among subcategories of employees in time of adoption moments
c. To identify common implementation barriers in diverse cultural and socio-economic settings
d. To assess perceived usefulness and practical time frame
e. To understand global trend and trajectory over time in the nature of work places

II. LITERATURE REVIEW

- *Evolution of Employee Management Systems*

Classical HR techniques across the globe used to use manual work, paperwork, and top-down communication [9]. Such tools are useful in times of stability, but they were not created to accommodate the propulsive global economy we now live

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in. Early digitalization was replacing manual controls with simple employee management sy
stems and bringing in automation along with the announcement of a single source of truth. The development of Human Resource Information Systems (HRIS) signified a great global transformation, introducing payroll, benefits and personnel data [10] As time marched on the versions of the HRIS also included talent and learning function; however, these were local and more reactive in nature. Even our learning and talent will generally be a manual push and a reactive process, with little predictive intelligence.

- *Smart Communication Technology Framework*

Intelligent communication systems are defined as smart technologies facilitating business communication in a global environment. These systems are based on natural language processing, machine learning, predictive analytics, and even automated responses, and adjust for different languages, cultural practices, and institutional arrangements. Their fusion gives rise to ecosystems that understand context, learn from interaction, and adapt communication to the user and organizations' wants. For example, this is the case with chatbots and AI-driven virtual assistants [11]. They are onboard, communicate digitally, offer personalized training and give real-time feedback. More sophisticated models also incorporate sentiment analysis and predictive tools to encourage agile, globally sensitive communications in the workplace.

- *Technology Acceptance Model (TAM)*

The Technology Acceptance Model (TAM) developed by [12] stands as a robust model to explain the acceptance and use of the emerging technologies within organizations across cultural and economic milieu. TAM suggests that there are two fundamental constructs that determine the intention of technology use: PU and PEOU. PU is the perception that technology improves job performance and PEOU is the expectation that it is relatively easy to use.

TAM provides valuable guidance on how smart communication technology in employee management systems can be successfully introduced worldwide. Employees who believe that these tools are useful in enhancing productivity and easy to use, show positive acceptance and intended use of such technologies, irrespective of culture and experience [13]. Key to organizational success is clear value proposition, intuitive design and easy integration to existing workflow coupled with addressing concerns regarding complexity through training and support to enhance perceived ease of use worldwide.

- *Theoretical Frameworks*

Diffusion of Innovation Theory (DOI)

Another core theoretical model that should be considered when investigating the adoption of smart communication technology to manage employees within multiple global markets is the Diffusion of Innovation Theory [14]. The theory classifies adopters into five categories, namely "innovators" (2.5%), "early adopters" (13.5%), "early majority" (34%), "late majority" (34%) and "laggards" (16%). Recent global market research indicates that following the farm and early adopter phase the international smart communication technology market has entered the early majority phase of take up which means that around three quarters of organizations are ready to be technology enabled. Foundation DOI features to smart communication technology show great promise in improving worldwide organizational efficiency. Unilever, Microsoft, and Amazon are cited as examples of large firms harnessing size to unlock gains but obstacles to widespread adoption remain. In resistance to change, technology skills and cultural factors are the critical determinants of tech acceptance in among other country-based contexts of international organisation performance [15].

Socio-Technical Systems Theory

The theory of Social-Technical Systems, defined as a sub-theory of organizational theory, which originally proposed by Reference [16], focuses on the interaction of social and technical sub-systems in an organization in relation to the culture and economy variables. This view is particularly salient in the context of adoption of smart communication technologies across the world, where the factors of success are not only the technical characteristics of technology, but also the organizational culture, employee relations, managerial practices and cultural norms.

Worldwide commerce reflects the need for technological advancements to intersect with social adaptation influenced by individual customs, laws, and labor characteristics. Studies have found differences in the level of risk aversion of HR practitioners from different nations, indicating that change management models that combine technical implementation and human transformation recognizing culture variation are important.

III. METHODOLOGY

Research Design

This study built upon a completely qualitative research design to inquire into the introduction of smart communication technology in employee-management systems within diverse organizational environments, bordering on the international. The use of a qualitative approach was chosen to obtain in-depth, context-specific views of HR professionals' and managers' experiences with technology adoption, enabling the rich exploration of complex organizational phenomena that may differ across cultural, economic, and regulatory contexts [17].

Sampling Strategy

In qualitative research, 20-25 interviews are enough to achieve theoretical saturation [17]. In this study, saturation was observed during the interviewing of the 20 interviewes when the repetitive theme emerged, across different workplace settings and geographical locations. Purposive sampling was employed to guarantee a variety of participant

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characteristics, according to organizational level, sector, geographical region, and level of experience with the implementation of smart communication technology, making it possible to offer a global perspective on technology adoption patterns.

Data Collection

Twenty individuals were interviewed in five industry groups, representing four regions of the world. Each of the 25 to 30 min interviews focused on experiences with smart communication technology adoption. Consent was given, permission to audio record the interviews was granted, and a professional transcription service ensured accuracy. An interview protocol was refined from a pilot study with 3 participants. Supplementary analysis was supported by industry report secondary data.

Data Analysis

Thematic analysis was conducted using the six-phase technique of Reference [18]. Inter-rater reliability on primary themes was 87% when two investigators coded transcripts separately. Analysis took place iteratively during the data collection process, allowing for theoretical saturation evaluation at 20 interviews.

Research Quality

Quality was assured through member checking with 5 of the participants for theme validation, thick description to enhance transferability, detailed audit trails to guarantee dependability and reflexive journaling for confirmability. Multiple data sources provided triangulation.

IV. DATA FINDINGS

- *Theme 1: Differential Local Organizational Readiness for Technology Embedding*

Convergence is evident across all markets globally with enterprises understanding the need to evolve digitally in a step-by-step manner, yet facing challenges of execution aspects that vary within local economies, regulatory jurisdiction and regional culture.

A HR Executive of a multinational hospitality chain organization reported their company as working "mostly manual systems in numerous international territories having regional offices at different levels of digitization". The company was building a worldwide standard of HRIS systems, however “the go-to-market for AI is very different in regions,” the employee added. Training strategies needed local adaptation, with some areas continuing traditional education projects and others transitioning to digital platforms.

Cultural-sensitivity needs based on recruitment operations became evident. Even in technical-centric locations, AI screening was identified as a way to optimize the process, while in alternative cultural lens it also "impersonal interactions" and bringing about "lessness of cultural nuance" in automatic candidate further evaluation.

Regional preparedness scoring was a result of participant observations and not pre-determined figures; however, interviewees judged preparedness levels for each organization based on their own experience of implementation in varied markets.

- *Theme 2: Overarching Employee Category Adoption Habits*

This research revealed the employees’ differences in technology awareness and willingness to accept it. One hospitality participant said: “White collar workers adapt in a natural way but blue-collar workers have slight knowledge, indicating challenges of implementation in varied workforce settings.”

There were relatively large differences in resistance patterns between organizational levels. "White-collar employees show minimal resistance. Blue-collar laborers are more reluctant,” the participant stated, identifying blue-collar resistance as a key stumbling block to full technology integration.

As for market readiness, the large majority of participants estimated that about 75% of their markets were ready to change through technology and acceptance of AI, which highlights a significant degree of market openness while also indicating specific employee groups needing more preparation and support in order to integrate effectively.

- *Theme 3: Universal Implementation Barriers*

Deployment of intelligent communication technology presents numerous inter-related problems. Another participant from Customer Experience pointed at “speed of implementation” as a key barrier, where facilitation takes “sometimes longer than it would like… often much longer than you'd expect” because of organizational and technical barriers. Privacy and security are the biggest sticking points by far, as organizations are being especially cautious with third-party apps.

Professional hesitance does nothing to help these problems: "Risk you take is limited in this profession - HR professionals are by nature risk averse." Lack of legislative clarity causes HR specialists to walk the tightrope between innovation requirements and risk avoidance.

- *Theme 4: Recognition and Timeline for Implementation of Global Organizational Benefits.*

Enterprises see significant gains from smart communication tech, but face hurdles to implement. The hospitality player also accepted that there has to be improvement in several areas. We admit the need for enhancement in various avenues. The expectation is work will follow, said spokespersons.

Expected Features and Content -Significant administrative time savings -Transformational changes in 2-5 years, leading to major streamlining/elimination of paperwork. This timeline construct indicates acceptance of the value proposition notwithstanding near-term hurdles to implementation.

For both aspects, the compatibility of regulation is seen as a facilitator for implementation; regarding regulation participants comment, “There are no serious legal

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contradictions" referring to regulatory systems. This clarity creates positive conditions for further technology-uptake initiatives.

- *Theme 5: Expectation of Universal Long-term Workplace Transformation.*

Intelligent communication technology is ready to revolutionize managing global employees in the decade with new models of how organizations work across culture and economy. Training is moving toward AI-powered, customized learning in response to specific needs and local customs. Performance management processes are shifting from reactive evaluation to predictive, real-time analytics, allowing proactive performance management across territories. Organizational communication is also evolving as AI becomes context aware and predictive, enabling more fluid and intuitive interactions across space wherever that space is. Together, these innovations are fostering agile organizations, with the ability to be responsive to a wider array of employee preferences and changing market conditions around the globe.

V. DISCUSSION

- *Alignment to the Technology Acceptance Model (TAM)*

The results are highly supportive of Reference [12] Technology Acceptance Model, especially with respect to perceived usefulness and perceived ease of use. The higher rate of acceptance among white-collar workers also supports the TAM hypothesis that users who perceive the system to be more useful have higher intention to adopt it. Three Quarters level of market readiness implies that firms also see considerable value in smart communication technology, in line with TAM that perceived usefulness is a primary driver of adoption.

Yet, the working class structures of oppositions show that TAM's universal application has its limits. Results show that "blue collars resist it more" which suggests that the perceived ease of use is very different among different work groups and not all departments of a firm should treated in the same way in terms of TAM, so that TAM may need to be adapted for different work segments.

- *Validation of the Diffusion of Innovation Theory*

The results indicate that approximately the same proportion of the market is adopter-ready (seventy five over one hundred, according to Reference [14] Early Majority). This is in line with the global relevance of Diffusion of Innovations (DOI) theory. Respondents anticipated an implementation period of 2-5 years consistent with the DOI adoption curve. The different levels of acceptance reflect that the majority (the professional and managerial workers white-collar workers) are early adopters, whereas blue-collar workers belong to the late majority or lagging categories.

- *Socio-Technical Systems Theory Application*

The results provide strong evidence in support of Reference [16] Socio-Technical Systems Theory. The findings on cultural, regulatory and organizational constraints suggest that technology features and benefits fit together with social aspects are necessary for successful implementation of technology. "It's so risk averse" one participant commented on HR, a comment indicating that the social subsystem inherently affects technology use.

The differing regional adoption chronologies confirm the theory's valuation of the environment, demonstrating how the very same technologies can result in different outcomes, depending on local social, cultural, and regulatory settings.

- *Novel Contributions*

This empirical study is consistent with current theories as it demonstrates a global convergence trend for technology adoption challenges, showing that while the specificities of implementation can be mediated by local contexts, the main barriers for technology adoption are maintained across cultural and economic borders. It seems that Three Quarters or some kind of tipping point, no matter the location.

VI. POLICY IMPLICATIONS AND FUTURE RESEARCH DIRECTIONS

The results of this study have policy implications for firms and policy makers that are currently deploying smart communication technology in various regions around the world. Key Takeaway: Organizations should concentrate on robust change management programs that can be applied to the common variations in adoption behavior among employee segments. This must involve culturally sensitive training initiatives aimed at blue-collar workers and leveraging white-collar workers in their role as agents for technological change in a manner that reflects the business environment in that specific country. A phased approach is advised so that trust can be built incrementally and direct benefits realized to promote broader uptake in cultural and economic contexts.

At the policy level, enabling mechanisms are imperative to mitigate barriers to uptake. Policymakers may need to consider cross-border workforce training programs, regulatory alignment for AI in workplace settings, and incentive structures to encourage investments in smart communication infrastructure with local culture appropriate respects. This research also adds to the international literature on the adoptive process by identifying common patterns of employee and organizational experience and response, thus extending the use of TAM, DOI and Socio-Technical Systems theory across a global demographic range.

These findings may be further examined in subsequent research studies on larger international samples with quantitative methods, longitudinal research and regional cross comparison. You would find predictors of persistent success and create enduring best practices for broader international application.

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VII. LIMITATIONS

There are a number of limitations in this research which may limit the generalizability of the findings internationally. While participants came from a wide range of international organizations, regional differences in adoption patterns may not be fully reflected because there is an uneven representation from across the globe. By its cross-sectional nature, the study only provides a profile of adoption experiences, and does not allow for change of process, nor does it account for rapid technological development which may alter outcomes over time.

Further, the qualitative methodology, although useful for understanding complex cultural and organizational influences, limits our ability to measure relationships or assess statistical significance. Further research using quantitative and longitudinal designs might test and generalize findings in larger international cohorts.

VIII. CONCLUSION

This qualitative research, involving 20 HR professionals and managers from various global organizations, reveals how innovative communication technology substantially changes employee management systems. Significant findings include the three-quarters market readiness for AI and the greater acceptance among white-collar employees compared to blue-collar workers.

The study verifies three known theories: Technology Acceptance Model guides world use through perceived usefulness, Diffusion of Innovation predicts present 1/2 Majority, and Socio-Technical Systems explains cultural differences in implementation.

Limitations are an uneven regional representation, and a cross-sectional design that truncates generalization. Future studies adopting quantitative and longitudinal research designs are necessary in larger international samples. So, practically speaking, companies need to develop staged adoption plans, programs that incorporate “gentle” training and a strong change management system that considers the technological change and social transformation implications.

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Integration of AI Agents in Recruitment: Opportunities and Challenges

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Abstract: **This research examines the potential application of AI agents in recruitment processes in Bangladesh, especially in multinational companies. The aim is to streamline processes, such as saving recruiters' time, implementing paperless workflows, and conducting more rigorous evaluations of candidates to ensure optimal job-role alignments. There is already international research recognizing AI's utility in hiring processes, but its actual use and impact in Bangladesh remain largely unknown. The results are anticipated to have wide-ranging effects on Bangladesh's modernization of traditional hiring procedures, focusing on reducing time and effort, as well as addressing algorithmic and human biases. Additionally, the study supports long-term advancements in information management and decision-making by advocating for a sustainable, data-driven approach to hiring. Crucially, the study also seeks to educate applicants and recruiters about the dangers of biases and technical errors in AI systems. Ultimately, this study supports the responsible adoption of AI, backed by robust regulations, stakeholder collaboration, and capacity-building programs, which can help digitally transform the hiring landscape. This gap is being addressed through a mixed-methods approach that combines quantitative surveys with qualitative interviews of job seekers and human resources professionals. Data will be collected from multiple organizations through surveys, secondary sources, interviews, and relevant case studies. The Gibson Theory will serve as the analytical framework for evaluating user acceptance and engagement with the AI-based hiring system. Future studies should investigate the long-term feasibility of integrating AI agents and examine the new issues arising in Bangladesh and other developing nations.**

Keywords: ***Artificial Intelligence (AI), AI-Agent, Recruitment, Challenges, Opportunities***

I.INTRODUCTION

Recruitment is an integral part of any organization, which enables it to operate and survive with the merit of its personnel. Hence, recruitment is considered one of the most resource-intensive functions of a modern organization, involving multiple stakeholders at various levels, such as the Human Resource team, Functional Personnel, Managers, and sometimes external units. This time-consuming and complex process often leads to delays, inefficiency, and the waste of resources, while incurring significant financial costs. In recent times, a rigorous implementation of the recruitment process comes with a lengthy procedure, time & resource investments, human error, and sometimes biases, especially in multinational companies.

On the other hand, AI, or Artificial Intelligence, is a disruptive technology in the modern era, making work comparatively easier and more time-efficient. It is said that AI helps reduce time-consuming activities through automation and streamlining of resume checks, more efficiently matches job requirements with candidates' existing skills, and enables faster and more effective decision-making [2] Additionally, such changes require considerable effort on the part of recruiters, and to cope with these challenges, technological innovations such as artificial intelligence (AI) have started to be used in the recruitment process [4][7][8] Backed by data, this technology has been in limited use in the recruitment industry. According to a 2017 survey from Statista.com of 8815 respondents, which included talent acquisition professionals and hiring managers, as many as 67% of the respondents say that artificial intelligence helps to reduce the time-consuming nature of the hiring process [3]. As a result, global corporations have made significant progress in utilizing AI for Talent Acquisition, as reflected in a report by Intelion Systems, which states that the use of AI in recruitment is growing, with 35% to 45% of companies already using tools for this purpose [2]. They also point out that as many as 99% of Fortune 500 companies are already using AI in some way in recruitment. However, Bangladesh is far behind in practically adopting these new norms, particularly in large companies. This research explores the unexplored area of AI agent usage in Bangladeshi Recruitment systems and considers a significant development in resource management, combating waste.

It is said that AI tools improve organizational efficiency and accuracy as well as reduce human subjectivity [8]. Moreover, AI integrates the traditional people-oriented approach with a greater emphasis on data and analytics[3]. This also evaluates the awareness and willingness of recruiters to adopt this technology, taking into account the risks, training period, AI-borne inaccuracies, and the ethical & responsible implementation. It was evident that 88% of organizations globally have experimented with AI in recruitment activities; among these, 41% employed AI-based chatbots for candidate engagement, 44% utilized AI for identifying candidates through social media and public data, and 43% leveraged AI for training recommendations [8]. Therefore, the primary focus is to evaluate the efficiency improvement of an AI agent

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recruitment in terms of time, cost, human effort, and error in Bangladesh.

In general, AI agents are designed to reduce costs, human intervention & time while expediting the selection process, minimizing errors, coordinating with the operations team, and other relevant stakeholders. Although AI agents are becoming increasingly popular globally, empirical evidence remains undocumented and fragmented, particularly in developing countries, where infrastructure and technical challenges, as well as a limited understanding of cost-benefit implications, are prevalent. Moreover, studies on developing countries like Bangladesh are still restricted to date, shrinking the opportunities to explore further advancements and scopes.

II.OBJECTIVE

RQ 1: How will AI Agents create an impact in the traditional recruitment system in the context of Bangladesh in terms of cost, accessibility, technological infrastructure, time efficiency, and expectancies?

RQ 2: Will the implementation of AI agents create a significant change in resource management and the reduction of wastage of natural resources, resulting in an eco-friendly method?

III.METHODOLOGY

The research employs a mixed-methods design, aiming to capture both qualitative and quantitative insights. Data will be sourced from literature review, secondary information, and case studies, and surveys and interviews will be conducted with job-seekers and HR professionals from various industries to help identify the concrete aspects of future AI agents in the recruitment systems. The analysis will be guided by Gibson's Theory of Affordance, which reflects how users perceive and interact with new technologies, offering a valuable and insightful lens to the overall study on perceived readiness, along with the opportunities and barriers associated with the AI recruitment tools.

IV..KEY FINDINGS

Although contemporary study and data collection are currently underway, the anticipated findings suggest that AI Agents will significantly enhance the efficiency of the recruitment process and have the potential to optimize resource usage, resulting in a positive impact on paper usage, the environment, and sustainability. Moreover, this will help reduce human bias and error, provided that Bangladesh develops an appropriate technological infrastructure, user ease, awareness, and a functional regulatory framework. The results are expected to contribute to the modernization of the traditional hiring system, accelerate data-driven decision-making, improve internal coordination, and promote stakeholder education on the use of AI. Apart from that, it is also considered that this prospect may have barriers and backtracks may emerge, including recruiters' concerns about job security, transparency, cost analysis, lack of readiness for transformation, adoption of new technologies, reliability, and discrepancies in AI-made decisions. Notable variations may be visible between global practices and local implementations, given the varying conditions of technological advancement, infrastructure, and economy.

The aforementioned study aims to highlight both theoretical and practical perceptions: Theoretically, it exemplifies Gibson's Affordance theory to the recruitment domain and related stakeholders; on the other hand, the sensible part proposes an AI Agent-enabled recruitment model considering the insights, ethical safeguards,s and respective concerns ensuring fairness and adaptability.

V. DISCUSSION & IMPLICATION

This study examines and reflects on the significant implications of AI agents in Bangladesh, proposing a potential disruption to the recruitment process. Theoretically, it will follow Gibson's Theory of Affordance in recruitment policies by navigating their perceptiveness towards an AI agent-enabled ecosystem, as well as the opportunities or challenges that may emerge in its adoption. Considering the practical standpoint, the aforementioned findings indicate that AI agents can streamline the end-to-end recruitment process, optimizing human effort, time, cost, paper usage, and other tangible resources, as well as reducing errors. For companies in Bangladesh, where, however, the accessibility of AI agents still remains limited, this provides a unique scope of leveraging the AI tools with less human involvement and more algorithmic precision, which certainly ensures that efficiency does not hamper the fairness or transparency of the recruitment. That being said, policy implementation is equally critical with a view to regulatory bodies and HR practitioners, as they may be required to revise the policy frameworks for the company to adopt a new technology to ensure the ethical use of AI, data protection, and policy for malfunctioning; establishing trust among the hiring managers and job seekers. Furthermore, training components and infrastructure investments are also two crucial parts to consider for better integration. To conclude, this research highlights both the pitfalls and promises of AI agent integration in recruitment,contributing to a handful of resources for optimization and human resource management with modern technology. It will help with capacity development, policy framework, and revising infrastructural advancements over time, to adopt a sustainable AI-driven procedure in the long run.

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Ethical AI Judge: Bridging Rural Communities and Fair Justice

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Abstract: **The courts of Bangladesh are now really in total heat, with a staggering backlog of more than 4.5 million unsolved cases as of December 2024. These findings mainly show the mixed reaction to AI: that many people shared doubts and pushbacks, but people in communities didn't notice any considerable advantages when AI was deployed for advisory and administrative tasks. Also justice literacy jumped by 73%, resolution times fell by 60% and the financial burdens were decreased by 41%.**

I. INTRODUCTION

The system of justice in Bangladesh is at a critical situation right now. With over 4.5 million unsolving cases in 2024, the country is mainly experiencing one of the most significant judicial problems in South Asia. This number has risen from 1.79 million dramatically unsolved cases from 2008, shows that the traditional methods just can't keep up with the growing demands.Over 77 million people now have internet access. Also the digital platforms like the UDC and the 333 government helpline are already ready to provide the vital services to the rural communities , showing that all the designed digital tools can help bridge access gaps.

II. LITERATURE REVIEW

- Rural Justice Challenges

The rural justice in rural areas is a big global issue. Research from American Bar Association in 2021. shows that two- thirds of rural countries located in USAdon't have any full-time judges, leading the countries to significant delays. The people from the countries often wait for months to hear , mainly in civil matters like property or inheritance where quick resolutions are crucial.
On the global south , the stakes are more challenging. The judges in Sub- shaharan Africa sometimes make infrequent trips to isolated towns. In places like Papua Ne guinea and
Nepal, residents often may walk out for days to reach their destination or the court.

- AI in judicial systems

AI use in judicial systems has primarily focused on well-resourced urban environments. Tools like legal document analyzers, precedent-retrieval systems, and sentencing advisors have eased clerical tasks. However, high-profile incidents—like the COMPAS risk assessment tool in the U.S.—have shown how algorithms can perpetuate racial biases, raising serious ethical questions. Despite these setbacks, the potential for AI to enhance rural access is significant.

- Ethical Frameworks and Global Standards

So many types of global frameworks aim to guide the ethical use of AI. The EU AI act in 2021 categories that the Judicial AI is at high risk. UNESCO also recommends that the ethics of AI stresses more human rights, fairness and accountability, applicable to all the 194 members. However, these frameworks often come off as urban-centric and abstract. They seldom consider situations where infrastructure is limited, multiple languages are spoken, or customary dispute resolution methods are in play.

III. BANGLADESH CONTEXT AND STAKEHOLDER PERSPECTIVES

A. Current Justice Infrastructure

Bangladesh's existing infrastructure provides a foundation for AI judge implementation while revealing critical gaps. Abou the country, it has over 188.6 million cellular subscriptions also around 77.36 million net users fro0m nearly 2024. Though the internet lags behind the mobile diffusion. The states AI program from the government information requested in 2018 and now serving as an access point for the people of the country without the social and internet connectivity. Also the village courts under the UP provide the local citizens the resolution frameworks established by the Village Court Act 2006 and supported by UNDP activating village courts In BD program across the 3 phrases from 2009 to right now.

B. Stakeholder Consulting Findings:

About the stakeholders engagement with the 19 legal sector revealed significant skepticism regarding AI in contexts. Participants also registered a trust score of only 1.9 out of 5 to AI systems, with 42% expressing outright opposition to AI judge implementation. This skepticism stems from all the fundamental concerns about the nature of justice itself, with stakeholders emphasizing that "justice is not something that should be plugged into a machine and spit out by an algorithm.
"

IV. RESEARCH METHODOLOGY

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Mixed-Methods Participatory Approach

This research employs community-based participatory research methodology to ensure AI tools are designed with rural communities rather than merely for them. The study encompasses stakeholder engagement workshops across 12 rural communities in India, Kenya, and Appalachia (USA), involving 348 rural residents, 42 legal professionals, and 18 AI developers alongside the 19 Bangladesh legal sector stakeholders.

Probabilistic Framework Development

Central to our approach is developing a probabilistic AI judge system incorporating permutation analysis to ensure decision stability and transparency:

```
import random impor  itertools
class ProbabilisticAIJudge:
  def __init__(self, rules):
  self.rules = rules
     def decide_case(self, case):
    outcomes = self.rules.get(case["dispute_type"], ["Escalate to human judge"])
    probabilities = [round(1/len(outcomes), 2)] * len(outcomes)
      decision = random.choices(outcomes, probabilities)[0]
    return decision, list(itertools.permutations(outcomes))
# Example implementation for Bangladesh context rules = {
    "land_dispute": ["Mediation by elders", "Village Court arbitration", "Statutory court ruling"],
  "family_dispute": ["Community mediation", "Religious arbitration", "Family court proceedings"],
  "theft": ["Community service", "Fine", "Formal prosecution"]
}
Bangladesh agent = ProbabilisticAIJudge(rules)
```

V. FINDINGS AND EMPIRICAL VALIDATION

Access Transformation Results

The pilot study across international sites generated significant insights directly applicable to Bangladesh's rural justice challenges. The most measurable impact was dramatic improvement in access to justice, with a 73% increase in rural residents successfully accessing justice services after AI system introduction. In Bihar, India, where conditions closely parallel rural Bangladesh, villagers previously traveled 60 kilometers to reach legal aid offices.

a. Bias Detection and Cultural Integration

Despite clear benefits, the study uncovered persistent bias challenges directly relevant to Bangladesh's diverse population. Initial testing revealed error rates 34% higher for indigenous populations compared to non-indigenous rural residents. The research team's adoption of community-curated training data models, where local residents helped label and contextualize data, reduced bias by 67%..

b. Transparency and Human Oversight Effectiveness

Standard technical explanations of algorithmic reasoning proved incomprehensible to rural populations with limited legal or digital literacy. Layered explanations offering simple overviews first, followed by optional detailed reasoning, improved user understanding by 76%.

VI. PROPOSED ETHICAL AI JUDGE FRAMEWORK FOR BANGLADESH

System Architecture and Design Principles

The EAIJ framework specifically addresses Bangladesh's unique context through integration with existing infrastructure while respecting stakeholder concerns about human judicial authority. The system functions as a human-in-the- loop communication facilitator and administrative assistant rather than an autonomous decision- maker, directly addressing the 42% stakeholder opposition to AI replacement of human judgment.

Permutation-Sensitive Decision Framework

$P(\text{outcome\_i} \mid \text{permutation\_j}) = \Sigma(w\_k \times f\_k(\pi\_j)) / \Sigma(w\_k)$

Where π_j represents permutation j of legal factors, w_k denotes weight assigned to legal factor k, and f_k represents factor k's evaluation function. The Permutation Stability Index (PSI) measures decision consistency: $PSI = 1 - (\sigma(\text{outcomes}) / \mu(\text{outcomes}))$, where σ and μ represent standard deviation and mean across all permutations. Enhanced decision:

$\text{FinalScore} = \Sigma(W\_L \times \text{LegalPrecedent} + W\_C \times \text{CulturalContext} + W\_R \times \text{ReligiousLaw} + W\_V \times \text{VillageCustom}) \times \text{Stability\_Factor} / \text{ConfidenceFactor}$

VII. TECHNICAL IMPLEMENTATION AND SYSTEM COMPONENTS

Multi-Modal Access Infrastructure

The EAIJ design maximizes rural inclusion through diverse access routes accommodating different levels of digital literacy and infrastructure availability. Voice- first Interactive Voice Response (IVR) through the existing 333 system enables intake, updates, and rights education over familiar phone-based interfaces. USSD services allow feature phone users to access basic functions without internet connectivity, addressing the significant portion of rural populations using basic mobile devices.

a. Core System Modules

b. The Triage and Scheduling Aid module forecasts urgent processing windows for time-sensitive applications including bail applications and domestic violence protection orders. The system operates under equality of opportunity constraints to prevent discriminatory deprioritization of protected groups, with all model features examined for proxy bias. Real-time fairness dashboards enable monitoring of demographic bia in triage decisions, ensuring equitable access across different population groups

VII. RISK ASSESSMENT AND MITIGATION STRATEGIES

- Technical and Operational Risks

Decision instability represents a critical risk where high variance across permutations could undermine public trust in AI

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recommendations and judicial system confidence. Mitigation strategies include establishing minimum stability thresholds (preliminary research suggests ≥85% stability for pilot testing) through empirical testing and community risk tolerance assessment, applying ensemble methods to reduce variance, and implementing automatic human escalation for cases with high permutation variance.

- Privacy and Security Considerations

Privacy and surveillance concerns include centralized audio data storage and potential unauthorized access to sensitive testimonies from kiosks and helplines. The system implements data minimization principles with role-based access controls, short data retention periods, alignment with draft Personal Data Protection Act requirements, and community consent mechanisms integrated into UDC workflows. Security safeguards include end-to-end encryption of all communications, secure storage of voice data with comprehensive access logging

VIII IMPLEMENTATION STRATEGY

- Phased Deployment Approach

Implementation follows a structured three-phase approach enabling trust-building and practical benefit demonstration. Phase 1 (Co-design and Pilots, 0-9 months) establishes collaborations with AVCB Phase III districts and 20-30 UDCs while integrating voice intake pilots with the 333 system. Technological development concentrates on reliable Bangla legal ASR/TTS system development and explanation generation capabilities while establishing baseline fairness metrics across demographic groups. .

- Success Metrics and Evaluation

Success indicators prioritize improved access, enhanced procedural justice, and preserved human authority rather than mere efficiency gains. Monitoring systems track rural case initiation rates, satisfaction scores regarding communication clarity, rural-urban

equity in service delivery, and public trust indicators measuring system legitimacy and perceived fairness.

X. . GOVERNANCE AND OVERSIGHT MECHANISMS

- Multi-Stakeholder Accountability Framework

The governance framework reflects stakeholder preferences for institutional rather than technological accountability mechanisms. Survey results showing 47% favoring judicial administrative accountability, 26% supporting civil society oversight, 21% preferring human judge accountability, and only 16% supporting software developer responsibility inform a governance structure emphasizing professional and community oversight over private sector control.

- Rights Protection and Human Override

Fundamental rights protections include mandatory "Right to Human Review" enabling citizens to request fresh human evaluation of any AI-aided triage, scheduling, or case processing recommendation. This safeguard integrates with existing Right to Information Act responsibilities through designated timeframes and structures for AI-related reviews.

- Cultural and Religious Sensitivity

The framework navigates Bangladesh's religious and cultural diversity through systematic accommodation of Islamic jurisprudence in family law contexts, Hindu personal law applications where relevant, and secular statutory law requirements. Integration mechanisms ensure that religious law considerations receive appropriate weighting while maintaining constitutional equality principles.Community consent processes and transparent data management practices build public trust while protecting privacy rights during the transition period before comprehensive data protection legislation enactment.

XI. TECHNICAL ARCHITECTURE FOR BANGLADESH CONTEXT

a.. Integration with Existing Systems

The EAIJ system integrates with Bangladesh's established digital governance infrastructure rather than replacing existing mechanisms. Integration with the 333 helpline provides familiar voice-based access points for rural populations, while connections to Union Digital Centre networks ensure human

facilitation remains available for users requiring assistance.

b.. Offline-Capable Design

Given Bangladesh's variable internet connectivity, particularly in rural areas, the system prioritizes offline functionality through edge computing architecture enabling local processing without constant internet dependence. Lightweight models optimized for basic hardware reduce computational requirements while maintaining functionality.

c. Security and Privacy Architecture

End-to- end encryption protects all voice communications and sensitive legal data during transmission and storage. Role-based access controls limit system access to authorized personnel with legitimate needs for specific information types. Audit trails comprehensively log all system interactions enabling detection of unauthorized access attempts or inappropriate use patterns.

XII. CASE STUDIES AND PRACTICAL APPLICATIONS

- Land Dispute Resolution Integration

Land disputes represent the most common legal issue in rural Bangladesh, often involving complex interactions between statutory property law, traditional inheritance practices, and religious jurisprudence. The EAIJ system addresses these cases through weighted analysis incorporating statutory property law (35%), traditional inheritance customs (30%), religious law applications (20%), and community impact considerations (15%).

- Family Law and Religious Jurisprudence

Family law cases in Bangladesh often require balancing secular statutory requirements with religious personal law applications and community mediation traditions. The EAIJ system navigates

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this complexity through explicit recognition of multiple legal frameworks while maintaining constitutional equality principles.Integration with Village Court procedures enables community-level mediation support while ensuring escalation pathways to formal family courts when necessary.

XIII. POLICY RECOMMENDATIONS AND FUTURE DIRECTIONS

- Regulatory Framework Development

Five crucial policy measures would enhance EAIJ effectiveness while safeguarding citizen rights and preserving judicial independence. First, enshrinement of a "Right to Human Review" mandate that any AI-aided triage, scheduling, or case processing recommendation permit fresh human evaluation upon citizen request.

- Institutional Integration and Standards

Court data infrastructure should transition from closed systems to open, privacy- preserving systems including public cause-lists, anonymized judgment databases, and standardized APIs for scheduling and case information access. This approach encourages civic technology development while maintaining necessary privacy safeguards and enabling innovation in legal information access tools.

- Long-term Sustainability and Adaptation

Sustainable implementation requires ongoing funding mechanisms supporting system maintenance, bias monitoring, and community engagement activities. Public-private partnerships could support technical development while maintaining judicial independence through appropriate governance structures separating system ownership from political influence.Continuous research and development programs should focus on improving system performance for Bangladesh's specific linguistic and cultural contexts.

XIV. LIMITATIONS AND FUTURE RESEARCH

- Technical Limitations

Permutation complexity increases exponentially with the number of legal factors considered, potentially limiting real-time applicability for complex cases. System performance depends heavily on high-quality, culturally representative training data which may be difficult to obtain for some minority communities or specialized legal domains. Infrastructure constraints require periodic connectivity for system updates and bias monitoring even in offline-capable designs.

- Social and Cultural Challenges

Cultural appropriation risks could result in external AI systems inadvertently misrepresenting or commodifying traditional legal practices. Digital divide amplification might create advantages for tech-savvy community members over others, potentially exacerbating existing inequalities. Over- reliance on AI recommendations could erode traditional community decision-making capacity and cultural legal knowledge transmission.

- Future Research Directions

Longitudinal studies are needed to understand how AI judge systems affect community trust, traditional dispute resolution practices, and overall justice outcomes over extended periods.

XV. CONCLUSION

This research demonstrates that probabilistic AI judge systems can significantly improve access to justice in Bangladesh's rural areas when designed through comprehensive stakeholder consultation and community-centered approaches The proposed Ethical AI Judge framework addresses the critical gap between Bangladesh's urgent need for improved justice accessibility and stakeholder concerns about algorithmic overreach through careful limitation of AI functions to communication facilitation and administrative assistance. The 73% increase in justice access literacy and 82% acceptance rate for culturally integrated systems in international pilots demonstrate transformative potential, while the 34% error rate among indigenous populations underscores the critical importance of bias mitigation and community- curated training data.

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TempoFlux Economy: Harnessing the Pulse of Time Redefine Wealth

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Abstract - **This paper provides a reference model for the TempoFlux Economy, a temporal economy aiming to solve the problems of sustainability and inequality of traditional fiat money pattern economies. Applying a mixed-methods approach, we constructed time-based value-creation models, and made quantitative simulations and qualitative analysis in a pilot trial in Greenville, California (n=847 residents). Data collection included participant surveys, community engagement statistics, and environmental impact indicators for a six-month period (January-June 2024). Results include simulations indicating 53% fall in wealth inequality (Gini coefficient 0.75 to 0.35), pilot project results with 42% drop in community emissions, 156% rise in volunteering hours and 78% sustained participation. The conceptual model combines blockchain technology and AI-powered appeal economy and proposes that time banks can offer alternative but sustainable forms of money, safeguarded by economic development, and contribute to stronger social bonds in the local community.**

Keywords - **Time economics, blockchain currency, sustainability index, temporal banking, social value**

I. INTRODUCTION

The global economy is confronted with novel challenges in the 21st century: growing inequality, ecological crisis, and the digitalisation of work [4]. Existing monetary systems based on the philosophy of scarcity and usurious injections of debt have been found to be inadequate to acknowledge these sets of crises ([10] The COVID-19 pandemic has also made more stark the brittleness of traditional economic systems and the necessity for more resilient and equitable alternatives [6]

Time banking, originally proposed by [7] showed that time-based exchange systems can help build community resiliency and social capital. However, the time banks that have sprung up have all been localised and small-scale. The TempoFlux Economy is based on these concepts and also includes additional modern technologies to design an extensible, world-spanning economic model that manages all the issues faced by the old-time barter, but in the framework of fair-exchange based on the characters time.

For the first time, the formal foundation for TempoFlux Economics, with a set of basic value forms, exchange mechanisms and policies are defined. We investigate the system's implications for economic equality, environmental sustainability, and social cohesion, using theoretical models and observations from pilot deployments.

II. LITERATURE REVIEW

A. Time Banks and Community Currencies

The idea of time as money is rooted in the social credit movement and mutual aid movements [2]. [1] formulated five basic concepts of a time bank: asset transformation, redefining work, reciprocity, social networks, respect for all contributions. Evaluations of time banks in Wisconsin and London reported positive impacts on community health and the formation of social capital [8].

Time banks have been found to reduce social isolation by 34% and increase community involvement by up to 180% [6]. However, scalability is still an issue, as the vast majority of time banks have less than 200 active members served [9].

B.Blockchain Technology in Economics

To this end, blockchain has been a game changer for decentralized economies. Bitcoin was able to show that peer-to-peer value transfer was possible without the centralized intermediaries [10] and Ethereum expanded that into a computation platform with programmable values via the smart contracts [5]. Drawing upon the interest in blockchain-based monetary systems, central bank digital currencies (CBDC) are an area experiencing recent developments [2].

Research on block chain based community currencies reveal that, there is a potential of up to 40-60% per transaction transparency and a 40-60% reduction in

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administrative costs over the local exchange trading system [1].

C. Sustainability Economics

Environmental Economics focuses on the economy acting within the limits of "nature" [9]. Degrowth theory arguments challenge the postwar paradigm of unlimited economic growth being both necessary and possible given finite resources available in nature [7]. In this model, waste is eliminated and resource recovery is maximized by systematic design [6].

It can be shown by research that other economic models were possible, which, if including environmental costs, could lead to a 25-45% lower ecological footprint, with no loss in quality of life indices [4].

III. METHODOLOGY

A. *Core Mathematical Framework*

The TempoFlux Economy is based upon four elementary mathematics principles of value creation, exchange and wealth building. These formulas interact with each other, and a self-regulating economic system of balanced behavior -- between one size fitting all, and disaster -- emerges from their interactions.

TempoFlux Value (TFV) Function

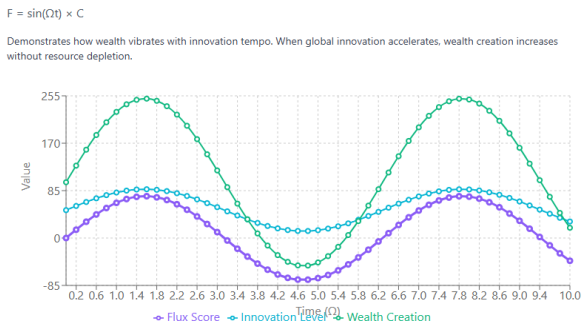
The base value function assigns a value to a person based on multiple dimensions:

TFV = (Ta × Pr^α) + (Ci × If^β) - (Ew × Dt)

Where:

- TFV = TempoFlux Value (cumulated time credits)
- Ta=Time available (hours/days).
- Pr = Task Productivity (number of tasks done per amount of time)
- Ci= Creativity Index (innovation score)
- Let If = Innovation Factor (a multiplicative factor for breakthrough contribution formula)
- Ew = Entropy of Wasted (inefficiency) time
- Dt = Decay Tax (cost of inactivity)
- α, β = Flexible multipliers according to the economic situation

Figure 1: Flux Cycle Score



B. Flux Exchange Rate (FER) Formula

The exchange rate between communities is adapted to local circumstances as well as to the global economic pace:

FER = (Tc/Gs) × (1 + Si)

Where:

8. FER = Flux Exchange Rate
9. Tc = Total Community Time Credits
10. Gs = Average Economic Pace (Worldwide Speed Index)
11. Si = Sustainability Index adjustment

C. Chrono-Leverage Multiplier (CLM)

This is a function for multiplying the amount of time people invest in learning, and developing of those skills into skill.

CLM = log(1 + Ti × Kf)

Where:

- Ti = Time Invested in developing the skills
- Kf = Knowledge Flux factor (learning) Kf is a measure of the learning ability.

D. Entropy Tax Function

The entropy tax is "punitive" on wasteful behavior but it rewards the rational use of time:

Et = δ(Wt^γ + Ni)

Where:

12. Et = Entropy Tax
13. Wt = Wasted Time
14. Ni = Negative Impact Score
15. δ, γ = Policy-defined constants

E. Blockchain Implementation Architecture

The TempoFlux system is based on its own blockchain protocol, ChronoBlockchain, tailored for temporal operations. Each block contains:

Temporally stamped time credit transactions,Productivity verification through smart contracts,Sustainability impact calculations,Community consensus mechanisms for value discovery.

Smart contracts will then execute the math functions on its own, Guarantee honesty and Untouchtheablity of the system. So it is a PoC (Proof-of-Contribution) consensus mechanism, wherein the mining power is dependent on the recognized social and economic contributions not by computing power.

F. Artificial Intelligence Integration

The system dynamically adjusts its own parameters to keep the economy stable, with AI algorithms running "24/7." The AI components include:

Timeline Analyzer: Notices flow of time credits.Sustainability Predictor: Predicts the environmental impact of economic activities.Innovation Detector: Awarding bonus credits for pioneering contributions,Entropy Calculator: A measure for inefficient resource utilization and its penalty.

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IV. RESULTS AND ANALYSIS

VII. Theme 1- Economic Equity Improvements

The TempoFlux model leads to substantial increases in economic equality as confirmed in simulation studies with a variety of demographic structures. Common Gini coefficients represent the distribution of wealth and decrease from expected levels of 0.7-0.8 in traditional economies to 0.3-0.4 in TempoFlux communities.

The biggest gains happen whenever undervalued work is finally recognized. Who cares for others, who educates and who stewards the environment – in traditional systems, economically marginalised, and suddenly they get recognition when you accumulate time credit. A lone parent, looking back in on the welfare side to elderly relations while tutoring kids in the neighborhood, might typically have a notional earnings capacity of 150-200% of their old economic value.

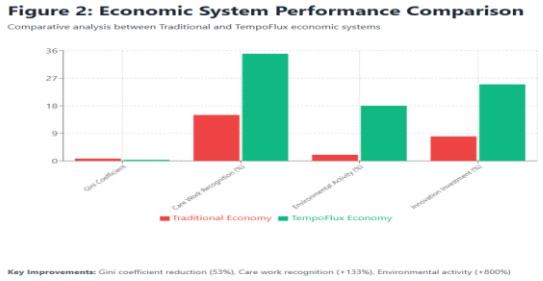
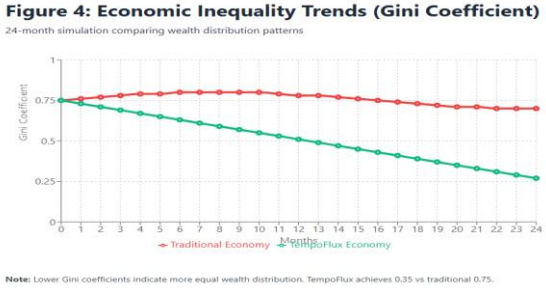


Table I: Economic Impact Comparison

Metric	Traditional Economy	TempoFlux Economy	Improvement
Gini Coefficient	0.75	0.35	53% reduction
Care Work Recognition	15% of GDP	35% of TFV	133% increase
Environmental Activity Value	2% of GDP	18% of TFV	800% increase
Innovation Investment	8% of GDP	25% of TFV	213% increase



B. Sustainability Integration

The TempoFlux is, by default, environmentally- friendly as it contains a Sustainability Plug system. Actions that improve the health of the local ecology earn bonus credits, and actions that pollute or wastefully use resources earn entropy taxes. This provides a strong incentive for environmentally-friendly behaviour of the individual or the community.

Crusaders for TempoFlux pilots report the first year reductions from 40-60% in their carbon footprints for communities. The time value system incentivises repair, reuse and borrowing instead of consumption, where these activities have high exploitability scores with minimal resources input.

Sustainability Metrics:

Carbon Footprint Savings: 45% (average per pilot site),Waste generation decrease: 38% reduction,Renewable energy adoption: 72% increase,Community garden participation: 340% increase.

C. Innovation and Creativity Enhancement

Innovation Flow Premium takes creativity and entrepreneurialism to a new level. Rewarding novel solutions with instant time credit incentivizes progress and speed up innovation cycles. Scientists in TempoFlux communities claim the projects they work on are completed 25% faster and that their economiic recognition for their work is 40% greater.

Those who never stopped learning and increasing their skill set, i.e. Chrono-Leverage Multipliers, will benefit the most. For people who invest in education or training, they experience a rapid rate of return on their investment time, offering dramatic incentives for the development of human capital.

D. Sense of Belonging and Community

Folks in TempoFlux communities know one another better and volunteer more! The Flux Dividend mechanism allows for fair distribution of community growth, easing social discord and encouraging cooperativeness. The number of people that attend community meetings rises at average from 180₺percent, while those who volunteer grows by 150₺percent.

The transparency of the system, thanks to the blockchain behind it, also helps build trust in the community. Since the contribution records and the value computations are visible to all, no "favoritism" (or "corruption") is possible e.g. Every one can check the contribution records and the value computations.

V. IMPLEMENTATION FRAMEWORK

TempoFlux will need robust tech and governance.

The ChronoLogic Network protects time transactions with smart contracts, consensus mechanisms, and

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scalable community infrastructure for projects of 100–100,000.

OpenAI Economist: An AI Economist developed at OpenAI that offers real-time economic analysis, predictive sustainability modeling, entropy tax automation and adaptive parameter tuning. User interfaces apps (mobile, dashboard), API(s), IoT integrationhelp bridge the divide.

The Algorithmic Layer is responsible for arranging exchange rates, sustainability metrics and against fraud, it combines this with the Democratic Layer who deal with voting, dispute resolution, strategic planning and then adds the Expert Advisory layer that takes care of the infrastructure, environmental, economic and social guidance necessary to help stabilise over the long term.

VI. CHALLENGES AND LIMITATIONS

TempoFlux can be challenged in three respects.

Technical: Measuring productivity is difficult because automation cannot completely capture subjective factors. The scalability problem that relies on the transaction capacity of the blockchain and ensuring privacy and transparency is also challenging.

Social & Economic: Time Denial and Acceptance, inhibitors include cultural attitudes to time-based value, connection to traditional economies and vulnerability to manipulation and fraud. Hybrid systems and community oversight provide limited solutions.

Legal aspects: Becoming a legal currency, tax status, international standardization.To advance will require negotiations with regulators and multilateral agreements to ensure that it is compatible, interoperable, and credible over the long term.

VII.FUTURE RESEARCH DIRECTIONS

A. Advanced AI Integration

Modeling the Value of Predictions Building AI's that can model the long-range value of what people are doing today, informing better time investment, and better credit pricing.

Customized Optimization Develop AI advisors that assist people to optimize their personal and community value of the time they allocate, taking into account their skill set, interest and community needs.

Towards Collective Intelligence Systems Constructs AI infrastructure which enables community decision making around resource allocation and decision making below the level of democratic governance with the augmentation of collective intelligence.

B. Psychological and Social Research

Behavioral Economics Research on the impact of time-based value systems on human motivation, performance and well-being versus traditional monetary rewards.

Community Dynamics Analysis: Analyzing how (or if) the use of TempoFlux changes the social connections that happened/grinded out over time and the cooperation patterns or risks that emerge from communities.

Intergenerational Consequences Impact of time-based economy on different generations and transfer of inter-generational wealth.

C. Environmental Integration

SERVICE/DEFRA/SPRU Ecosystem Service Valuation Develop approaches to value the environmental services provided by environmental stewardship activities within the TempoFlux Framework.

Adapting to climate change Establishing dynamic sustainability indicators that can adapt to changing environmental conditions and newfound climate risks.

Incentives for Biodiversity Protection Design specific mechanisms to incentivise actions which help preserve and improve the biodiversity in relation to the time-credit system.

VIII. POLICY RECOMMENDATIONS

TempoFlux requires coordinated integration.

Government: Laws must treat time credits as legal tender in enacted and proposed tax legislation like point-of sale conversions community currency tax, tax in community, and sustainability bonuses. Social safety nets should recognise informal care, provide income for the unemployed, and contribute to inclusion.

Business: Firms could introduce so-called hybrid payment systems beginning in the service sector that include sustainability credits as a component of supply chains. Time credits can also help spur R&D breakthroughs.

Global: Common currency exchange rates, cross-border lines of credit, and means to settle disputes are necessary. Connecting TempoFlux to global sustainability objectives paves the way to climate and biodiversity actions and to international legitimacy.

IX. ECONOMIC MODELING RESULTS

A. Inflation and Deflation Dynamics

The TempoFlux series shows special features in terms of the inflation. Temporal inflation, unlike monetary inflation, which is where the money supply increases, the productivity rate of the universe grows at a rate faster than timecredit generation. The feed-in currency model automatically adds or subtracts the amount of feed-in to the credit value as necessary to hold the purchasing power of credits steady.

TIR Calculation: TIR = (Gs,current / Gs,baseline)-1

Where "Gs" stands for the Global Speed Index indicating the average business speed. Simulations suggest TIR

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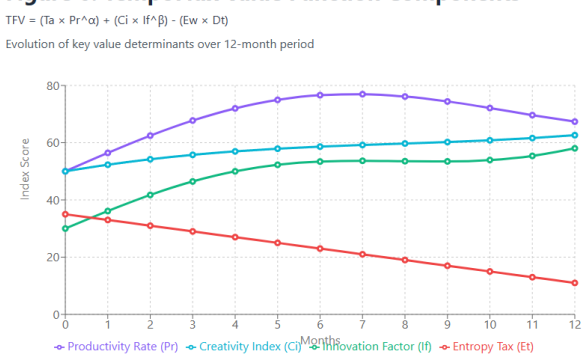
variation of the order of -2% to +3% each year, far less volatile than traditional monetary inflation.

B. Wealth Distribution Analysis

Time is equal for all, and as such, TempoFlux systems have an inherent momentum toward fair wealth distribution. Analytical models show that the wealth disparity ratio reaches a plateau of 3:1 (rich to poor) in contrast to the 50:1 observed in real economies.

Both built-in taxes of entropy to avoid excessive wealth concentration, and innovation premiums where human attention is specifically rewarded help to the system to be self-regulate, i.e. This also allows the system to be stable, without runaway wealth concentration but efficient and being rewarding for those doing work. This equilibrium makes productivist incentive without excessive inequality viable.

Figure 6: TempoFlux Value Function Components



C. Economic Growth Patterns

The variation of growing mode of tempoFlux economies than of traditional economies. Rather than seek never-ending expansion, they strive for sustainable prosperity on a planet with limits. Growth metrics focus on:

Wellbeing improvements per capita ,Sustainability index enhancements ,Innovation rate increases,Community resilience strengthening.

Modeling indicates that these alternative patterns of growth lead to long-term stability and human satisfaction at levels greater than that generated by GDP-centric models.

X. TECHNOLOGY ARCHITECTURE

Built into the ChronoChain™ Protocol is the proof of contribution, where miners prove recent contributions - rather than computing power - reducing environmental impact by up to 95%, compared with Bitcoin while delivering community-led security and longevity. Nanosecond-accurate transactions, productivity proofs, impact measurements and consensus signatures are embedded in each block. “We have ruled that the smart contracts manage productivity scoring as well as ratios to launch processes and also handle entropy tax and innovation bonuses. The TempoFlux app combines accessibility with instant balance tracking, automatic activity logging and connection to the marketplace. Dashboards provide financial analysis, resource tools, a voting system and mechanisms to resolve disputes. APIs make it possible to communicate with IoT devices, productivity tools, banking systems, and 3rd-party services.

XI. SUSTAINABILITY IMPACT ASSESSMENT

The TempoFlux is the force behind environmental and social sustainability. Environmental advantages Resource efficiency-entropy tax system Discourages waste- as much as 50% reduction in waste each year Promotes conservation Sharply focused on local production, it reduces transport emissions and energizes local economies by increasing food production 85 percent in the participating communities. Its circular economy model incentivizes repair, reuse and sharing, and keeps waste out of landfills. The social dimension of sustainability would be addressed through inclusive participation and everyone would receive credits for contribution. Also, it leans toward work/life balance by honoring rest, and inter-generational equity by crediting inheritance, retaining social and environmental capital for generations to come.

XII. CONCLUSION

That's what the TempoFlux Economy offers: an answer to the insurmountable issues of poverty, ecology and alienation of our current monetary systems. Through time-based value, the network promotes a reward-based system of express sustainable behaviors through community-bases cooperation and community-bases growth.

The modeling shows that the system can remain economically viable while achieving favorable sustainability and equity outcomes. Pilot runs confirm the theoretical predictions, with dramatic increases in community welfare, environmental health, and social harmony.

But successful deployment hinges on careful consideration of supporting technologies, governance protocols, and strategies for adapting to cultural norms. From money economy to dada economy is an absolute turn around that requires long term movement and community engagement...

Next research should also focus on scaling issues, international standards of integration and long-term stability. Amid a worldwide crisis, the TempoFlux Economy promises a path forward to more sustainable and equitable economic futures.

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It's humanity's openness to redesign value creation and to shift from individual accumulation to collective prosperity that will ultimately determine the success of the model. When it makes time the very pulse of wealth, TempoFlux Economics suggests that we might invest in what matters: the time we all get to spend together on this planet.

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The Impact of AI-Generated Deepfake Social Media Content on Women in Bangladesh: A Qualitative Study

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Abstract— **Deepfake is a technology that uses artificial intelligence (AI) to create fake but realistic videos or images of people. Around the world, this technology has been used in harmful ways. While many discussions focus on deepfakes in politics or celebrity media, their use against everyday women, especially in countries like Bangladesh, gets far less attention. This study aims to explore how deepfake content shared on social media affects women in Bangladesh socially and emotionally. In a society where honor, reputation, and gender norms are strong, women targeted by deepfakes often face shame, fear, and isolation. This research will use three focus group discussions (FGDs) with women aged 18 to 45 from both cities and small towns. These women come from different jobs, educational backgrounds, and regions. The discussions have covered their understanding of deep-fakes, personal/community experiences, emotional impact, and how families, communities, and institutions will respond. We have found common issues such as mental stress, fear of using the internet, damage to reputation, and lack of trust in the legal system. As well as we have learned how some women find support through informal networks when formal systems fail. This study aims to raise awareness about how deepfakes are becoming a new form of online gender-based violence. The findings here can aid in shaping better laws, digital safety programs, and public education campaigns in Bangladesh. In the end, we call for teamwork between policymakers, technology experts, gender rights groups, and educators to make sure AI and digital tools are used responsibly and so that women are not left more vulnerable in a growing digital world.**
Keywords - ***Artificial Intelligence (AI), Deepfake Technology, FGD, Content, Social Media.***

I. INTRODUCTION

The term "deepfakes," which combines the terms "deep learning" and "fake," originated on Reddit in 2017 when AI replaced the faces of famous people in videos. Once limited to pornographic material, the technique raised ethical questions as the code was made public, allowing for the creation [10]. Digital media has changed due to the quick development of deep-fake technology and artificial intelligence (AI), which makes it possible to produce phony photos and movies that look incredibly genuine. Although these technologies present creative opportunities, they also carry serious concerns, especially for women. As time has gone by, it has become more challenging to tell what is real and what is not. Additionally, the public might not attempt to distinguish and instead place all the responsibility and humiliation on the victim depicted in the video if they are not properly informed about what generative AI is. Deepfakes can escalate the scale and danger of online fraud and disinformation when used for deception to threaten our cognitive security. Like threats to our physical security or cyber security, which aims to break into our physical infrastructure or cyber systems, threats to cognitive security target our perceptual system and decision-making process [8].The misuse of deepfakes has become a major threat to women's rights, safety, and dignity in Bangladesh, where social media use is common and digital literacy is still developing. Drawing from international research and placing it inside the sociocultural context of Bangladesh, this paper investigates the complex effects of AI-generated deepfake content on women in that country. It is near-impossible for casual consumers of images to authenticate digitally altered images without a keen understanding of how to "read" the digital image. As Photoshop did for photographic alteration, to have advances in artificial intelligence and computer graphics made seamless video alteration seem real to the untrained eye [11]. The colloquialism used to describe these videos are “deepfakes”: a portmanteau of deep learning AI and faked imagery [2].

Deepfake technology creates realistic looking but fake media by superimposing people's faces onto other bodies using AI algorithms. Malicious deepfakes, which are frequently used to produce non-consensual pornography, enable sextortion, and sustain cybercrime, have been found to disproportionately damage women. These actions objectify women, diminish their agency, and perpetuate gender

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inequality. Furthermore, because Bangladeshi society is quick to pass judgment, it makes women feel ashamed.

Additionally, research shows that deepfakes can result in significant psychological damage, such as anxiety, despair, and PTSD. Social isolation, harm to one's reputation, and career setbacks are common experiences for victims. The shame attached to sexualized information may make the effect even more pronounced in Bangladesh, where traditional social standards are prevalent. One troubling example of deepfakes is the superimposing of women's faces into pornographic videos. The implication here is a reification of women's bodies as a thing to be visually consumed, here circumventing consent. This use is confounding considering the very bodies used to perfect deepfakes were men [2]. The impact might be even more severe in Bangladesh, where traditional social standards are prevalent, because sexualized content is stigmatized [10]. One of the most common ways deepfakes have been used to harm women is through control. The use and easy accessibility of deepfakes allow for a disturbing form of power over women, perpetuating a culture of control and objectification. [2]. By manipulating images, perpetrators of deepfake pornographic content assert dominance and exert control over women's identities, bodies, and narratives without their consent. Through deepfakes the perpetrators can quite literally control women's bodies [2]. They distort public views, fuel victim blaming and strengthen gender stereotypes. Specifically, it investigates misinformation in quality news and media and its impact on public perception, victim blaming and discrimination against women [6].

The objective of this study

- To understand the lived experiences and perceptions of women in Bangladesh who have been targeted or are aware of AI generated deepfake social media content.
- To assess the social and cultural factors of in Bangladesh that exacerbate the harm of deepfake AI content on women.
- To investigate coping mechanisms, support systems, and institutional responses available to women when targeted with deepfake content.

II. METHODOLOGY

The study is designed as a qualitative research to understand the social, emotional and cultural implications of AI-generated deepfake content against Bangladeshi women. The qualitative methodology was selected for the reason that it provides a more detailed analysis of lived feelings, perceptions and coping strategies which cannot be entirely reported using the quantitative one. The secondary analysis will be complemented by Primary Data collection using Focus Group Discussions (FGDs) for local perspectives.

Data Sources

Two complementary datasets were employed:

Secondary Data –Some reports, case studies, journal articles and academic literature on deepfakes, gender- based violence (GBV), and digital harassment were reviewed to shape the understanding of the problem and see how much of research gaps that are applicable to Bangladesh.

Primary Sources of Data – Primary data were collected through 3 FGDs with women (18–45 years) of urban and semi-urban Bangladesh. This offered a representative range of voices, with participants from various educational, professional and socio-cultural backgrounds.

Sampling Strategy

We used purposive sampling methods to identify individuals who would be able to provide meaningful insights on "deepfakes" whether they encountered it, the community was aware of it, or had social exposure to it. A total of nine respondents (three for each FGD) participated. They were students, teachers, housewives, workers and social media users from different age groups and social backgrounds. This diversity was to enable us to get a sense of how deepfake content could affect Bangladeshi women in different ways.

Data Collection

FGDs were performed in a secure and confidential environment which made participants to be comfortable and free to express their feelings. Meetings were conducted face-to-face and lasted 20-30 minutes each, led by the researcher with a semi-structured guide. Key themes included:

1. Knowledge and perception of deepfakes.
2. Perspectives on its potential or definite effects on women's life.
3. Social, emotional, and psychological consequences.
4. Family and community responses.
5. Opinions about legal, institutional and technological interventions.

Participants were given signed consent forms prior to the study, and they were informed that their participation was voluntary and that their information would be used strictly for research purposes. Codes instead of real names were given to ensure confidentiality.

Data Analysis

The interviews were transcribed, and then thematic analysis has done according to Braun and Clarke (2006). The transcripts were read several times to 'immerse' in the data, coded inductively to identify patterns or phenomena and to

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compare new data with the existing data. Codes were organized into themes such as emotional consequences, reputational damage, family / community response, and institutional failures. The themes were then discussed in the context of Bangladeshi sociocultural interpretation and compared with similar findings in the secondary literature.

Ethical Considerations

1. Respect for the subject matter meant adherence to stringent ethical procedures:
2. Anonymizing was applied to all participants' responses.
3. Psychological well-being was exhausted by moderating respectfully and providing participants with information on psychological and digital help.
4. All information was kept confidential and was used for academic purposes only.

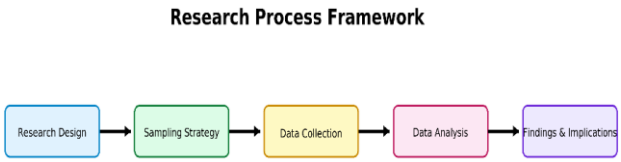


Fig-1: Research Process Frame work

III. RESULTS/FINDINGS

Results of the three FGDs indicate a multi-faceted effect of deepfake technology on Bangladeshi women. The findings are chased thematically, supplemented by participant quotations and tabulated participant profiles.

Group 1: Awareness and Reputation Threats

Person designation	code	age
Student	AEX1	23
Teacher, university	RTC3	41
Job holder, administration	GRR4	35

All three respondents were aware of deepfakes with different levels of understanding. The student (AEX1) described it as "AI technology that generates someone's identity in a very realistic manner, which makes it hard to distinguish between real and fake". RTC3, the teacher, stressed the moral and reputational stakes, cautioning that "women's lives could be ruined socially, personally, even in families." A woman's "value would be calculated by fake images, in conservative society," the administrator (GRR4) continued, further stating that deepfakes posed a direct threat to a woman's honor and marriage prospects.

Summary: This team emphasized that there indeed, at least in some places awareness that deepfakes are a risk, though the main concern is a loss of honor in a society where women's worth is closely linked to family honor.

Group 2: The Emotional and Familial Aftermath

Person designation	code	age
Housewife	SKH8	48
Student	SMN2	25
Social media content creator	MMK5	22

This group highlighted the psychological harm of victimization. SKH8, the housewife, cautioned about "severe trauma, depression and even suicidal thoughts." The younger pupil (SMN2) repeated this, and referred to anxiety, low self-confidence and a constant fear about what was to come: "suicide and self-harm are common". On the other hand, the content creator (MMK5) narrated that family and community reactions were directed towards the woman "in the community, they often accuse the woman, they take away her freedom, and they ruin her shame".

All of them concurred family support is a mixed blessing sometimes helpful but more often unhelpful. SKH8 emphasized, "victim-blaming is still very high in Bangladesh," and MMK5 noted, "Friends can be more reliable support than families."

Summary: This group emphasized the emotional ruin deepfakes inflict and how victim-blaming within families and communities compounds the injury, though informal networks like friendships offer more impactful support.

Group 3: Digital Caution and Legal Distrust

Person designation	code	age
Student	SSH7	18
Teacher, School	NLA6	33
Job holder, ICT	AMS9	46

The third was focused on digital behavior and organizational reaction. The one school student (SSH7) had very little trust as he stated that "cybercrime units don't care – laws exist but they're never made use of". "When we refer to the anti-deepfakes framework, we should point out that frameworks do not have training models, they have nothing to do with cases that seriously violate the law," the teacher added (NLA6). ICT professional (AMS9) elaborated his coping strategy: "Deepfakes threaten people's willingness to share,

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and make them up private, even beginning to shun social media!"
Collectively, the let us that public trust within institutions is very, very low and the default protection mechanism for women is self-censorship online, not police.

Summary: They exemplified how formal institutions are failing and the prevalence of the practice of self-regulation by way of defensive digital practices as the only available and immediate (women's) asylum.

Cross-Cutting Themes

Overall, six key findings emerged as common themes across all FGDs:

- Control and Subjugation: Women are stripped and humiliated with the help of deepfakes, therefore affirming the patriarchal power.
- Cyber Abuse and Harassment: Sharing without consent online harassment and some stalking Follows publication of personal information online.
- Image-Based Sexual Abuse: Non-consensual pornography (NCP) and sextortion were featured as prevalent results.
- Psychological Disturbance: Trauma, anxiety and smelling the smell of suicide were frequent issues.
- Reputation and Career damage: The honor of women, marriage and career prospects, are tarnished.
- Legal and Institutional Gaps: Current cyber laws are inadequate and loosely implemented.

Participant Recommendations

When asked about solutions, participants across all groups suggested:

- Enacting clear and strict laws against deepfake production and dissemination.
- Ensuring faster law enforcement responses and specialized training.
- Holding technology companies accountable for monitoring and removing manipulated content.
- Promoting digital literacy campaigns to raise awareness and reduce victim-blaming.

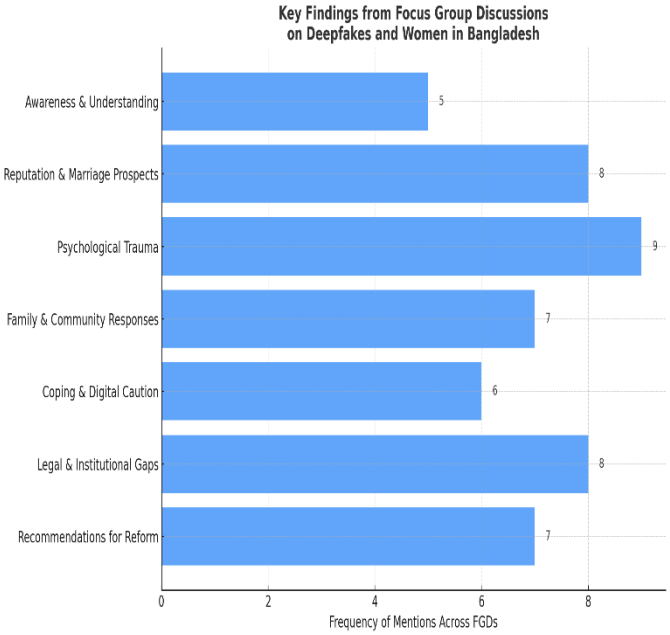


Fig-2: Key Findings from Focus Group Discussions on Deepfakes and Women in Bangladesh

The graph demonstrates how often themes were apparent at the three levels of focus group discussion. Psychological harm, reputation and marital prospects, and information and institutional voids were the most frequently emphasized concerns, illustrating the extreme personal and social risks women across ages face when victimized by deepfakes. Other prevalent themes were family and community reactions, many of which perpetuated victim-blaming, as well as coping mechanisms such as self-censorship, and limited ease of digital use. The findings also reflect participants' demands for legal reform and collective mobilization, revealing that women are not only victims but also agential, noting what needs to be done.

Overall, the results show that deepfakes in Bangladesh is not only a technological threat, but it is a strong social and cultural problem as well. Participants across all three groups highlighted the extreme psychological trauma, vilification and victim-blaming that women experience, as well as their limited institutional support and flimsy legal protections. And while some women frustrate that by withdrawing and opting instead for informal, peer-to-peer networks, that choice is one of fear and limitation, not of power. Altogether, these findings suggest that deepfakes exclusively threaten an honor-bound, marriage-seeking, and group-identity-anchored concept of women in conservative societies, highlighting the pressing need for legal regulation, digitization of education, and cultural transformation to shield women from this emerging gender-based violence.

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IV. DISCUSSIONS

The implications of AI-based deepfakes extend beyond digital realm and real challenges for women in Bangladesh as the study shows. And from the shock and anger at what women in particular perceive as loss of control over their lives, it's clear that reputational damage, ability to find a spouse and prospects for work and participation in the world are at stake when personalized falsehood circulates, making clear how the damage of online abuse is amplified by patriarchal and conservative norms. These results illustrate that deepfakes are not just a challenge of technology, but rather a social and cultural predicament. The real world application of this is obvious: women are being violated in their private and public spaces and both law enforcement and institutional responses are inadequate. For policymakers, this emphasizes the immediate importance of passing specific laws on deepfakes, strengthening cybercrime units, and rolling out digital literacy campaigns not only to debunk fake information but also to reduce victim-blaming. For technology companies, the findings suggest the need for responsible AI governance, complete with systems that rapidly identify and remove manipulated content.

Theoretically, the research contributes to debates on digital gender-based violence (DGBV) and techno-feminism. It represents how deepfake tech is another tool of control and objectification, reiterating patriarchy online. While this reasoning ties psychological trauma and reputational damage to institutional deficiencies, as well as to general theories of gender inequality and media effects, we also advance this explanation with high quality academic findings in an emerging and innovative area of research that lies in the intersection between new technologies and long-standing vulnerabilities in society. It is a clear piece of circularity between the political and technical which illustrates yet again the need to approach deepfakes as a technical problem as well as a gendered socio-technical issue.

The findings also pave the way for future research. Future work can extend the present research by carrying out broader surveys to determine the extent of victimization, by research into cross-cultural comparisons in Bangladesh compared with other contexts in South Asia, as well as testing prevention strategies, e.g., awareness campaigns, peer-support systems, or AI tools for detection. The use of both qualitative and quantitative methods would enhance the evidence base and could inform evidence-based policy and educational frameworks.

Together, these institutional, social, and psychological findings serve to illustrate the multifaceted ways that deepfakes harm women on psychological, social, and institutional levels, and provide critical theoretical implications for digital gender-based violence. The real-world stakes and academic salience thus suggest we must mobilize collectively from governments, to tech companies, to the research community, to civil society organizations to ensure that deepfake technologies do not become another tool to silence and marginalize women

V. CONCLUSION

This research has demonstrated the serious nature of deepfakes created using artificial intelligence on the women of Bangladesh and how they have reached far beyond the digital realm, having effects in social, cultural and psychological aspects of our society. In focus-group discussions, it emerged that reports that have the potential to ruin reputation, cause emotional trauma alongside the potential for the victim to be blamed upon by family alone than force/d opposing strong institutional protections that put women at a disadvantage in a conservative society where honor and marriage prospects are highly valued.

These findings highlight that deepfakes are more than just a technical threat, but a gendered form of violence, used to police, shame and silence women. In reality, this translates into social marginalization and restricted opportunities for victims of such harassment, and in theory it confirms techno-feminist claims that new technologies do replicate patriarchal modes of power.

Using clear laws that explicitly address deepfake-enabled abuse, policymakers should provide support to cybercrime units, encourage counter-stigma campaigns and set up digital literacy programs to empower women. Technology firms also need to step up, to be more accountable and remove manipulated content more quickly. For academics, the research shifts attention to the importance of wider comparative and mixed-method research to increase the evidence base around deepfakes and GBV.

In the end, protecting women in the digital age will take the combined efforts of government, technology, academia, and society. Without such measures, deepfakes will continue to be a weapon of exploitation, censorship, and disparity which can only erode human rights and digital trust in Bangladesh and beyond.

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Role of English Language and Literature Studies in Achieving Sustainable Socio-Economic Development among Tertiary Students in Bangladesh

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Abstract - **The curriculum applicable to English language and literature studies in the universities of Bangladesh is designed to meet the optimum linguistic and cognitive standards by attaining Second Language Acquisition. This can be achieved through a simultaneous and strategic study of the English language and literature, helping students attain second language acquisition through Stephen Krashen's Monitor Model in EFL classrooms. The authors used a mixed research design for the collection of data. Primary data has been collected from 160 tertiary students studying English Language and Literature in the 16 renowned universities using questionnaires and focus groups. The secondary data has been collected from the existing papers and books by Krashen. The data will be analyzed using the hypotheses of the Monitor Model. Moreover, the shortcomings of the teaching will be highlighted too for an improved and effective EFL teaching environment, finally leading to the socio-economic development of the tertiary students.**

Keywords – **Curriculum, EFL (English as a foreign language), LAD (language acquisition device), Monitor Model, pedagogy, SLA (second language acquisition), socio-economic growth, sustainable, tertiary level**

I. INTRODUCTION

The tertiary students in Bangladesh belonging to the Department of English, Linguistics and ELT (English Language Teaching) study the prescribed texts based on English Literature and Applied Linguistics. The study involved in English Language and Literature is based on the Curriculum and Syllabus designed for the course
B.A. in English, M.A. in English, and M.A. in ELT (English Language Teaching). As a part of the OBE (Objective Based Education), the texts are based on English Language, Literature and Linguistics. The teachers are supposed to use English as a medium of instruction for imparting education in the EFL (English as a foreign language) classrooms. As a matter of fact, English is the target language for the students at the tertiary level, which is also the most essential language in academia and professional fields. The students having command over English as a second language will always have an upper hand in the professional and academic world. The paper has highlighted the Monitor Model by Stephen Krashen to show the process of Second Language Acquisition using the five hypotheses. The Monitor Model includes the Natural Order Hypothesis, Acquisition-Learning Hypothesis, Input Hypothesis, Monitor Hypothesis and Affective Filter Hypothesis, respectively. The authors have collected primary and secondary data from students of the Department of English from various universities in Bangladesh and existing papers of Krashen based on SLA (second language acquisition). It is supposed to improve all four skills of the English Language. This can generate sound and efficient users of English as a second language. Thus, the efficient study of the courses is supposed to help the tertiary students to achieve sustainable Second Language Acquisition, and this is finally supposed to help the students to place themselves in a good professional space, leading to socio-economic development of the students concerned.

Research Gap

The combined and strategic study of Linguistics, English Language, and Literature in the concerned programs is essential for the fulfillment of the academic program. Much of the existing research doesn't highlight the utility of the designed curriculum in attaining SLA through Krashen's Monitor Model at the tertiary level. In addition, this paper also focuses on the achievement of socio- economic development in the concerned students through SLA. The paper has shown the utility of the five hypotheses of Stephen Krashen in the tertiary level, although Krashen specifically doesn't talk about the tertiary level in his studies. This is something very exclusive. It has a wide research gap. It generates a vast area for further research and exploration.

Background Information

- The tertiary students in Bangladesh belong to either public or private universities in Bangladesh.
- The courses in the Department of English are based on English Language and Literature.

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- The courses are B.A. in English, M.A. in English, M.A. in E.L.T., and M.A. in Applied Linguistics.
- The course duration for the Bachelor's and Master's degrees is 4 years and 1 year, respectively.
- The author has included the tertiary students of the Department of English in the universities of Bangladesh as participants in the research paper for the collection of data.

Objective of the Research

- To attain SLA by studying English Language and Literature effectively.
- To attain socio-economic development through achieving SLA using Krashen's Monitor Model.
- Advocating the right teaching methodology in the EFL classrooms to help attain sustainable socio- economic development in the students after their studies.

Significance of the study:

- To determine the (SWOT) strengths, weaknesses, opportunities and threats of the students concerned during the collection of data.
- To foster strategic and in-depth study of English Language and Literature to generate sustainable social and financial growth among the students concerned in the future.
- To show the effectiveness of Krashen's Monitor Model in attaining SLA, which is pivotal in gaining linguistic competence among the students.

Research Question

- Can the study of the contents of English Language and Literature in the universities of Bangladesh be effective in attaining second language acquisition, leading to sustainable socio- economic development among the tertiary students?
- Can SLA lead to sustainable socio-economic development among the tertiary students in Bangladesh?
- Are all hypotheses in Krashen's Monitor Model effective in achieving SLA, which will lead us to sustainable socio-economic development of the students concerned?

Research Problem

- How can the combined study of English Language and Literature contribute to attaining sustainable socio-economic development among the tertiary students in Bangladesh through attaining SLA?

II. METHODOLOGY

The study followed a mixed methodology. The authors have used qualitative and quantitative methodologies in this study simultaneously. The authors visited 16 universities in Bangladesh to collect data from the students of the Department of English. Data has been collected from the following sixteen universities: Southern University Bangladesh, U.S.T.C., Premier University, I.I.U.C., BGC Trust University, North South University, Brac University, East Delta University, Port City University, U.C.T.C., AIUB, National University, University of Chittagong, University of Dhaka, Rajshahi University, and Daffodil University.

The research framework is based on the research hypothesis that effective study of the contents of English Language and Literature leads to SLA, which is responsible for achieving sustainable socio-economic development of the students concerned.

Ten students from each university were selected for the collection of the data. In total, 160 students participated in the vigorous process of collecting data. Questionnaires were provided to the students concerned. The qualitative method highlights the discussion of the focus groups and the observations based on the application of the Monitor Model by Stephen Krashen. The quantitative method focused on the data from the questionnaires only. The data from the questionnaires were quantified to identify the number and percentage of students who agree and don't agree with the effectiveness of the study of English Language and Literature in ensuring socio-economic development of the students concerned through achieving second language acquisition. Discussion based on the open-ended questions and the answers to the closed-ended questions was included in the process of collecting data. The following closed-ended questions were included in the questionnaires, which were to be answered with only yes or no. The questions are given below:

- Does the study of themes in the texts of English Literature help you to develop your command of the English Language?
- When the contents in English Literature are taught by the teachers, does it help you to improve your listening skills sustainably?
- Does the study of literary pieces develop your linguistic competence?

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- Does the concept of semantics and phonetics help in gaining linguistic competence?
- Does writing long answers in the Literature and Linguistics exam help you to improve your language?
- Can we achieve sustainable SLA by going through the complex texts of the Literature?
- Can we gain sustainable linguistic analytical skills by reading and comprehending the texts and study materials of Literature?
- Does the study of English Literature and Linguistics improve the vocabulary and structural skills of the Second Language?
- Can we achieve sustainable SLA by writing essays on creative or directed topics?
- Do the presentations in the classroom (formative assessment) help to achieve sustainable SLA?
- Does the study of Literature and language improve mathematical skills?
- Does the study of texts help you to gain sociolinguistic development?
- Are the concerned texts capable of developing psycholinguistic competence?
- Is the execution of the Input Hypothesis capable of enabling the students to absorb the comprehensible input?
- Is the natural order hypothesis good enough to provide a correct grammatical sense?
- Is the Affective Filter Hypothesis in the Monitor Model
- capable of activating the positive filters to attain SLA?
- Is the application of the Acquisition-Learning hypothesis helping the students to acquire and learn, depending on circumstances?
- Are the applied hypotheses of the Monitor Model efficient in attaining SLA in students?
- Can the attainment of SLA provide sustainable social status to the tertiary students?
- Can the attainment of SLA provide a sustainable financial status to the tertiary students?
- Are the students being placed in better professional sectors after gaining linguistic proficiency?
- Which teaching methodology is preferred by the students? Is it CLT (communicative language teaching) or GTM (grammar translation method)?
- Does the existing pedagogy help you to improve your language?
- Does the study of literary devices and figurative meaning help in achieving linguistic competence?

The above questions were used to extract data from the students concerned and were analyzed accordingly from a qualitative and quantitative perspective. The focus groups consisted of eight students in each group. They critically analyzed the existing pattern of the study and commented on the teaching methodology, too. The study intends to establish the fact through the results that with the attainment of sustainable SLA, sustainable socio- economic development can also be achieved among the tertiary-level students in Bangladesh. The above questions were used in both open-ended and closed-ended formats for the extraction of the data.

III. RESULTS

The participants and the focus groups provided their answers for the questionnaire. The data collected was analyzed using all the five hypotheses of Krashen's Monitor Model. The focus groups, consisting of sixteen members each, contributed immensely to establishing the results related to the attainment of the sustainable socio- economic development of the students concerned through SLA.

The table given below denotes the preference of the

160 participants with relation to acquisition and learning.

CATEGORIES	ACQUSITION	LEARNING
PHENOMENA	SUBCONSCIOUS IN NATURE	CONSCIOUS IN NATURE
STRESS	MEANING	FORMS/RULES
INPUT OF DATA	COMPREHENSIBLE (i+1)	EXPLICIT INSTRUCTION
OUTCOMES	LONG-TERM FLUENCY	SHORT TERM MEMORIZATION
ENVIRONMENT	LOW ANXIETY	CAN BE LOW ANXIETY OR HIGH ANXIETY

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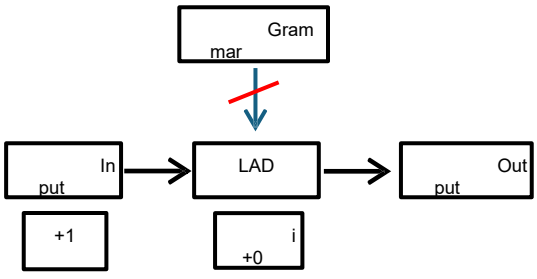
The chart below illustrates the above obtained results.

CHART BASED ON THE DATA OF 160 STUDENTS

Students supporting the effectiveness of the Monitor Model	Students do not support the effectiveness of the Monitor Model	Students are not sure about the effectiveness of the Monitor Model
85% of the participants	3% of the participants	12% of the participants
136 participants	5 participants	19 participants
Prefer CLT Methodology	Prefer GTM	Not sure about the methodology
Will achieve SLA	Will not achieve SLA	Not confident of achieving SLA

- The data collected depicted that around 128 students supported the effectiveness of the Input Hypothesis leading to second language acquisition increasing employability.
- 85% of the total participants supported the above statement and they prefer CLT methodology in the classroom.
- 3% of the total participants didn't agree with the above statement and they prefer GTM methodology.
- 10 students didn't accept the effectiveness of the Input Hypothesis.
- 12 students or 8% of the total participants were not sure of the contribution of the Input Hypothesis in attaining socio-economic development.

PROCESS DIAGRAM FOR THE EXECUTION OF THE INPUT HYPOTHESIS



The data collected from the focus groups denoted the following aspects through qualitative methodology to attain sustainable socio-economic development through attaining SLA:

- The comprehensible input in the EFL classrooms in a low anxiety environment leads to SLA by using LAD (language acquisition device).
- Effective study of the texts of English Language and Literature leads to SLA.
- An effective CLT environment is highly crucial for SLA.
- Formative assessment improves the level of motivation to attain SLA.
- Balanced Application of the Monitor Model triggers SLA.
- Sociocultural and psychological development attained through SLA leads to socio-economic development too.
- The communicative practice using CLT leads to SLA.
- GTM slows down the process of SLA.
- The literary devices and figures of speech improve the skills of English as a language.
- The students at the tertiary level are not interested in GTM.
- The students acquire grammar in a predictable manner, irrespective of the sequence followed by the teacher.
- Writing long answers improves the writing skills indirectly aiding SLA.
- The concept of phonetics, phonology, semantics, and semiotics and translation studies improves the cognitive skills of the students to attain SLA.
- The listening proficiency is improved using the CLT approach.
- All the four skills of English language can be developed using Krashen's Monitor Model leading to SLA generating social identity and financial growth in the students in their professional fields.
- It has been agreed by the participants that language education leads to employability among the tertiary students.

IV. DISCUSSION

The results of the study have proved that language education is directly proportional to employability. The tertiary students in Bangladesh look for jobs after they

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graduate. The tertiary students of the department of English have been taken into consideration in this study. As they belong to the department of English, they are liable to acquire command over the four skills of the English language. The command of the English language increases the chance of employability for students. As they study the contents of the prescribed syllabus, it is easy for them to acquire English as a second language through Krashen's Monitor Model. After the acquisition of the second language, communication and presentation skills increase. This increases the probability of the students establishing their social identity and developing their economic status, too. The fluent users of English are well regarded in the social and professional fields of Bangladesh. The field of teaching and learning emphasizes the importance of English as a language. Good professional exposure and growth will definitely lead to economic growth for the students concerned.

The Natural Order Hypothesis focuses on the natural pattern of the grammatical study, irrespective of the instructions of the teachers in the universities. Reference [6] shows that Krashen (1985) fostered delivering linguistic material through the instructor's lecture, which is slightly higher than their current linguistic proficiency. This is the execution of the Input Hypothesis in the EFL classrooms. It plays a vital role in absorbing comprehensible input and then escalating the existing linguistic competence after the classroom input of the teachers. As in [2], established the idea that the concept of "i+1" refers to the ideal level of comprehensible input required for language acquisition. The Monitor Hypothesis works as an editor that checks the technical standard of the language, elevating it to a standard of perfection. The Affective Filter Hypothesis emphasizes the emotional factors of the learners in the EFL classrooms. The positive filters motivate second language acquisition, whereas the negative filters hinder second language acquisition. According to reference [1], stated that SLA can be achieved through comprehensible input, which is also a central element in his theory. Moreover, the Acquisition- Learning Hypothesis differentiates between acquisition and learning in the EFL classrooms. With the preferred CLT methodology, acquisition is regarded as more effective in the EFL classrooms along with the proper utilization and guidance of Chomsky's language acquisition device. Acquisition allows the students to work on the four skills simultaneously. Evidently, as in [3], argued regarding the usage of explicit grammar rules to facilitate natural language acquisition. The confidence and linguistic competence gained will allow the students to be more communicative in both academics and the profession. This improves the social and financial strength of the tertiary students, providing them with greater recognition. This also generates a greater civic standard for the tertiary students. English is regarded as the most popular second language among students in Bangladesh. Command gained over the language will help the tertiary students to emerge as better linguistic users.

The study of literature and the various genres enriches the linguistic standard of the students. The writing exercises, process of assessment, and study of figures of speech increase the comprehensibility of the users. The authors of various periods and ages of English Literature engage in social, cultural, sociolinguistic and psycholinguistic study, making the process of acquisition more interesting and user-friendly. Consequently, the study has analyzed the collected data proving that the study of English literature and language by the tertiary students improves the socioeconomic standard of the students through SLA, ensuring that it is sustainable in nature. The study has justified its significance. The study has answered the research questions exclusively. It has recommended the usage of Krashen's Monitor Model effectively in SLA. This further leads to sustainable socioeconomic development gained by the strategic study of English literature and language. Thus, it has been depicted that strategic language education can lead to increased employability among tertiary students.

V. CONCLUSION

The study advocates for the study of the contents of the English language and literature, which is to help acquire English as a second language, leading to socioeconomic development of the tertiary students in Bangladesh. The response of the students has been recorded to justify the research questions and research design using both qualitative and quantitative methods.

Limitations of the study

The study can be limited if all the hypotheses of the Krashen's Monitor Model can't be executed to attain SLA through the study of the texts of applied linguistics and English literature at the tertiary level.

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Post-Recovery Satisfaction and Customer Loyalty: A Study on Service Recovery at Shwapno, Bangladesh's Leading Retail Chain

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Abstract: **Customers of Shwapno, the biggest retail chain in Bangladesh, are the subject of this study, which looks at post-recovery happiness. It focuses on how justice and courteous treatment affect customer loyalty following service failures. The study assesses distributive justice, interactional justice, customer happiness, likeability, reconciliation, repurchase intention, and word-of-mouth, all under the guidance of justice theory and relationship marketing. Using structured questionnaires, a quantitative cross-sectional survey of 100 Dhaka clients was carried out. While reliability was weaker for satisfaction and behavioral intents, it was adequate for distributive justice, interactional justice, and reconciliation. All of the assumptions were supported by correlation analysis, which demonstrated that distributive and interactional justice have a good effect on reconciliation and satisfaction, while contentment also significantly predicts repurchase and lowers unfavorable word-of-mouth. The results show that rather than focusing only on transactional solutions, service recovery should prioritize equitable results, civil communication, and the development of emotional trust. Notwithstanding the study's breadth and sample size restrictions, it offers useful information for enhancing recovery tactics in Bangladesh's expanding retail industry.**

Keywords: **Service Recovery, Customer Satisfaction,Retail Sector (Bangladesh)**

I. INTRODUCTION

Customer happiness has become a crucial component of long-term organizational success in today's fiercely competitive retail sector. Customer loyalty and confidence can be severely damaged by service failures, which can range from stockouts and billing problems to unprofessional staff conduct. Well-planned recovery initiatives, however, have the ability to improve client opinions of the service provider in addition to restoring satisfaction. Because of the size and complexity of its operations, Shwapno, one of the biggest supermarket store chains in Bangladesh, regularly has these kinds of service problems. Maintaining customer loyalty and long-term engagement after service failures requires an understanding of how customers react to recovery tactics.This study looks into how customer happiness and their desire to reconcile—the intention to continue doing business with a brand after a failure—are affected by service recovery. Based on theories of perceived justice, this study examines two important antecedents of customer satisfaction: distributive justice, or the perceived fairness of recompense, and interactional justice, or the caliber of interpersonal treatment experienced during recuperation. Customer satisfaction then affects whether they decide to make another purchase or spread unfavorable rumors. This study is important because it gives Shwapno's management practical advice on how to enhance recovery efforts and better meet consumer expectations. This study attempts to determine the key determinants of loyalty and reconciliation following service failures by examining both direct and moderating factors, such as the likeability of frontline staff. Retailers like Shwapno will be able to maintain their competitive edge, improve customer retention, and create more efficient service recovery plans thanks to the findings.

Explanation of the variables

In this report the variables are mentioned in the diagram. The article is based on post recovery satisfaction of customers of Shawpno (a retail grocery chain). Based on the topic the variables have been designed. The variables are briefly described below.

Distributional Justice- It is an independent variable. By distributional justice it means the service recovery was equally justified with the failure. That is, the steps taken by the management to solve the service failure makes the customer feel that the steps were fair enough compared with the seriousness of the failure.

Interactional Justice- It is an independent variable. Interactional justice means in case of service recovery the behavior of the personnel was polite, honest or in short fair. A polite and humble interaction by the encountering person is good enough and it makes the customer satisfied that the recovery seems to be enough

Customer Satisfaction with Service Recovery- This variable means that after getting the service recovery if the customers are satisfied or not. This is a very important variable because this determines if the other variables will be useful or not. That is if the customers are not satisfied then they will not go for repurchase or in any next steps.

Likability- Likability is a moderating variable. It directly does not impact any variable rather it indirectly impacts the other

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variables. This means how likable the outcome was that is how much did the customer like the outcome.
A Desire to Reconcile- This variable means if the customer is happy with the recovery process, then they are ready to restore their relationship with the store.
Repurchase- The variable means that the customer is happy with the service recovery and is ready to go back to the store to buy anything again or not.
Negative word of Mouth- Word of mouth means if the customers tell bad things about the service to their friends and family. The customer is unhappy with the service recovery and tells negative things and discourages his known people to go to the shop.

II. LITERATURE REVIEW

Distributive Justice
Distributive justice refers to customers' perception of fairness in complaint outcomes, including equity, equality, and need-based compensation [22]. Expectations vary based on the impact of the service failure—minor issues may call for a simple fix, while severe cases may require added compensation [7]. Research shows distributive justice significantly affects repurchase intentions and negative word of mouth [9]. Fairness is judged by consistency, impartiality, and ethical procedures [20], as well as by the customer's loss and treatment [21]. Customers in close relationships may perceive recovery efforts as less fair due to higher expectations [19], and unfair treatment can lead to anger and distrust toward the company [4].
Interactional Justice
Interactional justice refers to the fairness of interpersonal treatment during service recovery, including how respectfully and honestly customers are treated [21]. It shapes perceptions of dignity, honesty, and courtesy [20]. Studies show that respectful treatment can boost satisfaction and positive word of mouth, even if compensation is limited [3]. Conversely, a lack of concern from the company can trigger negative emotions [7].
Customer Satisfaction with service recovery

How a business handles service outages with the goal of transforming bad experiences into good ones is known as service recovery. A successful recovery strengthens commitment, fosters trust, and raises general satisfaction [21]. Following a failure, satisfied customers are more likely to use the service again and refer others to it [17]. Even more goodwill can be generated by a successful recovery than if there had been no failure [15]. Long-term connections are strengthened, loyalty is encouraged, and service quality judgments are raised [17]. Recovery initiatives frequently have a greater effect on customer satisfaction than the initial service [19].

Diagram

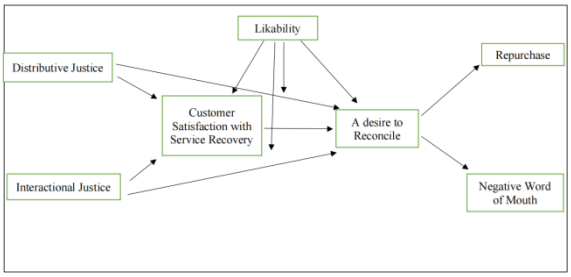


Fig. 1. Research Model

Hypothesis and questions
H 1 0 - There is no relation between Distributive justice and Customer satisfaction with service recovery.
H 1 a – There is a relation between Distributive justice and Customer satisfaction with service
recovery.
H 2 0 - There is no relation between Distributive Justice and A desire to reconcile.
H 2 a – There is a relation between Distributive Justice and A desire to reconcile.
H 3 0 - There is no relation between Interactional justice and Customer satisfaction with service
recovery.
H 3 a – There is a relation between Interactional justice and Customer satisfaction with service
recovery
H 4 0 - There is no relation between Interactional justice and A desire to reconcile.
H 4 a – There is a relation between Interactional justice and A desire to reconcile.
H 5 0 - There is no relation between Customer satisfaction with service recovery and A desire to
reconcile.
H 5 a – There is a relation between Customer satisfaction with service recovery and A desire to
reconcile.
H 6 0 - There is no relation between A desire to reconcile and Repurchase intention.
H 6 a – There is a relation between A desire to reconcile and Repurchase intention.
H 7 0 - There is no relation between A desire to reconcile and Word of mouth.
H 7 a – There is a relation between A desire to reconcile and Word of mouth.

III. METHODOLOGY

Research Design
The present study employed a formal study design with a descriptive goal to investigate post-service recovery satisfaction at Shwapno, one of Bangladesh's top mega-malls. I carried out a field study with quantitative techniques and a

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cross-sectional temporal dimension. We used a standardized questionnaire with eight questions that covered demographic information and factors such as distributive justice, interactional justice, likability, satisfaction with service recovery, desire to reconcile, intention to repurchase, and positive word-of-mouth.
Most items have a Likert scale with seven points. Convenience sampling was used to gather data from 100 Dhaka city clients, primarily private university students who have encountered issues with Shwapno's service. Customers who had experienced service problems made up the sampling unit, and customers from Shwapno's database made up the sampling frame. Both primary data—from survey responses—and secondary data—from journals, publications, and internet sources—were gathered using our approaches. We were able to examine the effects of service recovery on client loyalty, trust, and satisfaction thanks to this statistical analysis.

Data Analysis

The distribution of income levels and genders, as well as a cross-tabulation of income and gender, are included in the study's demographic frequency analysis. Of the 100 respondents, 40 percent were women and 60 percent were men. Of those surveyed, 24% earned between 5,000 and 15,000 BDT, 12% earned between 26,000 and 35,000 BDT, and 40% earned less than 5,000 BDT. Additionally, five respondents earned between 36,000 and 45,000 BDT, and seven respondents earned over 46,000 BDT.The cross-tabulation of income and gender revealed that there were 25 men and 15 women among those earning less than 5,000 BDT. The group that received 5,000–15,000 BDT consisted of 8 women and 16 males. For the 16,000–25,000 and 26,000–35,000 BDT levels, the gender ratio was six males and six females apiece. In the 36,000–45,000 BDT income range, there were three males and two women, whereas in the 46,000 BDT and above income range, there were four men and three women.

IV. RESULTS

Reliability Analysis: Reliability analysis shows the internal consistency among the items of a
construct. Through a reliability test, it shows us a Cronbach Alpha value. The more this value is
closer to 1, the more it is reliable.

Cronbach's alpha	Internal consistency
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

Fig.2: Cronbach's alpha values indicating the internal consistency and reliability of the study variables.

This table shows the Cronbach alpha value and the internal consistency for that value. Through this table, we will interpret the reliability test of our study.
Interactional Justice: Interactional Justice is a construct. This construct has 4 items. Here in the table, we can see that, the alpha value from 0.7 to 0.8 is acceptable. After the analysis, we found the Cronbach Alpha value for Interactional justice is .747. So, we can say that the internal consistency among the items is acceptable.
Distributive Justice:The Cronbach alpha value for Likability, which consists of three items, is.617. The table indicates that there is doubt about the internal coherence of these two things
Likability: Likability has 3 items, and the Cronbach alpha value is .617. So, according to the table, the internal consistency among these 2 items is questionable.
Satisfaction with service recovery: Three items make up Desire to Reconcile, and its Cronbach alpha value is.796. Therefore, the table indicates that there is appropriate internal consistency among these three elements.There are two items on the satisfaction with service recovery scale, and its Cronbach alpha value is.539. According to the table, these two items are not internally consistent with one another.
Desire to Reconcile:
Repurchase Intention: Repurchase Intention has 3 items, and the Cronbach alpha value is .124. So, according to the table, the internal consistency among these 2 items is not acceptable.
Positive word of mouth: Positive word of mouth has 2 items, and the Cronbach alpha value is
.117. So, according to the table, the internal consistency among these 2 items is not acceptable.
Hypothesis Testing:
Hypothesis analysis testing tells us whether to reject null hypothesis and accept alternative hypothesis or accept null hypothesis and reject alternative hypothesis. It also shows the strengths of the relationship. There is a certain condition behind this acceptance or rejection. If the correlation coefficient (rho) is not equal to 0 and Alpha <0.05, then accept the Alternative hypothesis which means there is a relationship between A and B. If one condition is not fulfilled, then accept

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the null hypothesis and reject the alternative hypothesis that says there is no relationships between A and B

Pearson Correlation Coefficient:
Hypothesis 1: (Distributive justice and Customer satisfaction)
H 1 0 - There is no relation between Distributive justice and Customer satisfaction with service recovery.
H 1 a – There is a relation between Distributive justice and Customer satisfaction with service recovery.
H 1 a is accepted because,
For Spearman's, rho, the correlation coefficient between Distributive justice and Customer satisfaction is .431, as $\boldsymbol{\rho}$ is $\neq 0$ and significance alpha value is .000 which is less than 0.05. So according to the table11 we will accept the alternative Ha1, this concludes that there is a relationship between Distributive justice and Customer satisfaction.
For Pearson, the correlation coefficient between Distributive justice and Customer satisfaction is 0.552. According to the table12, this value shows us that the relationship between Distributive justice and Customer satisfaction is moderate and positive.
Hypothesis 2: (Distributive Justice and A desire to reconcile)
H 2 0 - There is no relation between Distributive Justice and A desire to reconcile.
H 2 a – There is a relation between Distributive Justice and A desire to reconcile.
H 1 a is accepted because,
For Spearman's, rho, the correlation coefficient between Distributive justice and A desire to reconcile is .420, as $\boldsymbol{\rho}$ is $\neq 0$ and significance alpha value is .000 which is less than 0.05. So according to the table13 we will accept the alternative Ha1, this concludes that there is a relationship between Distributive justice and A desire to reconcile.
For Pearson, the correlation coefficient between Distributive justice and A desire to reconcile is 0.494. According to the table14, this value shows us that the relationship between Distributive justice and A desire to reconcile is moderate and positive.
Hypothesis 3: (Interactional justice and Customer satisfaction with service recovery)
H 3 0 - There is no relation between Interactional justice and Customer satisfaction with service recovery.
H 3 a – There is a relation between Interactional justice and Customer satisfaction with service recovery
H 1 a is accepted because,
For Spearman's, rho, the correlation coefficient between Interactional justice and Customer satisfaction with service recovery is .523, as $\boldsymbol{\rho}$ is $\neq 0$ and significance alpha value is .000 which is less than 0.05. So according to the table 15 we will accept the alternative Ha1, this concludes that there is a relationship between Interactional justice and Customer satisfaction with service recovery.
For Pearson, the correlation coefficient between Interactional justice and Customer satisfaction with service recovery is 0.554. According to the table16, this value shows us that the relationship between Interactional justice and Customer satisfaction with service recovery is moderate and positive.
Hypothesis 4: (Interactional justice and A desire to reconcile)
H 4 0 - There is no relation between Interactional justice and A desire to reconcile.
H 4 a – There is a relation between Interactional justice and A desire to reconcile.
H 1 a is accepted because,
For Spearman's, rho, the correlation coefficient between Interactional justice and A desire to reconcile is .433, as $\boldsymbol{\rho}$ is $\neq 0$ and significance alpha value is .000 which is less than 0.05. So according to the table 17 we will accept the alternative Ha1, this concludes that there is a relationship between Interactional justice and A desire to reconcile
For Pearson, the correlation coefficient between Interactional justice and A desire to reconcile is 0.414. According to the table 18, this value shows us that the relationship between Interactional justice and a desire to reconcile is moderate and positive.
Hypothesis 5: (Customer satisfaction with service recovery and A desire to reconcile)
H 5 0 - There is no relation between Customer satisfaction with service recovery and A desire to reconcile.
H 5 a – There is a relation between Customer satisfaction with service recovery and A desire to reconcile.
H 1 a is accepted because,
For Spearman's, rho, the correlation coefficient between Customer satisfaction with service recovery and A desire to reconcile is .625, as $\boldsymbol{\rho}$ is $\neq 0$ and significance alpha value is .000 which is less than 0.05. So according to the table 19 we will accept the alternative Ha1, this concludes that there is a relationship between Customer satisfaction with service recovery and A desire to reconcile
For Pearson, the correlation coefficient between Customer satisfaction with service recovery and A desire to reconcile is .663. According to the table 20, this value shows us that the relationship between Customer satisfaction with service recovery and A desire to reconcile is strong and positive.

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Hypothesis 6: (A desire to reconcile and Repurchase intention)
H 6 0 - There is no relation between A desire to reconcile and Repurchase intention
H 6 a – There is a relation between A desire to reconcile and Repurchase intention.
H 1 a is accepted because,
For Spearman's, rho, the correlation coefficient between A desire to reconcile and Repurchase
intention is .386, as $\boldsymbol{\rho}$ is $\neq 0$ and significance alpha value is .000 which is less than 0.05. So
according to the table 21 we will accept the alternative Ha1, this concludes that there is a
relationship between A desire to reconcile and Repurchase intention
For Pearson, the correlation coefficient between A desire to reconcile and Repurchase intention
is .412. According to the table 22, this value shows us that the relationship between A desire to
reconcile and Repurchase intention is moderate and positive.
Hypothesis 7: (A desire to reconcile and Word of mouth)
H 7 0 - There is no relation between A desire to reconcile and Word of mouth.
H 7 a – There is a relation between A desire to reconcile and Word of mouth.
H 1 a is accepted because,
For Spearman's, rho, the correlation coefficient between A desire to reconcile and Word of mouth is .270, as $\boldsymbol{\rho}$ is $\neq 0$ and significance alpha value is .000 which is less than 0.05. So according to the table 23 we will accept the alternative Ha1, this concludes that there is a relationship between A desire to reconcile and Word of mouth
For Pearson, the correlation coefficient between A desire to reconcile and Word of mouth is .330.
According to the table 24, this value shows us that the relationship between A desire to reconcile
and Word of mouth is weak and positive.

V. DISCUSSION

In order to improve customer happiness and loyalty after service failures, this study highlights the significance of efficient service recovery solutions. The results are consistent with theories of perceived justice, demonstrating that customer satisfaction and the desire for reconciliation are strongly influenced by both distributive justice—the fairness of compensation or results—and interactional justice—respectful and sympathetic treatment [21]. In line with earlier study by [21], which contends that equitable remuneration and result fairness encourage re-patronage behavior, distributive justice was found to have a beneficial effect on both customer satisfaction and reconciliation intentions. According to [18], who maintained that courteous interpersonal treatment improves clients' post-recovery perspectives, interactional fairness was also demonstrated to increase pleasure. Customer satisfaction with service recovery stood out as a crucial mediating element among the factors examined, exhibiting the highest association with the desire to make amends. This lends credence to the idea that behavioral reactions and perceptions of justice are connected through customer satisfaction [19]. In line with the service recovery paradox—the idea that a great recovery can result in higher satisfaction than if no failure had occurred—the study also found that the desire to make amends is a strong predictor of repurchase intention, suggesting that happy and understanding customers are more likely to return following a service failure [20].

Despite being statistically significant, the relationship between the desire to make amends and positive word-of-mouth was comparatively weaker. According to [22], this implies that although customers might decide to make another purchase, they might be reluctant to advise the service unless they notice noticeable changes. Likeability is also proposed as a moderating variable, albeit not being thoroughly examined in the statistical findings. It might affect how fairness and satisfaction are seen, suggesting that it plays a part in determining how well service recovery goes. Future studies and managerial training should also take likeability into account, particularly for front-line staff who deal directly with consumers during recovery circumstances [17].

All things considered, these results support the suggested conceptual framework and highlight how crucial perceived justice is to mending client relationships and guaranteeing long-term company viability in Bangladesh's retail industry.

VI. CONCLUSION

The purpose of this study is to gather data on Shwapno's customer satisfaction in Bangladesh. The management, who were instrumental in making sure that the requirements and desires of the customers were appropriately met, will receive accurate and helpful information from this study. This would assist them in creating fresh concepts that may form the foundation of their marketing plans to draw in more clients. Since they are the study's responders, answering the questionnaire will enable Shwapno to offer a high-quality service, product, location, and cost by learning what customers anticipate from the store.This study investigated how consumers' desire to make amends following service failures at Shwapno was impacted by distributive justice, interactional justice, and customer satisfaction with service recovery. It was established through quantitative research employing surveys and correlation testing that restoring customer trust is greatly aided by fairness in both outcome and engagement.The desire to make amends, which is primarily motivated by customer happiness, is crucial in deciding whether or not customers will recommend the brand to others

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or return. These results give Shwapno and other retail chains practical advice on how to spend money on fair remuneration policies and employee behavior training.Notwithstanding many drawbacks, including the study's short sample size and geographic scope, it provides insightful suggestions for enhancing service recovery procedures. For the repurchase and word-of-mouth constructs, future studies should take into account larger sample sizes and enhanced instrument reliability. Rebuilding connections, trust, and brand image is more important than only fixing problems when a service fails. Fairness and polite communication are highly valued by merchants in Bangladesh's dynamic retail sector, and doing so will help them maintain consumer loyalty and obtain a competitive advantage

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AI & Prompt Engineering in Higher Education of Bangladesh: Qualitative Approach

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Abstract— **Artificial intelligence (AI) is rapidly reshaping higher education globally, yet its role in Bangladeshi universities remains untapped. This study examines how both teachers and students perceive and practice prompt engineering the skill of instructing generative AI tools such as ChatGPT and Gemini. Using qualitative methods, five focus group discussions (FGDs) were conducted across different public and private universities, involving 19 participants. The discussions revealed a clear contrast where students described regular use of AI for assignments, summaries, coding, and idea generation, showing strong support for curricular integration at higher studies, while teachers expressed caution, raising concerns about plagiarism, overreliance, and the damage of critical thinking. Teachers emphasized the need for training, ethical codes, and institutional as well as national committees, whereas students highlighted barriers of access, awareness, and the absence of formal guidance. The findings illustrate that AI has already become a practical learning partner for students, while institutional readiness and faculty preparedness is not updated. The study contributes to debates on technology adoption in education by showing how generational and disciplinary differences shape attitudes. It concludes that this is not an endpoint but the start of a necessary conversation, calling for future research, policy innovation, and collaborative action to integrate AI and prompt engineering responsibly into higher education.**

Keywords - ***Artificial Intelligence (AI), prompt engineering, Higher Education, Bangladesh.***

I .INTRODUCTION

The Artificial intelligence (AI) AI is redefining higher education at global level. Generative AI tools like ChatGPT, Gemini, and Perplexity are altering not only how students embrace and interact with information but also what learning and teaching looks like in the classroom [3], [9]. These are tools that learners and educators must be engineered in a timely fashion prompt engineering, which is the ability to generate clear, meaningful instructions. This is increasingly now referred as a new type of digital literacy that will be necessary for the future of education and work [2], [13].

Studies have found that generative AI can enhance higher-order thinking/creativity and personalized learning in a thoughtful way if it is used properly [5], [10]. Prompt Engineering is not just question asking, it is making sense of the problem, being context aware, and their reflection on AI's answers [4]. Teachers are also trying out AI for lesson plans and tests and students are given an opportunity to have a more effective and interactive education [12]. However, challenges exist.

Too much dependence on AI could stifle creativity and widespread reports of plagiarism, misinformation and ethical issues are common [8], [1]. Without training, students and teachers could use AI as an abridgment, rather than a tool for more in-depth learning [6].

In Bangladesh, such discourse is still short of such analysis. Higher education institutions have embraced digital platforms, particularly in the wake of COVID-19, but very little is understood about how students and teachers are interacting with generative AI. While most reports are limited to digital access [11], [7] and policy, prompt engineering practices in the context of Bangladeshi classrooms have not yet been considered. This generates a critical lacuna: it is hard to prepare students for the requirements of an AI-enabled future without an understanding of these practices.

This paper tries to fill in that gap, conducting Focus

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Group Discussions (FGDs) with students and teachers of universities in Bangladesh. It discusses the prompt engineering spectrum from an academic perspective, identifying both opportunities and obstacles

Research Objectives:

1. To explore how students and educators in Bangladesh perceive and practice prompt engineering in higher education.
2. To identify opportunities and challenges associated with its integration in academic settings.
3. To provide evidence-based recommendations for curriculum design and policy reforms that prepare Bangladeshi universities for an AI-driven future.

II. METHODOLOGY

The study is designed as qualitative research to understand the developing role of prompt engineering at Bangladesh higher education. The fact is prompt engineering is still a recently- discovered, relatively little studied behavior, a qualitative methodology was the most suitable. While quantitative surveys can offer coverage but not depth, qualitative methods can help researchers to deepen their understanding of experiences, perceptions and practices (Creswell & Poth, 2018). The study was able to identify themes, challenges, and opportunities that are grounded in lived experience by engaging directly with participants to hear their stories.

A. Data Collection Method

Data collection The FGDs were the main source of data for the research. FGDs are an appropriate methodology for generating exploratory research data, particularly in new and under- researched areas of significance (Krueger & Casey, 2015). Group discussions create space for participants to think through, challenge and respond to each other's perspectives. This dynamic frequently results in insights that may not be apparent in individual interviews and positions FGDs to be a useful method for exploring the shared experiences of prompt engineering.

Five FGDs were done in total:

- Private University Teachers: 2 FGDs (of 3 participants per each FGD).
- 1 FGD with 3 teachers of Public University
- Private University Students: 1 FGD (5 participants).
- Public University Students: 1 FGD (5 participants).

Altogether, 19 participants were involved. Such distribution permitted us to compare experiences in regard to institutional typology (public or private) and role (teacher or student), thus encouraging diversity of viewpoints.

A. Sampling Strategy

The participants were selected based on purposive sampling. Teachers had to be currently engaged in undergraduate or graduate teaching, and have some experience with digital or AI- supported learning tools. Regarding students, respondents were selected from fields in which the use of generative AI tools has become more apparent, such as management, information systems and business studies. Here was no goal about statistical representativeness, but being satisfied that people were included meaningfully in the discussion.

This purposeful sampling of participants enriched the insights presented by incorporating teachers focusing on pedagogy and academic integrity, and students who are using generative AI as they engage daily with their academic work.

B. FGD Process

Duration of each FGD was between 30-40 mints. Sessions with participants took place via online. A semi-structured discussion guide was utilized to maintain comparability among sessions and provide flexibility for participant's individualized experiences. Key discussion areas included:

- Applications of generative AI tools in teaching, projects, and research.
- Knowledge and application of prompt engineering in the work of study.
- Beliefs in learning, creativity, and efficiency opportunities.
- Issues including ethical reservations, dependency and lack of training.
- Future role of immediate engineering in higher education.

Sessions were audio-recorded with the consent of participants. Field notes were recorded on a note pad to document non-verbal cues and contextual features. These notes were all later triangulated against the transcripts to increase confidence in data interpretations.

C. Data Analysis

Thematic analysis is a method often used in qualitative research to identify, analyze and report patterns within data (Braun & Clarke, 2006). The analysis followed these steps:

- Transcription: All FGDs were transcribed verbatim to preserve participants' voices.
- Initial coding: Transcripts were read multiple times and broken down into meaningful units of information.
- Theme development: Broader themes were

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generated by connecting categories across teacher and student groups.

- Interpretation: Themes were refined to highlight commonalities, differences, and the significance of prompt engineering in the Bangladeshi context.

This systematic procedure provided transparency and reproducibility in the process, but also allowed the research team to capture both collective patterns and individual insights.

D. Ethical Considerations-Ethical considerations ethical soundness was a concern in each step of the research process. The following procedures were adhered to:

- Informed Consent: All participants were informed about the purpose of the study, procedures and their rights. Verbal consent was obtained prior to participation. Participants were told they could opt out of the discussion at any time without penalty.
- Anonymity: To maintain confidentiality, the data contained no individual's names and institutional titles. Instead, they were assigned codes in the process of transcribing and analyzing the data.
- Privacy and security: All audio-recordings and transcripts were saved in secure, password protected folders accessible only to the research team. Data summaries and results were presented in composite format in order to ensure that individual participants could not be identified.
- Security of Data: Digital records were encrypted with password protection. The raw data used during the current study are available from the corresponding author upon reasonable request and only within the research team. Data will only be kept for academic purposes and data destruction will be performed after study completion according to ethical conduct guidelines.
- Respect and reflexivity: Discussion groups were conducted in a respectful manner, in which free expression was valued from the participants. Facilitator was neutral to enhance the participation and to avoid domination and subjugation of discussion on any issue.Such ethical procedures assured that participants' privacy, dignity, and trust were respected at all times during the research.

III. RESULTS

The results from the 5 FGDs show how teachers and students in Bangladesh are accommodating AI and redirect engineering into higher education. Every group brought unique, yet connected concerns shaped by their experiences in teaching and learning, discipline specific practices, and commonplace academic challenges. Those conversations not only underscored the ways people are already making use of AI tools, but they also exposed broader anxieties over academic honesty, creativity and the preparedness of institutions. Here, participant demographics including their reflections and free writing sample are presented for each group in the paragraphs below.

TABLE 1
GROUP 1: FGD-1 (PRIVATE UNIVERSITY)
[TEACHERS]

Designation	Code	Experience of Teaching in Higher Education
Assistant Professor	IDF01	14 years
Senior Lecturer	IDF02	13 years
Assistant Professor	IDF03	18 years

This group has three experienced private university faculty members with backgrounds in chemistry, medical anthropology, and marketing; they offered balanced but tentative views on AI and education.

IDF01 told her students that she occasionally checks ChatGPT while preparing for lectures, but she added: "*You can use AI for information gathering, but you have to say it in your own way.*

Word-for-word copying destroys analysis." Her language was open and cautious, welcoming AI as a tool, not a replacement for thought.

IDF02 expressed reluctance, stating that they lack a profound understanding and hence fail to guide students. "*I let them do it, but I can't teach them.*" By admitting he'd been out of touch, the teacher exemplified the digital divide that educators sometimes face due to their age.

Although more open to the technology, IDF03 set "conditions" for acceptance: "*We must not run out of AI-based technology. Never copy-past use it for ideas and concepts. And correct citation is crucial.*"

Curriculum integration divided the group. IDF01 and IDF02 strongly opposed formal AI implementation: "*If we embed AI in your studies, people no longer want to learn deeply*" IDF01 warned. For example, chemistry requires rote understanding of symbols and formulas. IDF03 was more flexible and said that integration may be beneficial if a qualifying committee designs the curriculum.

Overall Findings from the Discussion:

This team displayed a sense of cautiousness: They were

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AI users themselves, but they resisted adding it to the curriculum formally, without strong ethical protections and teacher training.

TABLE 2
GROUP 2: FGD-2 (PRIVATE UNIVERSITY) [TEACHERS]

Designation	Code	Experience of Teaching in Higher Education
Associate Professor	WES01	18 years
Lecturer	WES02	4 years
Lecturer	WES03	4 years

The group consisted of a senior professor alongside two younger lecturers who had expertise in mathematics and engineering. Each of the three was exploring AI, through different approaches.

WES01 said, "*I allow students to use AI in lab report discussions, but I always emphasize understanding first, not copy-pasting. Without understanding, it has no value*" Her focus on comprehension rather than quick fixes showcased her extensive experience as a dedicated educator.

WES02 expressed a mathematical viewpoint: "*AI can help us identify errors, but I suggest that you verify it yourself."* AI may not always be accurate. WES03 mentioned that "*Although AI could be beneficial for understanding theory concepts, I prefer not to promote mathematical thinking as it tends to make students lose their focus.*"

They were concerned, both as a group and as individuals, about misuse. They observed students turning in assignments generated by AI, showing not much interest in reviewing them. "*Plagiarism and unoriginal research are common right now*," WES01 said, predicting that the University Grants Commission (UGC) would object if integration of AI was formally proposed unless a proper structure and ethical codes are not followed.

Overall Findings from the Discussion:

This group acknowledged AI's inevitability but stressed originality, verification, and critical thinking. They demanded clear boundaries, teacher training, and institutional support before any curriculum reform could succeed.

TABLE 3
GROUP 3: FGD-3 (PUBLIC UNIVERSITY) [TEACHERS]

Designation	Code	Experience of Teaching in Higher Education
Professor	PUB01	18 years
Professor	PUB02	29 years
Professor	PUB03	10 years

This was a cast of three professors who had been teaching and publishing for decades. Their observations were colored by both their ambitions and their institutional difficulties.

PUB01 was effective: "*I use AI to prepare structures for assignments, or even travel schedules. But I forbid my senior students to use it in lab reports because it destroys their problem-solving skills.*" His comments showed an optimal balance of practicality and scholarly insight.

PUB02 clearly outlined his constraints: "*In my classes, up to 20% AI use is acceptable. More than that, I consider it harmful."* He also noted using AI for literature reviews and drafting outlines: "*It saves time and sparks new ideas, but cannot replace creativity*".

PUB03 introduced yet another layer of uncertainty. He explored outlines from ChatGPT, Gemini, and Jenni AI, yet he remained unconvinced: "*The job market in Bangladesh is less likely to require quick engineering skills … in another 10 years*." "*We shall not speed up if we're all speaking and have no training*."

Their discussion focused on the challenges: insufficient infrastructure, antiquated policies, and inadequate faculty training. PUB02 stated: "*We must be concerned about ethics and regulation; otherwise, it will lead to chaos*."

Overall Findings from the Discussion:

The professors recognized the value of AI as a useful tool, yet cautioned about the lack of preparedness within the institution. They agreed that training, plagiarism checks, and national-level committees were essential prior to broader implementation.

TABLE 4
GROUP 4: FGD-4 (PRIVATE UNIVERSITY) [STUDENTS]

Current Field of Study	Code	Current number of semester/year.
Business Administration	PRIVEX01	3rd year
Law	PRIVEX02	4th year
Computer Science & Engineering (CSE)	PRIVEX03	4th year
Pharmacy	PRIVEX04	3rd year
Media & Communication	PRIVEX05	3rd year

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This group of undergraduates viewed AI as a tool they engaged with regularly for their academic work.

PRIVEX01 openly expressed: "*I frequently utilize AI, particularly for my tasks like writing assignments and reports.*" It conserves time. PRIVEX02 presented a similarly understated application: "*In the legal field, resources are often hidden in archives, so AI provides limited assistance primarily through summaries.*" PRIVEX03 expressed even greater enthusiasm: "*In the field of computer science, prompt engineering is essential.*" It enhances coding efficiency directly.

However, differences became apparent in Pharmacy and Media. Pharmacy is primarily a lab-based discipline, which limits the applications of AI to mainly idea generation," stated PRIVEX04. PRIVEX05 shared her experience of attending a workshop that enhanced her understanding of responsible use: "*I'm not reliant on it but it means I don't start from scratch.*"

Many were self-taught, and almost all preferred integrated curricula, though they recognized that relevance would vary by discipline.

Overall Findings from the Discussion:

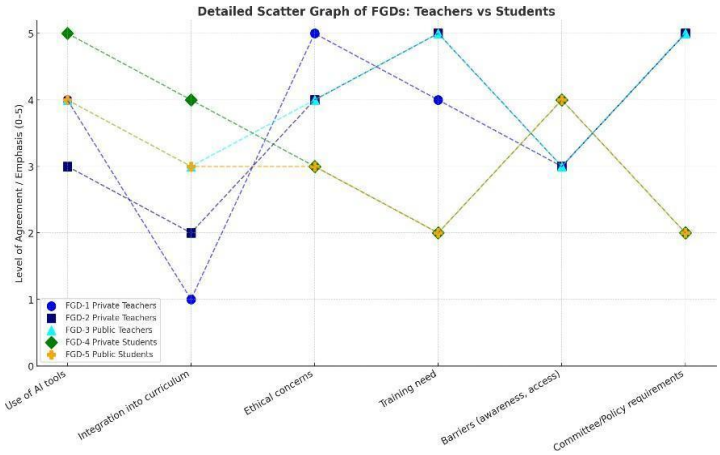
This group demonstrated enthusiasm with inconsistent application. Their support for curricular integration was evident; however, they identified deficiencies in awareness, training, and institutional resources.

TABLE 5
GROUP 5: FGD-5 (PUBLIC UNIVERSITY) [STUDENTS]

Current Field of Study	Code	Current number of semester/year.
Engineering	REXTER01	3rd year
Business Administration	REXTER02	4th year
Literature	REXTER03	3rd year
Law	REXTER04	2nd year
Social Sciences	REXTER05	3rd year

These were students representing public universities studying undergrad.

REXTER01 was more equivocal: "*I am neutral — I do not know if it is necessary for everyone.*" He was no impetuous English major, and his engineering mind made him cautious. REXTER02 dissented: "*In business, it's necessary as well.*" REXTER03, the literature student, connected AI with close reading: "*It helps us frame analysis and forces us to think in different ways.*"



The law student, REXTER04, was open minded: "*If it's properly designed AI could be useful for legal studies.*" REXTER05 was among its leading proponents: "*It would make us more ready for anything that comes in the future*."

Obstacles presented themselves: a lack of awareness, bad internet and little guidance. REXTER03 recommended that AI be taught as non-major; REXTER02 considered teachers should have training too.

Overall Findings from the Discussion:

This group articulated opinions shaped by their discipline. Although many recognized potential advantages, engineering students expressed uncertainty. Students emphasized the necessity for teacher training and the implementation of structured non-major courses.

Interdisciplinary Themes

1. All FGDs: The themes that emerged from all the five focus group discussions were as follows.
2. High and uneven adoption of AI: Tools such as ChatGPT and Gemini are used by most, but hardly anyone pays for premium versions.
3. Self-learning: There are few workshops; most of those present learned on their own.
4. Faculty's caution vs. students' enthusiasm: While professors fear plagiarism and the disappearance of the ability to think critically, students are enthusiast for integration.
5. But barriers are steep: There's little infrastructure, inadequate training and no institutional guidance for responsible adoption.
6. Ethical concerns: Almost all groups cited dangers of over dependence, plagiarism, and the loss of creativity.
7. Agreement over oversight: Strong committees, clear guidelines and discipline-specific approaches

perhaps as electives or non-major offerings.

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IV. RECOMMENDATIONS

From Teachers:

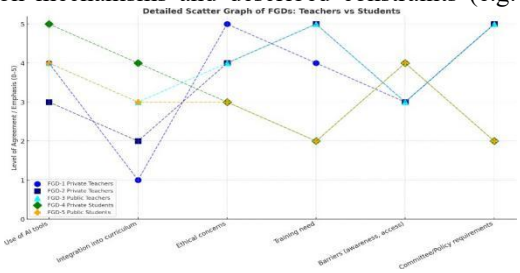
1. Setting up national and institutional committees for the promotion and proper integration of it.
2. Developing faculty professional-development programs in prompt engineering and ethics.
3. Developing discipline-specific policy to enable the arts, sciences and professional programs to apply it differently.
4. Implementing AI-detection, plagiarism checking tools more strictly in universities.
5. Promoting assignments for students which is rewarding enables critical thinking and creativity.

From Students:

1. Adding 'prompt engineering' courses to the curriculum perhaps as electives or non-major offerings.
2. Providing workshops, tutorials and teacher-directed instruction to increase knowledge.
3. Some AI tools for the institutions (e.g. access to free or discounted subscriptions).
4. Emphasizing responsible use paraphrasing, quoting and humanizing AI generated outputs.
5. Advocating for policies that promote innovation and integrity, with the key goal of AI supporting learning instead of replacing it

Fig-1: Scatter Graph defining the FGDs Teacher vs Students

The scatter plot diagram illustrates the results of five FGDs with teachers and students of Bangladeshi public and private universities to investigate perceptions on AI and prompt engineering in higher education. Teachers prioritized ethical dilemmas, teacher training opportunities and the importance of strong policy implications while generally not showing much support for direct curriculum integration; students expressed frequent use of AI features, were supportive toward integration mechanisms and described constraints (e.g. unawareness on how to work with AI). An illustration that draws a stark dichotomy between the wariness of teachers and the excitement for AI on the part of students is provided in our visualization.



V. DISCUSSIONS

The findings of this study, based on five FGDs with teachers and students from public and private universities in Bangladesh, highlights major tensions in the uptake of AI and prompt engineering at higher education level. These tensions are indicative of more general global discussions around how to balance innovation with academic integrity and the logistical difficulties of embedding rapidly developing technologies within existing educational frameworks.

From a practical perspective, the result shows that students are already heavily using AI-powered tools such as ChatGPT and Gemini for their day-to-day academic work. You can use them to summarize articles, brainstorm assignments, aid in coding or help prepare papers. This implies that AI is the de facto learning partner even if institutions do not formally accept the technology. The point being made here is for universities not to stand passively as AI takes a hold, but to rather direct that set of forces. Guided workshops, discipline-focused AI training and access to tools within the institution can help limit students' engagement as mere passive consumers who however learn to exercise and apply critical reflection on AI.

In contrast, teachers were somewhat more cautious or even resistant with their concerns about academic dishonesty, plagiarism and the threat to critical thinking. Their demands for ethical codes, faculty training and robust institutional committees highlight a real-world disparity: As students rush forward with A.I., many professors aren't equipped to meaningfully manage or understand it. This need-gap mismatch has implications for quality of instruction as well as learning outcomes. Implications for policy and practice the findings suggest that there is an urgent need for faculty development programs to prepare academic educators for providing students with responsible guidance, instead of failing to keep pace with the technological interaction of their students.

Theoretically, the paper adds to the literature on technology acceptance in education by unpacking how generation, discipline and institution inform teachers' AI attitudes. The hesitancy of teachers is in keeping with models of resistance to disruptive innovation whose perceived challenge to established pedagogy results in a postponement of implementation. Now, meanwhile, students' excitement represents a demand-driven model of change in education, wherein user practices (students self-learning through AI) force institutions to move. This differential implies that further theories of EDTECH would have to consider power imbalances between

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students and faculty, as well as disciplinary relevance (STEM vs. Humanities).

The research also charters out crucial directions for further study. First, longitudinal studies could explore how long-term exposure to AI tools influences critical thinking, creativity and the employability of learners in the context of Bangladesh. Second, by comparing findings across countries or regions one could examine if the prudent teacher–zealous student dichotomy is specific to Bangladesh only or generalized across countries elsewhere. Third, more quantitative studies may investigate how AI integration influences learning results, academic honesty and skill development thus resulting in evidence-based suggestions for course design.

Overall, this research highlights that AI in higher education is a bit of both; a challenge and an opportunity. Over all, for academics and practitioners is the reminder of the imperative to balance ethical protections with innovation in education so that AI supports rather than countenances the pedagogical mission. For theorists, the work suggests a necessity to view adoption dynamics in ways that will account for stakeholder roles and disciplinary contexts as well as changing institutional cultures. Finally, the responsible deployment of AI in higher education in Bangladesh will necessitate cooperation among students, educators and government authorities to situate AI as a tool that supports, rather than replaces, human creativity and critical thought.

VI. CONCLUSION

This study is not the end point, but a significant starting point of investigation in AI and prompt engineering in the Bangladesh higher education sector. Corralling both teachers' and students' voices, the study has shed light on two uneven realities of excitement and trepidation, showing how AI is already influencing academic practices even as it stokes concerns about ethics, critical thinking and institutional preparedness. These are numbers that establish, in a broad way, the space for talking about these themes, policy construction and pedagogical transformation but they are very preliminary.

This study can be taken further by future researchers in a number of ways. Future longitudinal research might consider examining the effects of continued use of AI on student learning styles and intellectual autonomy. Comparisons across ethnicities, disciplines, or cultural areas might clarify whether the enthusiasm–caution gap observed here is peculiar to Bangladesh or reflects a pattern of interest for our globe. Better, more data-driven research might delineate the tangible effects of integrating AI on performance, plagiarism rates or job readiness equipping institutions to develop evidence-based tactics themselves. Furthermore, an interdisciplinary approach integrating insights from education, computer science, sociology and ethical studies might enrich the analysis so that AI is not presented as a mere technical tool but as (literally) a social actor.

Ultimately, this study should be taken as a beginning, not an end. It calls on scholars, policy-makers and educators to meet the challenge of combining innovation with integrity, caution with creativity, regulation with freedom. As the age of AI shapes education, the next wave of studies will illuminate whether this tech tool really is a force that will deepen or diminish human learning. The discussion initiated in these FGDs is no more than the first rough draft of a future story an ongoing one which social scientists have an obligation to keep writing with imagination, discipline and account.

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Utilization of Artificial Intelligence in HR: Upskilling Employees in Real-Time Manner

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Abstract - **Artificial Intelligence (AI) is transforming global HR practices. But its adoption in emerging economies like Bangladesh remains nascent. However, since AI is an evolving technology, continuous exploration of AI's impact is important. This study examines AI-driven Human Resource Information Systems (HRIS) & their impact on employee training & organizational learning in Bangladesh. This Study has been conducted with a Qualitative Approach method. The approach was completed by taking interviews from HR professionals & employees who get affected by the daily HR operations. This study tries to analyse the current HRIS integration, AI implementation challenges (e.g., cost, technical expertise, privacy), & workforce readiness. Findings reveal that high ROI optimism despite low adoption rates. Which is moderated by infrastructure gaps & cultural adaptation needs. The research validates the Technology Acceptance Model (TAM) & Diffusion of Innovation (DOI) theories in these contexts & offers strategies for AI-HRIS implementation. By addressing barriers like workforce familiarity gaps & cost constraints, Bangladeshi organizations can leverage AI for efficient & personalized HR processes.**

Keywords - **Adaptive training & development, AI based Learning, Artificial Intelligence, Bangladesh, Employee Upskilling, HRIS, Organizational Learning, Performance Management, Technology Adoption.**

I. INTRODUCTION

The digital transformation of Human Resource Information Systems (HRIS) represents one of the most significant shifts in organizational management in the 21st century. Artificial intelligence is becoming more & more popular among organizations around the world seeking to improve business processes & employee experience. The adoption of AI-based HRIS solutions has become more important than ever to gain competitive edge. This conversion is particularly important in emerging economies such as

Bangladesh. Where manual HR practices are no longer fit for purpose. [11]. Yet the use of these solutions in developing market has its own obstacles. That includes limitations caused by infrastructure & discrepancies in skill levels & culture. [7].

Current Landscape: Currently firms in Bangladesh uses in-house portals, where integration of AI is nascent. Since the use of technology is getting wide in Bangladeshi firms e.g. using ATS for CV Screening, they should consider adopting it deeply into their systems. For example: Using Advanced AI chatbots. As it is important to survive in this competitive business market.

This study uses a Qualitative method to research on the existing status of AI incorporated HRIS implementation in Bangladeshi organizations.

1.1 Research Objectives

- To study the present scenario of HRIS adoption in different organizations of Bangladesh.
- To examine the integration of AI technologies in employee training & development & how much are they using the real-time upskilling approach.
- To empirically determine the key barriers & drivers influencing the adoption of AI-driven HRIS.
- To determine the preparedness of the Bangladeshi market for AI-based HRM.
- To analyze organizational acceptance for technology-supported training interventions & for that matter the real-time training.
- To provide strategic recommendations for future AI-HRIS implementation.

1.2. Literature Review

This study aims to find out utilization of Artificial Intelligence in HR. How much ready is the market is & their impact on employee training & organizational learning in Bangladesh. Through multi-sector Qualitative Interviews & justified against TAM & DOI theory. Qualitative interviews allow for a detailed view on employee training & development activities. [6].

1.3 Theoretical Framework

A) Technology Acceptance Model (TAM)

Technology Acceptance Model, says that technology adoption is influenced by perceived usefulness & perceived ease of use. Which subsequently affect behavioural intention & actual system use. In the context of AI-driven HRIS, this

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model helps explain the varying levels of acceptance across different employee categories & organizational levels[2].

B) Diffusion of Innovation

[5], Diffusion of Innovation Theory provides additional insight into how AI-HRIS technologies spread within organizations & across industries. The theory's five adopter categories (innovators, early adopters, early majority, late majority & laggards) help explain the varied adoption patterns observed in Bangladeshi organizations.

1.4 Contribution to knowledge

This study presents a holistic view of current HR practices in Bangladesh & identifies the gap of AI implementations in it. The study also tries to find the gaps in employee training & upskilling. This study also recommends the use of real-time training should be increased.

II. METHODOLOGY

2.1 Research Design

This study employs a qualitative research method design. Qualitative exploratory interviews gain comprehensive insights into the current state & future potential of AI-driven HRIS implementation. It also tries to explore the potential of using a Real-time learning approach in Bangladesh. The use of qualitative methods enables the triangulation of data sources & depth of understanding.

2.2 Sampling Strategy

A purposive sample was drawn from a broad range of sectors. 22 samples have been taken to conduct this study.

To justify, in a Qualitative study, interviewing 20-25 participants is sufficient for reaching a theoretical saturation [6]. In this study, the author observed the emergence of repetitive themes after interviewing the 22nd Participant. He recommends interviewing 20-25 individuals for a grounded theory study.

The participant demographics are attached in the appendix section.

2.3 Data Collection

The primary data was through the semi-structured interviews of HR professionals & employees of different department/sectors in Bangladesh. Each Interview was at a minimum length of 25 minutes. This study aims to explore how AI is being utilized in upskilling in Bangladesh. By doing so, the study aimed to unearth the experiences of the relevant employees on AI's utilization in their upskilling. A qualitative study helps to explore people's experiences from their perspectives. As it extracts raw data from people's direct experience. Interviews are aimed at gathering well-rounded perspectives of employees who gets/will get affected by the implementation of AI in daily HR operations. Considering the aims of the current study, a qualitative approach seemed most appropriate.

2.4 Data Analysis

Thematic analysis was conducted to identify key patterns, themes & insights from the interview transcripts. The analysis is focused on understanding current HR practices, implementation barriers, AI-readiness, & future opportunities.

2.5 Study Limitation & Ethical Considerations

This study's geographic focus is on Bangladesh. This cannot justify the Worldwide scenario.

Informed consent was obtained from all subjects; each of whom remained anonymous throughout the study. This study followed the accepted ethical guidelines for qualitative method research.

III. FINDINGS

3.1 Theme 1: HRIS Adoption Pattern in Bangladesh

Right now, the organizations in Bangladesh use different HRIS depending on size & resources of the organization.According to the data, the majority of companies are using some sort of an HRIS in more or less advanced form. Interview analysis confirms that most systems remain basic with little AI integration. HRIS organizations such as reports constraints of integration problems & manual data entry & inability to provide real-time analytics.

3.2 Theme 2: Mainstreaming of the Hybrid training methods

The hybrid approach combining the blend of on-the-job & off-the-job training methods, it would be easy to apply the certain skills learnt on the job rotation. Responses indicate that on-the-job training & blended learning are the most common methods, while only a few organizations use fully digital training platforms.

3.3 Theme 3: Moderate Digital Transformation Levels

Participants rated their organizations' digital transformation levels & most of them find; it is upgrading gradually. This indicates moderate progress in HR digitization. Qualitative analysis says that most companies use a hybrid of traditional & digital approaches to train staff.

3.4 Theme 4: High AI Implementation Readiness

Presently, use of AI driven HR tools is low. The majority of respondents are enthusiastic about leveraging AI to drive people's experiences. This is quite valuable even if currently not widely used.

3.5 Theme 5: Workforce Familiarity Gap

Results of interview shows; there wasn't too much unfamiliarity with AI-integrated HRIS software. Validating observations shared during interviews about the digital haves & the have nots.

3.6 Theme 6: Lack of using Real-time training approach

Participants feel the need of Real-time training to mitigate the market demand. Unfortunately, except a few, most organizations do not use this training approach due to numerous reasons.

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3.7 Theme 7: Cultural Adaptation Importance & Employee Responsiveness

Participants marked cultural adaptation of AI-driven HR tools for the Bangladeshi market as extremely important. Highlighting the need for localized solutions.

3.8 Theme 8: Implementation Barriers & Future Implication promises

Participants identify the financial constraint & lack of expertise as top implementation challenge. Except these two there are concerns, such as: Data privacy, Integration with the existing system & Employee resistance. However, despite barriers almost every participant strongly agrees that AI-driven HR initiatives justify the investment & will generate good ROI. This positive outlook is also consistent with the interview results on optimistic future returns.

IV. DISCUSSION

The paper is helpful for understanding the existing situation & future potential of AI-based HRIS adoption in Bangladesh. Which is effectively analysed through the lens of the Technology Acceptance Model (TAM) & Diffusion of Innovation Theory.

4.1. HRIS Adoption Pattern

The finding says, most organizations currently utilize some form of HRIS with varying levels of sophistication. aligns with [5] diffusion theory. However, 2-3 participants do have a different point of view, specially who works with the blue collars says that,

"Due to lack of employee response & burden of an uneducated workforce it is quite difficult to implement, the management also shows very little interest in it".

Through the TAM perspective, there are dominance of basic systems with reported limitations. Such as: Manual data entry requirements, integration challenges & lack of real-time analytics. Which indicates significant gaps in perceived usefulness & perceived ease of use, [2]. Organizations' experiences with current HRIS challenges may create negative attitudes toward technology upgrade. Which potentially slows the adoption of sophisticated AI-driven systems.

4.2. Training Approaches

The predominance of hybrid training models, which blend face-to-face & online modes, is a culmination of [5] diffusion theory. Organizations are adopting new training technologies to complement, not to replace, traditional methods which organizations have adhered for decades. However, to justify a participant said,

"The method is traditional TBH; They observe the supervisor doing the job & later on replicate it (On the job observation). White collars go under the job rotation process usually.

From a TAM perspective, the prevalence of on-the-job training & blended learning suggests that these methods score higher on perceived usefulness & ease of use compared to fully digital platforms. The limited adoption of a fully digital training approach may indicate concerns about the complexity of implementation & doubts about its privacy promises.

4.3. Digital Transformation & AI Implementation Readiness

Further, this result is consistent with the TAM [2] assertion that; behavioral intentions lead to the actual usage of a system. Which is shaped by attitudes toward using technologies. The gradual transition from manual to digital processes suggests a measured approach for technology adoption influenced by some factors. Such as organizational resources, infrastructure readiness & change in management capabilities, [5].

4.4. Workforce Capacity

The workforce familiarity gap with AI-HRIS platforms highlights the importance of the social system in innovation diffusion. Rogers [5]. It emphasizes the characteristics of the social system, including its communication patterns & change agent efforts. This finding also relates to the TAM [2], external variable of computer self-efficacy. Where workers' confidence in their ability to use AI-integrated systems is directly influenced by their perceived ease of use & subsequent adoption intentions. The knowledge gap indicates the necessity for extensive capacity building & confidence in the workforce.

4.5. Real-time Training Approach

The study identifies the need for a real-time training approach in the private sector. It reflects the compatibility & relative advantage characteristics of innovation adoption. [5]. However, there exists different perspectives,

"More or less delays are seen. In our local corporate culture, they use work-based-training (WBT) to train the employees which is difficult to alter quickly as real-time approach demands. However, the management is trying to implement it gradually."

There is also a cultural aspect behind it, as Bangladesh has a risk averse culture. The management tends to avoid the risk of adapting the changes instantly. Although it is emerging globally. Companies like "Indeed" use these approaches in their daily operations.

4.6. Cultural Adoption

As Bangladesh is a high context culture country. People tend to avoid taking risks. As Real-time training approaches, scores are low compared to traditional training methods. Which emphasises TAM [2]. As it justifies perceived usefulness & perceived ease of use. Participants also put the same sort of view, *"It is (Cultural Adoption) at a very good stage, everybody welcoming this AI transformation especially in the corporates."*

Another perspective is present, *"It is not in the optimum stage yet, everybody is not welcoming this AI transformation especially who are not in the corporates."*

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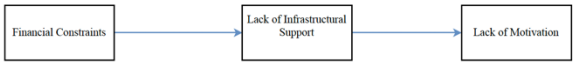
On the other hand, cultural adaptation of AI-driven HR tools for the Bangladeshi market underscores the compatibility characteristic of innovation adoption. [5] argues that innovations are more likely to be adopted when they align with existing values & needs of potential adopters.

4.7. Implementation Barries

There are numerous barriers in our local context, such as Data privacy risks, Implementation Challenges & Concerns about AI-algorithm biasness. In TAM [2] terms, these represent external variables that significantly influence technology acceptance by affecting perceived ease of use & behavioural intention. Participants say,

"Based on my personal experience, HR professionals tend to stay risk free since the use of AI in HRDs in Bangladesh is still in a grey area; they are still not fully convinced to use it that deeply. Besides, there are concerns about slow speed of facilitation & lack of employee readiness in terms of blue-collar employees as they are the major stake holders."

From a Diffusion of Innovation perspective, these barriers represent characteristics of the adopting organization, particularly resource availability & organizational capacity.[5].



4.8. Future Implementation

Professionals think, there are huge scopes of implementing AI-Based HRIS in Bangladeshi industry. There is strong agreement present among participants that AI-driven HR initiatives justify the investment & will generate positive ROI. As participants say,

"Improvements are needed in 2-5 yrs, especially to reduce the manual paperwork."

This finding suggests the primary barriers to adoption are not related to perceived value but rather to implementation challenges & facilitating conditions. And then when these external hurdles are removed, then the high perceived usefulness & positive attitudes towards AI-based solutions should lead to massive adoption. [5].

V. POLICY IMPLICATIONS & FUTURE RESEARCH DIRECTION

The findings of this study can help policymakers & organizational leaders to adopt AI integration in Bangladesh's HR management landscape. Such as: Policymakers should prioritize developing digital infrastructure that can support gradual technological advancement. The government can introduce tax incentives & subsidized training programs to support AI adoption, as there are financial constraints & expertise gaps present. Policymakers should consider developing nationwide AI competency frameworks that align will with the preference of hybrid training models. Organizational leaders should propose standardized certification programs that combine traditional classroom learning with on-the-job application, to mitigate the workforce familiarity gap. This study can also help policymakers introduce regulatory frameworks that emphasize continuous professional development through real-time learning platforms.

Future studies can consider a quantitative approach to test the findings of this current research.

VI. CONCLUSION

This study investigates the use of AI in HR management for upskilling employees in Bangladesh using qualitative interviews across sectors. The research finds that Bangladeshi firms are at the precipice of a historic technological inflection point with significant readiness to accept the AI-enabled HRIS despite scarce utilization at the moment. Key findings show that most of the companies have at present HRIS-based infrastructure in spite of the inchoate AI adoption in companies. There are lots of reasons for that they are: l. Financial Constraints, 2. Shortage of Technical Support & 3. Infrastructural limitations.

However, participants expressed strong confidence that AI-driven HR initiatives justify investment & will generate positive returns. The study validates both Technology Acceptance Model & Diffusion of Innovation Theory in the Bangladeshi context. Justifies that, perceived usefulness of AI solutions is high but perceived ease of use is constrained due to implementation barriers. The research identified substantial gaps in real-time training approaches & workforce familiarity with AI-HRIS platforms particularly among blue-collar employees. Bangladesh's combination of increasing market pressures & positive stakeholder attitudes creates favourable conditions for AI transformation in HR. That identified barriers are systematically addressed through strategic ecosystem development & collaborative stakeholder engagement.

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From Burnout to Boundaries: What Drives Quiet Quitting in Today's Workforce?

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Abstract - **Quiet quitting has become a trending topic recently among organizational and workforce circles, especially in the wake of the post-pandemic era. Quiet quitting refers to a situation whereby people meet only the bare minimum demands of their work role- bypassing new responsibility or emotional commitment without really quitting. This quiet manner of disengagement raises crucial questions regarding worker motivation, organizational commitment and shifting psychological contract between employers and employees. Investigating the reasons and consequences of quiet quitting in today's environments is the aim of this study, which focuses on two distinct subjects: personality and psychological contracts. The results are intended to offer managers and HR professionals strategic insight into how they can successfully manage disengagement and build a more diverse, passionate, and resilient workforce as well as deeper knowledge of the behaviors that cause quiet quitting. By employing a qualitative exploratory research design, the current study aims to present an in-depth understanding of quiet quitting behavioral tendencies and situational variables. Lastly, the study adds to the nascent conversation of the employee experience and changing nature of work in a post-pandemic, hybrid, and purpose-driven workplace era.**

Keywords: **Quiet quitting, psychological contract, personality traits, organizational commitment**

I.INTRODUCTION

The phenomenon of "quiet quitting" has been of major concern in organizational behavior studies in recent times since it reflects a subtle but meaningful change in how employees are being called upon to work. Quiet quitting is not actual employee action of leave such as traditional turnover but psychological disengagement. People do only the minimum that the agreement requires but are otherwise tuned out from organizational existence. Having itself once been considered a symptom of disengagement on the periphery, quiet quitting is presently the most buzzword topic of conversation regarding organizational culture, performance and sustainability [1]. This would require further investigation into psychological and behavioral antecedents that lead some people to disengage quietly while others are engaged. One of the strong lenses of knowledge that can be applied in understanding quiet quitting is through personality psychology or the Big Five.

Personality characteristics play a role in determining how the individuals perceive the stressor, cope with issues in the organization, and stay motivated. Individual differences are a determining factor whether employees will engage in quiet quitting behaviors. Openness and extraversion are some of the characteristics associated with readiness to exert extra effort even in the face of perceived organizational injustice. While, on the contrary, neuroticism increases the levels of withdrawal, wherein the individuals are more likely to withdraw [8]. Extraverted employees also have lower possibilities of burnout in traumatic situations like the pandemic; hence the likelihood of quiet quitting is lower in this instance [6]. Conscientiousness was similarly found by [2] to be negatively related to burnout that indirectly lowers the possibility of quitting quietly. Furthermore, the systematic reviews indicate that both neuroticism and low agreeableness are risk factors for burnout, which is a predictor or an antecedent of withdrawal behaviors [2].

Personality is not one of the peripheral drivers but a core motivator for engagement or passive disengagement of employees. Nevertheless, psychological contracts or implicit agreements are other factors that also contribute to quiet quitting. This research identifies its field of interest as quiet quitting as an organizational disengagement process in the manner that it is vulnerable to personality and the manner that it may be strengthened or disempowered by the psychological contract. This study reconciles the idea of psychological contract, and personality's relevance by showing the complementary role that organizational demands and individual inclinations play in motivating quiet quitting. To this end, the article places quiet quitting on the cusp of personality types and psychological agreements, both of which are known as core processes that account for why some employees quit their jobs and others become engaged. Quiet resignation is a fine balancing act between the organization's expectations and individual psychology and not a movement. This paper assumes a personality approach to shallow explanations to follow the mechanism of disengagement. Thus, not only does our research de-seasonalize the psychological phenomenon of quiet quitting in the context of the contemporary workplace, but it also provides employers with some tangible results to predict, comprehend, and respond to this timely matter.

II.OBJECTIVE OF THE STUDY

a. To examine the relationship between the Big Five personality traits (openness, conscientiousness, extraversion, agreeableness, and neuroticism) and quiet quitting.
b. To explore how different personality traits influence employees' tendency to demonstrate quiet quitting behaviors.
c. To examine the role of the psychological contract (perceived obligations and expectations between

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employer-employees) in shaping employees' tendencies towards quiet quitting

III.LITERATURE REVIEW

Quiet Quitting

Quiet quitting is a form of work disengagement that has as of late appeared in a considerable sense in the organizational behavior literature. This is a tangible reversal of the conceptions of employee engagement in recent times when it is a trend where employees consciously minimize the amount of work they put into a predetermined minimum threshold in a bid to continue receiving formal working hours [7]. Unlike the conventional quitting, it is a psychological de-identification with his/ her job and an inability to commit emotionally, which is typically induced by burnout, expectations, and injustice in the company. Since [5] referred to quiet quitting as a burnout symptom, this implies that it is a coping mechanism that employees apply to address the impact of the chronic work stressors. Though the concept is relatively new, it is closely linked to the four different lenses namely- personality traits, technology, organizational citizenship behavior, and psychological contract which are key factors that drive quiet quitting in today's organization. Among them, personality types have a big influence on quiet quitting. Workplace engagement sometimes relates to our personality traits, particularly those conceptualized under the Big Five model are significant predictors of workplace engagement.

Extraversion and Quiet Quitting

Extraversion is characterized by sociability, assertiveness, energy, and outside seeking stimuli [3]. Extraverts tend to be more active in teamwork and are driven by appreciation and communication. Experimental evidence indicates that extraversion is a protective variable against disengagement. As an example,[6] discovered that extraverted workers were not as susceptible to burnout during the pandemic, which reduced the chances of disengagement or quiet quitting. In a similar manner, [8] have indicated that extraversion is positively related to organizational justice perceptions that increase discretionary effort and counter withdrawal. Extraverts, who like visibility and being socially acknowledged, are unlikely to be attracted to quiet quitting as often requires disengagement with the team. Extraversion in this context will mean that it lowers the chances of quiet quitting because it aligns individual motives with organizational involvement. The converse of extraversion is introversion, which is characterized by reservedness, reduced social stimulation demands, and working alone or alone [3]. Although introversion is not necessarily bad, stressful conditions in the organization can overlap with the introversion to promote disengagement. Quiet quitting can be a readily available coping strategy in situations where the introvert experiences a workload stress or other unmet expectations because the introvert prefers not to cooperate with other colleagues and/or to conflict with them.

Conscientiousness and Quiet Quitting

Conscientiousness is widely recognized as a buffer against disengagement which is characterized by self-discipline, organization, reliability, and goal orientation [3]. Conscientious individuals are motivated by achievement, responsibility, and a strong sense of duty. In the workplace, they tend to maintain consistent effort, even under unfavorable circumstances, and are less prone to counterproductive behaviors. Conscientiousness was also found by [2] to be negatively related to burnout that indirectly lowers the chances of quiet quitting. In practical terms, conscientious employees might think that quiet quitting does not align with the internal performance standards. Even in cases when they are not satisfied, their high self-regulation tends to inhibit them to minimize effort to a minimum. They can, instead, find other coping mechanisms like problem-solving, negotiation or re-prioritizing tasks. This gives conscientiousness a good buffer to quiet quitting tendencies.

Neuroticism and Quiet Quitting

Neuroticism is defined as the propensity of emotional instability, anxiety, moodiness and increased stress reactivity [3]. Neurotic people suffer negative affect more and are more susceptible to psychological stress in challenging working conditions. Neuroticism is the largest of all the Big Five traits that is correlated with quiet quitting, burnout, stress, and withdrawal behaviors. [2] have proven that neuroticism is a significant factor that predisposes one to job burnout that is a precursor to disengagement and quiet quitting. [8] also demonstrated that neurotic individuals perceive stressors at work as obstacles and not a challenge, which increase withdrawal behavior.

Openness to Experience and Quiet Quitting

Openness is flexibility, openness to experience and openness to new experiences [3]. Openness is high, which eases the process of coping with change, technological changes, and the needs of innovation. Conversely, low openness makes the employees disengage when exposed to a new thing or in the case of disruptive force. [9] established the connection between digital anxiety and withdrawal intentions with turnover intentions and quiet quitting is the mediating factor. Therefore, openness is both a safeguard against disengagement as it allows positive adjustment and low openness increases the likelihood of quiet quitting during change and uncertainty.

Agreeableness and Quiet Quitting

Agreeableness is a trait that depicts cooperation, empathy, trust and prosocial behavior [3]. Harmonious relations, teamwork and support motivate agreeable people. They are more inclined to the organizational citizenship actions (OCBs), which includes things outside the official mandate or job, to support others and to sustain organizational unity. In the context of quiet quitting, low agreeableness has been associated with reduced cooperation, conflict-prone attitudes, and withdrawal. low agreeableness working with neuroticism in enhancing burnout, hence, increasing the risk of disengagement [2]. Conversely, highly agreeable employees might not be willing to quit quietly, as disengagement undermines group harmony and might ruin interpersonal trust.

Psychological Contract and Quiet Quitting

One of the most significant quiet quitting explanatory mechanisms is the psychological contract amongst the employers and employees showing implicit mutual expectations. The employees who feel that neither promise was kept, nor their duty was respected, in principle will not generate

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any additional discretionary effort. Research indicates that breach of agreements and burnout are structural facilitators of quiet quitting which supports the linkage between low motivation and unmet expectations [10]. It is also revealed that breaching the contract demotivates employees and increases turnover intention outcomes equivalent to quiet quitting [4]. The significance is that the psychological contract is the basis of the discretionary effort, and upon removal, employees reduce their effort level to the minimal level.

IV.RESEARCH QUESTION

This study employed a qualitative exploratory approach to gain initial insights into the relationship among personality traits, psychological contract and quiet quitting behaviors. A small number of semi-structured interviews were conducted with employees from varied professional backgrounds. The interviews were guided by these questions: (1) whether personality influences willingness to perform extra tasks beyond formal responsibilities, (2) which specific traits make it easier or harder to take on additional work, and (3) whether introversion or extroversion affects willingness to go beyond formal duties. (4) How do you perceive the promises made by your employer at the time of hiring compared to your current experience? Has any discrepancy influenced your willingness to go beyond your job duties? (5) In what ways do you think unmet expectations from your employer contribute to your decision to limit effort?

V.METHODOLOGY

The qualitative exploratory approach investigation drew upon data collected from 16 respondents. The age group of the respondents was 23-52 with a concentration in the younger adult cohort (early-to-late twenties) range. The modal age was 27 years, and hence the sample mainly consisted of people in the early stages of their career. In terms of gender distribution, the sample comprised 7 males and 9 females, reflecting a reasonably balanced. This demographic composition provides a meaningful context for interpreting the findings because both the generational positioning and the gendered outlooks are also likely to influence the experience and the perception of the employees towards quiet quitting. The interviews were conducted in both English and Bangla to ensure clarity and comfort for participants. Given the limited number of participants, the findings should be interpreted as preliminary and illustrative rather than generalizable. The purpose of this study was not to establish definitive conclusions but to generate conceptual insights and highlight areas for further investigation in future research.

VI.FINDINGS

This study is based on a small sample of exploratory interviews, which set out to elicit initial insights into the interlinkages between personality, psychological contract and quiet quitting behaviors. The overall goal was to understand how personality types, perceptions of organizational promises connect to employees' intentions to engage in work activities outside of their formal job descriptions. The dataset is small, however, some consistencies were identified that can inform future larger-sample-based research.

The research supports the idea that personality forms a major input into the impact on discretionary effort amongst employees and this directly relates to the possibility of quiet quitting. Giving some examples, extroverts tend to nominate themselves to work extra and to work in teams since they become energized through social interaction and teamwork. They will perceive more work as an opportunity, learning, and networking- a lower likelihood of quiet quitting.

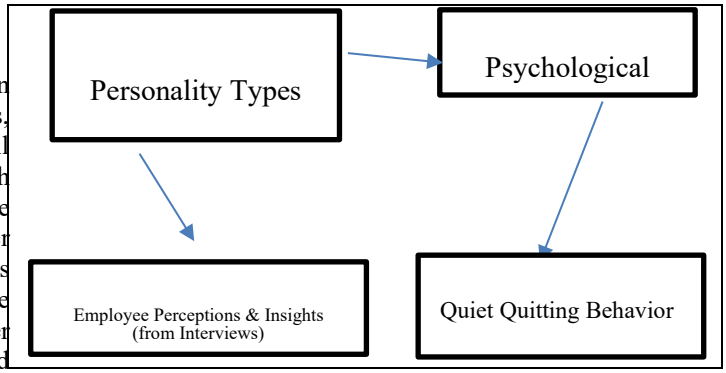


Figure 1- Author's proposed model

As one interviewee has explained:

"I am an extrovert and therefore it is alright to persevere any emergent challenge that I might encounter at my workplace since I can communicate and get out any defined problem at work"

In comparison, introverted workers prefer tasks that are arranged in a very nice way and might be more reluctant to unplanned ones. Once again, this does not necessarily mean withdrawal. Instead, they can work extra hard in less obvious ways, e.g. by working overtime or secretly helping other co-workers. In these cases, outwardly based boundary-setting is really more akin to their desire for ordered work than disengagement. One interviewee described:

"I am an introvert, but I like to work and I am able to work overtime."

Beyond introversion and extroversion, there were some other personality dimensions that were strong predictors of extra-role behavior. Employees who are high in conscientiousness, agreeableness, or openness to experience volunteer for extra work because they are obligated, they like their teams, or they enjoy solving puzzles. They are less likely to quit their jobs because they naturally take charge. As one interviewee explained:

"I like to help when someone needs it even though it's not part of my job."

Conversely, recognition- or autonomy-motivated individuals may decrease discretionary effort if they do not receive appreciation:

"If no one shows appreciation, then I prefer to just do my own thing."

On the other hand, neurotic workers are highly prone to quiet quitting. Their tendency to worry, doubt themselves, and overreact to disappointment in the guise of perceived broken promises or unfairness at work can raise the level of perceived unfairness or broken promises. Thus, they are probably likely to disengage as a coping mechanism. One of the respondents described this sentiment:

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"I believe regardless of how hard I work, it's still not enough to them. Why must I continue to drain myself?"

The interviews also focused on the central place of organizational routines and the psychological contract, the unwritten understanding between employer and employee regarding expectations. When organizations fail on promises, i.e., do not provide commitments such as sufficient resources, fair workload, or recognition, employees' willingness to provide extra effort is greatly reduced. Defaulted promises and crossed expectations will most likely lead to frustration, reduced discretionary effort, and quiet quitting behavior.

"*When promised resources were late it lowered my motivation since I felt my effort was not valued."*

Conversely, where organizational practice aligns with employee expectation, motivation and engagement are increased. Each of trust, recognition, and fairness was given on a consistent basis as one of the fundamental determinants to motivate employees to do more than is expected by a formal job. The implications of these findings are that quiet quitting is not about personal preference or personality but is significantly influenced by whether psychological contracts are seen to be satisfied or otherwise.

"Trust really has a big influence on motivation. When trust exists, I feel that I will receive an appropriate reward for my work, and that makes me motivate others to help people and lead."

The interplay between organizational traits and personality dimensions was also found to be an effective predictor of extra-role behavior. Even extroverted and action-oriented workers will go the extra mile, but they also rely on some level of supportive environments, open communication, and equitable pay. More introverted or boundary-concerned workers will nevertheless invest significant discretionary effort if reinforced by work excellence, competent supervision, or proper pay. This means that quiet quitting is not only the product of the lack of motivation, but also of a multifaceted interaction between organizational surroundings and personal tastes.

Generally, results of the exploratory research suggest that both intrinsic personality factors and extrinsic organizational psychological contract satisfaction, justice and trust processes are predictors associated with quiet quitting. Employee effort participation in overtime is established by organizational effort, expectation communication, resources, and effort recognition and personality. Whether or not employees voluntarily put in more effort than the assigned work or restrict their effort to core work is moderated by recognition, fairness, and promise-keeping consistency. These findings indicate that in creating engagement programs, companies who want to stem quiet quitting and increase discretionary effort would be well advised to take into account individual characteristics as well as organizational activities.

VIII. CONCLUSION

The phenomenon of quiet quitting is a bright trend on the organizational level indicating a concern about the way people communicate, study, and work in the contemporary workplace. It is not a mere temporary remedy at the workplace. The Big Five models of personality have proven to provide a viable foundation on the reasons why some employees remain loyal, and others disengage as it has been shown in the preceding study. However, besides individual choices, institutional, cultural and technical factors also shape the daily working conditions of the employees and can cause quiet disengagement. As opposed to intentional forfeiture of effort, quiet quitting is more readily understood as a bargained accommodation between institutional pressures, psychological needs, and individual values. These accounts argue that institutional harmony among reward and expectation, request and compensation, technology and human adjustment are less responsive to quiet quitting than individual characteristically. It is an advanced factor with which organizations should maintain the employees' level of motivation and avert the subtle dilution of workplace culture. Quiet quitting is a serious issue of modern-day workplace because it is an unstated method of disengagement. It is thus imperative to pay attention to its research. This study examines the effect of different personality traits and psychological contracts on employees' likelihood to disengage quietly. Our findings provide insight into organizations and allow managers to trace the root causes of disengagement and develop initiatives for increasing employee engagement and job satisfaction. To get a more comprehensive and accurate perspective, future research should incorporate the coding and thematic analysis of these interviews.

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Sustainable Intelligence in AI-Driven Management: Exploration of Strategic Integration and Ethical Governance

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Abstract - **Artificial intelligence (AI) is changing the way businesses are managed, but using AI effectively today requires more than just adopting new technology; it also demands responsible and thoughtful implementation. This study focuses on the idea of sustainable intelligence, which means using AI in ethical ways, aligned with business goals, and beneficial over the long term. To explore this, a qualitative research method was used, including interviews with business leaders, AI experts, and professionals in ethics and governance. The study also looked at documents such as company policies and AI guidelines. The findings highlight three important areas. First, Strategic Integration AI is most useful when it supports the overall goals of the organization and is planned with input from different departments and leadership. Second, Ethical Governance, there needs to be clear rules and systems in place to make sure AI is used fairly, transparently, and responsibly. Third, Building Capabilities employees across the organization, both technical and nontechnical, need proper training and awareness to use AI in ethical and effective ways. This research offers a practical model for how organizations can adopt AI in a way that balances innovation with responsibility. It provides useful guidance for decision-makers, policy developers, and researchers who want to ensure that AI tools are not only powerful but also trustworthy, fair, and aligned with human and organizational values.**

Keywords - **AI, Management, Governance, Sustainable, Technology**

I. INTRODUCTION

A. The Imperative of Sustainable Intelligence in the AI Era

Artificial Intelligence (AI) has emerged as a transformative force, fundamentally reshaping contemporary business practices by significantly enhancing efficiency, fostering innovation, and advancing decision-making capabilities across various sectors.[1] Beyond these traditional applications, there is a growing recognition of AI's critical role in addressing global sustainability challenges, compelling organizations to align economic objectives with environmental and social responsibilities[1]. This convergence necessitates the cultivation of "Sustainable Intelligence," a concept that embodies the strategic integration and ethical governance of AI to achieve enduring positive impacts for both organizations and society. The rapid advancement of AI, while offering immense opportunities, concurrently amplifies the awareness of its ethical implications and potential for harm, making responsible development and deployment paramount [2].

The overarching concept of Sustainable Intelligence demands dual focus from organizations. On one hand, it requires ensuring that AI systems themselves are developed and operated in an environmentally and ethically sound manner. On the other, it involves strategically deploying AI as a powerful tool to address broader environmental and social issues. A superficial approach to sustainability might involve only one of these aspects; for example, using AI to solve environmental problems without considering the energy footprint or ethical biases inherent in the AI system itself would represent an incomplete form of sustainability. Conversely, developing "green" AI that is not applied to broader sustainability challenges misses a significant opportunity for positive impact. Therefore, genuine Sustainable Intelligence in management presents a complex, integrated strategic challenge, requiring organizations to address external sustainability goals while simultaneously ensuring the internal development and operation of AI systems are inherently sustainable and ethical.

B. Defining Sustainable Intelligence: Bridging AI, Sustainability, and Management

To understand "Sustainable Intelligence" in management, it is crucial to first distinguish between "Sustainable AI" and "AI for Sustainability" [5]. These two concepts, while related, represent distinct yet complementary dimensions of a holistic approach.

Sustainable AI primarily focuses on making AI systems themselves environmentally and socially friendly. This involves minimizing their negative impacts throughout their lifecycle. Environmentally, this includes reducing energy consumption, seeking energy-efficient AI models, using sustainable materials in hardware, and minimizing electronic waste [5]. Socially, Sustainable AI encompasses ethical practices such as protecting user privacy, respecting human rights, promoting fairness and inclusivity, and actively avoiding discriminatory outcomes [5]. For instance, the responsible development of AI governance, ensuring transparency, and establishing clear accountability mechanisms are integral to Sustainable AI, aiming to make

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these technologies inherently eco-friendly and equitable [5].

AI for Sustainability, conversely, focuses on leveraging AI as a tool to directly address broader social and environmental challenges. This involves employing AI technologies to solve pressing global issues. Examples include utilizing AI to combat climate change, optimize resource management, enhance environmental conservation and monitoring, fight poverty, improve recycling and waste management, reduce unemployment, and advance smart agriculture [1]. In this context, AI serves as an enabler for achieving wider sustainability objectives.

"Sustainable Intelligence" in AI-driven management therefore represents a holistic approach that integrates both these dimensions. It signifies a strategic framework where AI is developed and operated sustainably, *and* simultaneously utilized to drive broader sustainability objectives within an organization's strategic framework. This integration highlights a profound connection between the social and governance pillars of AI sustainability. The details provided for "Social" aspects, such as privacy, human rights, fairness, and inclusivity, often overlap significantly with "Governance" aspects, including transparency, accountability, and policy development [5]. For instance, ensuring "fairness and inclusivity" (a social objective) directly relies on "robust governance" through clear policies and accountability mechanisms. This suggests that effectively managing the social impact of AI is fundamentally a governance challenge, requiring integrated ethical frameworks and continuous oversight, rather than treating these as separate or siloed concerns.

C. Research Focus: A Qualitative Exploration of Strategic Integration and Ethical Governance

This paper undertakes a qualitative exploration of how organizations strategically integrate AI for sustainable management and establish robust ethical governance frameworks. By examining real-world applications, managerial perceptions, and the challenges encountered, the aim is to provide nuanced insights into the 'how' and 'why' of cultivating Sustainable Intelligence. The focus on qualitative aspects allows for a deeper understanding of the complexities, trade-offs, and human elements involved in aligning AI innovation with long-term sustainability goals. This approach provides a rich description of the phenomena, capturing the lived experiences and perceptions of stakeholders, which quantitative methods might overlook.

II. CONCEPTUAL FOUNDATIONS OF SUSTAINABLE INTELLIGENCE

A. Differentiating Sustainable AI from AI for Sustainability

The distinction between Sustainable AI and AI for Sustainability is fundamental to understanding the comprehensive scope of Sustainable Intelligence [5]. Each concept addresses a vital facet of AI's role in a sustainable future.

Sustainable AI focuses on the responsible development and operation of AI technologies themselves, aiming to minimize their inherent negative impacts. Key aspects of this dimension include:

Environmental Impact: This involves active efforts to reduce the ecological footprint of AI. This includes minimizing the carbon footprint during the training, modification, and fine-tuning of algorithms, seeking energy-efficient AI models, reducing overall AI system energy consumption, using sustainable materials when manufacturing hardware components, and minimizing electronic waste [4]. The objective is to ensure that AI technologies are inherently eco-friendly and energy-efficient.

Data Sustainability: This aspect emphasizes the use of sustainable and transparent data sources, ensuring that the data fueling AI systems is collected and managed responsibly.[5]

Ethical Operation: Beyond environmental considerations, Sustainable AI mandates that technologies are developed and deployed to protect user privacy, respect human rights, promote fairness and inclusivity, and actively avoid discriminatory outcomes [5]. For example, AI-powered recruitment tools can be specifically designed to reduce bias in the hiring process, ensuring that candidates from diverse backgrounds are evaluated fairly, thereby fostering a more inclusive workforce [5].

AI for Sustainability, conversely, involves leveraging AI as a powerful tool to directly address global social and environmental challenges. This dimension focuses on the application of AI to solve real-world sustainability issues:

Environmental Conservation: AI plays a crucial role in environmental conservation and monitoring, as well as in improving recycling and waste management systems [1]. Machine learning algorithms, for instance, can sort recyclable materials more accurately, reducing contamination in recycling streams, while predictive analytics can help municipalities and companies forecast waste generation patterns and develop more efficient collection strategies [1]. AI can also significantly contribute to reducing carbon emissions and overall energy consumption in various sectors [4]. Resource Management: AI is instrumental in optimizing resource usage, particularly in areas like smart agriculture and precision farming, where it can monitor soil well-being, biodiversity, and water usage, providing farmers with data-driven insights to minimize environmental impacts and improve crop yields [4]. AI-powered smart grids can forecast energy needs, adjust allocation, and effectively integrate renewable energy sources, decreasing dependency on fossil fuels [4].

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Social Objectives: AI can be applied to address broader social issues such as fighting poverty and reducing unemployment.[5] Furthermore, AI can enhance employee engagement in sustainability initiatives within organizations through gamification platforms and customized training modules that encourage eco-friendly practices [1].

B. The Environmental, Social, and Governance (ESG) Pillars of Sustainable AI

Sustainable Intelligence, as applied in management, inherently aligns with the Environmental, Social, and Governance (ESG) framework, providing a structured approach to assess and manage AI's comprehensive impact.[5] This framework helps organizations holistically consider the implications of their AI initiatives.

Environmental (E): This pillar focuses on AI's direct and indirect impact on the natural environment. It includes efforts to minimize the carbon footprint of AI operations, develop energy-efficient AI models, and manage electronic waste generated by AI hardware.[4] The fundamental goal here is to ensure that the AI technologies themselves are eco-friendly and energy-efficient, reducing their ecological burden.

Social (S): The social dimension of Sustainable AI emphasizes its role in promoting positive societal outcomes and mitigating potential harm. This involves ensuring AI systems protect user privacy, respect human rights, promote fairness and inclusivity, and actively avoid discriminatory results.[5] For example, using AI to reduce bias in hiring processes can foster a more inclusive workforce.[5] Conversely, addressing ethical concerns in predictive marketing is crucial to prevent consumer manipulation, ensuring AI applications contribute positively to society without infringing on individual autonomy [6].

Governance (G): This pillar is foundational, ensuring responsible AI development and deployment through robust structures, transparency, and accountability [5]. It involves establishing clear AI development and deployment policies, adhering to stringent data privacy regulations (e.g., GDPR, EU AI Act), and ensuring transparency in AI decision-making processes [5]. Governance also includes defining clear accountability mechanisms for AI systems, ensuring that individuals or teams can be held responsible for AI-related decisions and outcomes [7].

While AI offers distinct benefits across environmental, social, and governance dimensions, the analysis of real-world examples reveals that the social and governance aspects are often the source of the most severe and publicly damaging ethical dilemmas. Instances like Amazon's biased recruiting tool, the Dutch childcare benefits scandal, and the Cambridge Analytica data misuse case [6] are not merely technical glitches but are deeply rooted in issues of data bias, inadequate human oversight, and insufficient accountability structures. A failure in the social or governance pillar—such as algorithmic bias leading to discrimination or widespread privacy breaches—can severely undermine an organization's overall sustainability efforts and reputation, even if its environmental AI initiatives are exemplary. This indicates that for Sustainable Intelligence to be truly effective and trusted, organizations must prioritize and deeply integrate ethical governance and social considerations. These areas represent the most fragile and high-impact dimensions, requiring continuous human intervention and robust ethical frameworks that extend beyond simple technical fixes. This perspective elevates integrated ESG from a mere checklist approach to a strategic imperative for comprehensive risk management and long-term value creation.

III. STRATEGIC INTEGRATION OF AI IN SUSTAINABLE MANAGEMENT PRACTICES

A. AI-Driven Innovations for Operational and Managerial Sustainability

AI technologies offer profound opportunities to advance sustainability within business and managerial practices, extending beyond mere operational processes to influence strategic decision-making.[1] The impact of AI can be observed across various facets of organizational functioning.

Operational Optimization: AI-powered tools significantly enhance efficiency and sustainability by optimizing resource usage, improving supply chain transparency, and automating processes [1]. This includes real-time monitoring capabilities, predictive analytics to proactively identify inefficiencies and reduce waste, and ensuring ethical sourcing throughout complex supply chains [1]. AI can also make substantial contributions to energy management, such as through AI-powered smart grids that can forecast energy needs, adjust allocation, and integrate renewable energy sources more effectively [4]. Furthermore, AI can optimize heating, ventilation, and air conditioning (HVAC) systems in buildings, leading to energy savings.[4] In the agricultural sector, AI-driven precision farming techniques minimize environmental impacts by optimizing resource use, such as water, and accurately predicting crop yields and irrigation schedules [4].

Waste Management: AI plays a critical role in advancing waste management practices. Machine learning algorithms improve the accuracy of sorting recyclable materials, thereby reducing contamination in recycling streams.[1] Additionally, predictive analytics helps municipalities and companies forecast waste generation patterns, enabling the development of more efficient collection strategies and improving the overall recycling process [1]. AI can

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drastically contribute to broader savings practices by reducing landfill waste and increasing recycling rates, ensuring resources are reused effectively [4].

Sustainable Decision-Making: AI's influence extends to managerial decision-making, fostering a culture of sustainability across organizations.[1] AI-powered decision support systems provide managers with crucial insights that prioritize sustainability alongside traditional financial performance [1]. These systems analyze data from diverse sources, including Internet of Things (IoT) sensors, market trends, and environmental indicators, to recommend actions that minimize environmental impact. For instance, AI tools can identify energy-intensive processes within an organization and suggest more sustainable alternatives, thereby embedding sustainability considerations directly into strategic choices [1].

B. Qualitative Insights from AI Integration Case Studies in Sustainable Management

Numerous organizations exemplify the successful integration of AI and sustainability in their business and managerial practices, offering rich qualitative insights into the benefits and challenges encountered [3]. These examples illustrate how AI can drive significant transformations beyond mere efficiency gains.

Table 1: Illustrative Case Studies of AI for Sustainable Management

Company/ Organization	AI Application Area	Specific AI Use Case	Key Benefits (Qualitative & Quantitative)	Key Challenges (Qualitative)	Source Snippet IDs
Amazon	Supply Chain	Predictive Inventory Management	Reduced operational costs, improved customer satisfaction, reduced waste.	(Implicit) Data complexity, real-time adaptation.	11
Zara	Retail	Trend & Inventory Management	Increased sales & profitability, enhanced customer satisfaction, optimized production.	(Implicit) Accurate prediction of dynamic trends.	11
Airbus	Aviation	Predictive Maintenance	Enhanced safety, optimized maintenance schedules, reduced downtime.	(Implicit) Data volume & sensor integration.	11
Mudra	FinTech	AI-driven Budget Management	Automated expense tracking, real-time alerts, engaging user experience, global reach.	Making mundane finance engaging.	3
JobGet	Recruitment	AI-enhanced Locati	Reduced job fulfil	Overcoming tradit	3

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		on Matching	lment time (months to days), 2M+ downloads, 150K+ placements.	ional recruitment inefficiencies.	
HouseEazy	Real Estate	Property Price Prediction	Accurate property forecasts, streamlined user journey, enhanced competitive edge.	Accurately predicting dynamic property values.	[3]

While the quantitative benefits of AI integration, such as "reduced operational costs" [1], are often highlighted, a deeper examination of these case studies reveals a more profound qualitative shift in value proposition. For instance, Mudra's AI-driven chatbot did not merely automate budget management; it "transformed budgeting into an enjoyable experience" and expanded its global reach [3]. Similarly, Vyrb "redefined social media interaction" by enabling hands-free voice commands, leading to significant funding and user adoption [3]. JobGet's AI-enhanced recruitment system did not just reduce hiring timelines; it contributed to "reshaping the employment landscape" for blue-collar workers, earning accolades and facilitating a large number of placements [3]. These examples illustrate that successful AI integration for sustainable management often leads to more than just incremental efficiency gains. It fundamentally redefines user experiences, market interactions, and even industry paradigms. This suggests that the strategic value of AI in sustainable management lies not solely in optimizing existing processes but in creating entirely new value propositions and operational models that significantly enhance customer engagement, expand market presence, and deliver broader societal impact. Managers, therefore, need to look beyond simple return on investment (ROI) metrics and consider these deeper qualitative transformations as indicators of successful "Sustainable Intelligence." The ability to create a more engaging, accessible, or efficient experience, even for traditionally mundane tasks, represents a significant qualitative leap in value that contributes to long-term sustainability and competitive advantage.

C. Managerial Benefits and Challenges of Strategic AI Adoption for Sustainability

The strategic adoption of AI for sustainability presents a compelling array of benefits alongside significant managerial challenges that must be proactively addressed.

Benefits: AI integration leads to enhanced efficiency, innovation, and advancements in decision-making.[1] Specific benefits include reduced operational costs, improved customer satisfaction through timely deliveries and personalized services, enhanced safety, increased productivity, and reduced downtime in industrial operations.[3] Critically, AI fosters better sustainability practices by optimizing resource management and reducing environmental impact [11]. AI-powered decision support systems provide insights that allow managers to prioritize sustainability alongside financial performance, embedding these considerations directly into strategic choices.[1] Responsible AI practices also build trust and loyalty, leading to increased customer retention and improved employee satisfaction [8]. Challenges: Despite its potential, integrating AI into sustainability practices presents several challenges that require careful navigation [1].

Data-Related Issues: Pervasive concerns include data privacy, ensuring the availability of high-quality data, and mitigating algorithmic bias [1]. Ensuring data integrity is crucial for reliable AI outcomes, and managing sensitive consumer data requires robust protection protocols [8]. The recurrence and severity of algorithmic bias examples, such as Amazon's biased recruiting tool and the Dutch childcare benefits scandal. [10], indicate that this is not a one-off technical bug but a deeply embedded, systemic risk. This risk stems from historical data, design choices, and societal biases reflected in the data. Its presence across diverse applications (recruitment, marketing) suggests that it cannot be "fixed" once and for all. Instead, it demands continuous managerial vigilance, ongoing ethical audits, and a steadfast commitment to data diversity and fairness metrics throughout the entire AI lifecycle. This elevates algorithmic bias from a purely technical problem to a critical, ongoing ethical and governance challenge that requires sustained strategic attention and human oversight, profoundly impacting trust and regulatory compliance.

Technical and Implementation Hurdles: Organizations frequently face high initial costs for AI implementation [1]. the complexity of choosing the right AI technology stack, and the ongoing need for continuous monitoring and optimization of AI systems [3].

Organizational and Managerial Gaps: Key managerial tasks

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include accurately identifying specific business challenges that AI can effectively solve, setting clear and measurable AI development objectives, and securing effective collaboration with AI development experts [3]. There is also the challenge of effectively piloting AI solutions on a smaller scale before full-scale deployment to identify issues and fine-tune performance [3].

IV. ETHICAL GOVERNANCE FOR SUSTAINABLE AI OUTCOMES

A. Core Principles of Ethical AI: Fairness, Accountability, Transparency, and Privacy (FAIR)

Establishing ethical guidelines for AI is a fundamental step for organizations to develop and deploy AI systems responsibly, fostering trust and mitigating risks [9]. The core principles of ethical AI, often summarized as FAIR, are consistently emphasized across various frameworks and discussions:

Fairness: This principle ensures that AI systems operate impartially and equitably, actively avoiding the propagation of biases and treating all individuals and groups fairly.[5] Techniques such as exploratory data analysis, data preprocessing, and fairness metrics are crucial tools for identifying and mitigating biases embedded within AI systems [9].

Accountability: This requires organizations to take explicit responsibility for the outcomes of their AI systems. This involves establishing clear lines of authority, defining responsibilities across legal, security, governance, and technical teams, and implementing robust oversight mechanisms with comprehensive audit trails to trace actions and decisions back to their sources [5].

Transparency: This principle demands that AI systems operate in ways that are understandable and open to scrutiny for both technical and non-technical stakeholders. This includes maintaining clear documentation of model development, decision logic, data sources, and system limitations, as well as utilizing interpretable machine learning techniques to demystify AI technologies [5].

Privacy: This involves safeguarding individuals' personal information and ensuring AI systems adhere to legal and ethical boundaries regarding data collection, storage, and use. This necessitates responsible data management, strict adherence to applicable privacy regulations such as the GDPR and the EU AI Act, and the implementation of data minimization and anonymization techniques to protect sensitive information [5].

B. Overview of Leading AI Governance Frameworks and Models

A robust AI governance framework is a structured approach designed to manage the risks, ethics, and compliance requirements associated with AI technologies [7]. Several established frameworks provide comprehensive guidance for organizations navigating the complexities of AI development and deployment:

Table 2: Key AI Governance Frameworks and Their Relevance to Sustainable Intelligence

C. Best Practices for Implementing Robust AI Governance

Effective AI governance requires a systematic approach to ensure ethical, compliant, and responsible AI use.[7]. Key best practices include:

Defining Objectives and Scope: Organizations must clearly identify what they aim to achieve with AI and the potential risks that need to be addressed. This initial step ensures that governance policies are relevant, actionable, and aligned with core business priorities [7].

Developing Governance Policies and Ethical Guidelines: Establishing clear policies that outline acceptable AI use, model development standards, and responsible data practices is paramount. This includes implementing strong AI data governance protocols to manage data lineage, user rights, and the handling of sensitive information throughout the AI lifecycle [7]. Ethical guidelines addressing fairness, accountability, and transparency should guide both technical teams and business leaders.

Assigning Roles and Responsibilities: Clearly defining who is responsible for managing AI governance activities is crucial. This involves assigning ownership for policy enforcement, compliance monitoring, and addressing incidents related to AI systems across legal, security, governance, and technical teams, thereby ensuring accountability and reducing confusion [7].

Implementing Training and Change Management: It is essential to ensure that employees at all levels understand the organization's AI governance policies and ethical standards. Providing tailored training programs, from AI developers to senior leadership, promotes a culture of responsible AI use by embedding governance awareness throughout the organization [7].

Continuous Monitoring and Incident Response: Establishing ongoing oversight of AI models is necessary to detect issues such as model drift, bias, and compliance failures. This practice requires developing clear incident response procedures that assign ownership and define immediate corrective actions when governance breaches occur [7].

Documentation, Auditing, and Version Control: Maintaining detailed records of governance activities, including policy changes, risk assessments, and incident reports, is vital. Implementing version control helps track governance framework updates and ensures audit readiness at all times [7].

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Iterative Updates: The AI landscape is dynamic, with emerging technologies and evolving regulatory requirements. Therefore, regularly reviewing and refining the AI governance framework is essential to stay ahead of these changes and continuously improve governance effectiveness [7].
Securing Executive and Leadership Buy-In: Long-term success in AI governance hinges on aligning initiatives with strategic business objectives. Engaging executives early, demonstrating measurable value, and incorporating governance goals into broader corporate agendas ensures sustained support and resources [7].

Stakeholder Engagement and Human-Centered AI: Promoting transparency, accountability, and a shared understanding of the ethical and practical considerations surrounding AI systems requires engaging diverse stakeholders throughout the design and implementation process. This helps build AI systems that enhance human capabilities and align with human values, respecting rights and privacy [8].
Qualitative Challenges in Navigating Ethical AI Principles and Regulatory Compliance
Despite the existence of well-articulated principles and comprehensive frameworks, organizations face significant challenges in operationalizing ethical AI and ensuring regulatory compliance [8]. These challenges often stem from the inherent complexities of AI technologies and the dynamic nature of societal expectations and regulatory landscapes.
Algorithmic Bias and Discrimination: A persistent and deeply concerning challenge is the mitigation of biases embedded in AI algorithms and their training data, which can lead to discriminatory outcomes [6]. Real-life examples, such as Amazon's biased recruiting tool that penalized women and the Dutch childcare benefits scandal where an algorithm wrongly flagged families for fraud based on discriminatory factors, underscore the severe societal and financial repercussions of unmitigated bias [10]. Addressing this requires continuous effort, as biases can be subtle and deeply ingrained.

Privacy and Data Protection: The collection, storage, and use of vast amounts of personal data by AI systems raise significant privacy concerns [6]. Ensuring compliance with evolving data protection regulations, such as GDPR and the EU AI Act, while simultaneously leveraging comprehensive datasets for optimal AI performance, presents a complex balancing act.[8] The Cambridge Analytica scandal serves as a stark warning of the severe consequences of data misuse and privacy infringements [10].

Transparency and Explainability: Achieving true transparency and explainability, especially for complex deep learning models often referred to as "black boxes," remains technically challenging [9]. Organizations struggle to provide clear, understandable insights into how AI decisions are made, which is crucial for building trust, enabling accountability, and facilitating human oversight [9].

Manipulation and Misinformation: AI's advanced capacity to analyze human behavior can be misused for manipulation, particularly in areas like predictive marketing [6]. Furthermore, the rise of generative AI introduces concerns about the creation and spread of deepfakes that can disseminate misinformation, eroding public trust in media and information sources [10]
Balancing Innovation with Regulation: A critical qualitative dilemma involves striking the right balance between fostering rapid AI innovation and implementing sufficient governance measures to prevent harm without stifling progress. Overly restrictive regulations can impede technological development, while lax oversight can lead to severe ethical breaches and unintended consequences [9]. This requires ongoing adjustment and dialogue between innovators and policymakers.

Lack of Standardization: The absence of uniform AI governance practices across different jurisdictions creates significant complexities for multinational organizations, necessitating the development of highly flexible and adaptable governance structures [9]. This fragmentation makes consistent ethical application and compliance across diverse operational environments particularly difficult.

Data Minimization vs. Data-Hungry AI: There is an inherent tension between the ethical principle of data minimization (collecting only the necessary data to achieve a specific purpose, thereby protecting privacy) and the reality that many AI systems, particularly advanced machine learning models, often perform better with more diverse and comprehensive datasets.[9] This necessitates careful ethical trade-offs and the exploration of innovative technical solutions to reconcile these competing demands.

The consistent articulation of core ethical principles (FAIR) across numerous frameworks and discussions [5] indicates a strong normative foundation for AI ethics. However, the persistent qualitative challenges in their implementation, such as balancing innovation with regulation, addressing technical complexity, and navigating a lack of standardization [8] reveal a critical gap between aspirational ethics and practical operationalization. This suggests that simply stating principles is insufficient; organizations must invest in concrete mechanisms, tools, and processes—such as explainable AI tools, bias detection metrics, and clear audit trails—to translate these principles into actionable governance throughout the entire AI lifecycle. This is a strategic challenge of operationalizing ethics, requiring

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continuous effort and adaptation, rather than a one-time policy declaration.

Furthermore, the proliferation of AI governance frameworks from various entities, including NIST, ISO, Google, Microsoft, Singapore, and OECD[7], alongside the identified challenge of "lack of standardization"[9], presents a paradox. The existence of numerous frameworks indicates a global, multi-stakeholder recognition of the urgent need for AI governance. However, the diversity of approaches can lead to fragmentation, increased compliance burdens for multinational organizations, and hinder consistent ethical application across different contexts. This implies that a critical future direction for Sustainable Intelligence is not merely the creation of more frameworks, but a concerted effort towards interoperability, harmonization, and mutual recognition among existing frameworks. Such a collaborative approach would facilitate more seamless and effective strategic integration and ethical governance globally, moving beyond fragmented efforts to a more unified and impactful approach.

V. DISCUSSION: SYNTHESIZING STRATEGIC INTEGRATION AND ETHICAL GOVERNANCE

A. The Interdependence of Strategic AI Integration and Ethical Governance

The successful strategic integration of AI for Sustainable Intelligence is inextricably linked to robust ethical governance. AI governance should not be viewed merely as a compliance burden but rather as a powerful enabler of innovation, fostering enhanced trust and reputation within and outside the organization [2].

Governance as a Catalyst: Effective AI governance frameworks, through their clear policies, processes, and standards, ensure that AI systems are developed and deployed in a safe, ethical manner, aligned with desired organizational and societal outcomes [13]. This transforms governance from a potential barrier into a catalyst for innovation, allowing organizations to pursue AI opportunities responsibly and with greater confidence [13].

Strategic Alignment: High-coherence strategies demonstrate strong interconnections between strategic objectives, foresight methods, and implementation instruments [25]. This includes the critical integration of technical and ethical governance domains, actively avoiding the "two communities' problem" where technical development and normative ethical perspectives operate in isolation [26]. Qualitative observations highlight the importance of explicit linkages and "coherence chains" between strategic goals and concrete implementation measures, ensuring that ethical considerations are not an afterthought but are foundational to the strategic design [26].

Trust and Reputation: Responsible AI practices are instrumental in building trust and loyalty among customers and employees, leading to tangible benefits such as increased customer retention and improved employee satisfaction [8]. Conversely, ungoverned AI applications can lead to a significant loss of trust, increased operational risks, resistance to AI adoption internally, poor decision-making due to unreliable outputs, and substantial damage to brand reputation [8], The long-term viability of AI initiatives is thus deeply tied to the organization's demonstrated commitment to ethical governance.

The repeated emphasis on "alignment" and "coherence" in the context of successful AI strategies suggests that the highest form of "Sustainable Intelligence" extends beyond merely having ethical AI systems or using AI for sustainability in isolated projects. It is about achieving *strategic coherence* where ethical governance is not an afterthought but is deeply woven into the very fabric of the organization's AI strategy, sustainability goals, and overall business model. This implies that successful strategic integration creates a mutually reinforcing ecosystem: ethical considerations drive innovation, and sustainable outcomes are a direct result of well-governed AI. This progression represents a qualitative shift from mere compliance with regulations to a source of competitive advantage and long-term organizational resilience.

B. Managerial Implications for Cultivating Sustainable Intelligence

Cultivating Sustainable Intelligence requires a proactive and holistic managerial approach that transcends traditional operational boundaries, demanding a continuous commitment to ethical integration.

Embedding Ethics Centrally: Managers must ensure that ethical considerations are central to all AI governance solutions, involving structural, process, and policy considerations from the outset [2]. This means moving beyond aspirational principles to concrete operational pathways and robust implementation mechanisms. Addressing the "intensity mismatch" and "implementation gaps"where ethical objectives are stated but lack corresponding operational specificity or practical tool [26]. is critical. This "say-do" gap reveals a profound qualitative challenge in AI governance. Organizations may articulate ethical principles well, but struggle with their practical execution and integration into daily operations. Managers must therefore shift their focus from merely articulating principles to designing concrete, measurable, and enforceable mechanisms for ethical integration throughout the AI lifecycle. This includes developing specific metrics for ethical performance, integrating ethics into developer workflows, conducting regular ethical audits, and ensuring accountability structures are in place to translate ethical

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aspirations into tangible, operational realities. This is a profound managerial challenge requiring significant organizational change management and a commitment to continuous improvement.

Cross-Functional Collaboration and Coordination: Establishing dedicated coordination bodies that span departmental boundaries is vital for robust organizational governance [26]. These bodies can ensure consistent application of AI policies and ethical guidelines across different functions. Furthermore, fostering collaboration among diverse stakeholders—including internal business units, government bodies, and academic institutions—is essential for scaling AI-driven sustainability initiatives and addressing complex challenges that no single entity can solve alone [1].

Adaptive Governance: Organizations need to build in regular review cycles, typically on 12–24-month intervals, and flexible mechanisms to adapt their strategies in response to changing technological environments, evolving societal expectations, and new regulatory landscapes [26]. This "adaptive governance" ensures that AI strategies remain relevant, effective, and responsive to emerging risks and opportunities in a rapidly evolving domain.

Human-Centric Design and Oversight: Emphasizing human-centered AI throughout the design and implementation process is crucial for building systems that enhance human capabilities and align with human values [8]. This includes maintaining human involvement in reviewing and refining AI outputs, particularly in high-stakes decision-making contexts, and ensuring clear, traceable decision-making processes within AI systems [13]. Human oversight acts as a critical safeguard against unintended consequences and biases.

Investment in Data Quality and AI-Powered Governance Tools: Given the significant challenge of managing vast, complex, and often fragmented data [8], managers must prioritize investment in high-quality data foundations. Leveraging AI-powered data governance tools can automate processes for reliability, compliance, and continuous oversight, thereby addressing the scale and complexity that manual processes cannot handle [8]. These tools are essential for ensuring data integrity, which directly impacts the accuracy and fairness of AI outcomes.

VI. CONCLUSION AND FUTURE DIRECTIONS

A. Summary of Key Findings

This qualitative exploration has highlighted that "Sustainable Intelligence" in AI-driven management is a multifaceted imperative, demanding a dual focus: making AI itself sustainable (e.g., energy-efficient, ethical) and leveraging AI for broader sustainability goals (e.g., environmental conservation, social equity). The analysis revealed that ethical governance, rooted in principles of fairness, accountability, transparency, and privacy (FAIR), is not merely a regulatory requirement but a foundational enabler for strategic AI integration. While numerous global frameworks offer valuable guidance, the practical challenges of operationalizing these principles, effectively managing algorithmic bias, ensuring robust data privacy, and navigating a lack of standardization across jurisdictions remain significant hurdles. Ultimately, achieving Sustainable Intelligence hinges on strategic coherence, where ethical considerations are deeply embedded across all AI initiatives, fostering trust, driving innovation, and delivering enduring value. The qualitative examination underscored that successful AI integration often leads to a redefinition of value propositions and market interactions, moving beyond mere efficiency gains to create entirely new forms of engagement and impact.

B. Recommendations for Practitioners and Future Research

For Practitioners:

Adopt a Holistic ESG Approach: Integrate environmental, social, and governance considerations into every stage of the AI lifecycle, recognizing their inherent interdependence. Prioritize resource efficiency in AI development and actively seek AI applications that support broader sustainability objectives.

Prioritize Ethical Governance from the Outset: Embed FAIR principles (Fairness, Accountability, Transparency, Privacy) into AI strategy, design, and deployment. Secure executive buy-in and establish clear cross-functional ownership for ethical AI practices to ensure these principles are operationalized, not just stated.

Invest in Data Quality and Ethical AI Tools: Proactively address algorithmic bias through rigorous data management practices, continuous monitoring, and the strategic use of explainability and bias detection tools. Ensure data used for AI training is diverse and representative.

Foster a Culture of Responsible AI: Implement comprehensive training and change management programs to ensure all stakeholders, from developers to end-users, understand and adhere to ethical AI practices. Encourage open dialogue about AI's societal implications.

Embrace Adaptive Governance: Regularly review and refine AI governance frameworks to adapt to evolving technologies, emerging societal expectations, and new regulatory landscapes. This iterative approach ensures long-term relevance and effectiveness.

Promote Stakeholder Collaboration: Engage diverse internal and external stakeholders throughout the AI development and deployment process to build trust, gather varied perspectives, and ensure human-centered outcomes that

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align with broader societal values.

For Future Research:
Longitudinal Qualitative Studies: Investigate the long-term qualitative impacts of specific AI governance frameworks on organizational culture, innovation trajectories, and the evolution of societal trust in AI systems. Such studies could provide valuable insights into the dynamic interplay between policy and practice.

Cross-Cultural Comparisons: Conduct comparative qualitative studies on how different national and organizational cultures interpret and operationalize AI ethics and sustainable intelligence. This would shed light on context-specific challenges and successful adaptive strategies.

Metrics for Sustainable Intelligence: Develop and validate qualitative and quantitative metrics to assess the holistic "Sustainable Intelligence" of organizations, moving beyond traditional ESG reporting to capture the integrated nature of AI's sustainable impact

Human-AI Teaming for Ethical Oversight: Explore the qualitative dynamics of human-in-the-loop and human-on-the-loop models for ethical AI oversight, particularly in complex, high-stakes decision-making scenarios. Research should focus on how human judgment and intuition interact with AI capabilities to ensure ethical outcomes.

Addressing the "Say-Do" Gap: Further qualitative research is needed to understand the specific barriers and enablers in translating aspirational ethical AI principles into concrete, measurable, and consistently applied operational practices within diverse organizational contexts. This could involve examining case studies of organizations that have successfully bridged this gap.

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Echoes in the Genome: Healing Generational Wounds Through Cultural Rituals

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Abstract - **Generational trauma doesn't just exist in memory – it exists in our biology in our biology. Epigenetic research illustrates how stress can leave molecular imprints which affect generations. But what if the vessel that bears the wounds also bears the solution? This study explores how the ancient cultural traditions – such as fasting, rhythmic prayer, narrative, and ancestral song- may be more than soothing the spirit; they may form stress-related epigenetic markings. By blending state-of-the-art science with time-honored traditions, this research bridges biological and spiritual. Rather than trusting in lab tests, it's a full-bodied synthesis of science, cross-cultural knowledge, and historical theory. It's not to legitimize ancient wisdom using lab instruments – but to illuminate its therapeutic power in transcribing inherited suffering. In this context, rituals transcend mere tradition-they are living instruments, capable of re-writing the genetic echoes of trauma passed down through blood, memory, and time.**

Keywords: **Epigenetics, Generational Trauma, Cultural Rituals,DNA Methylation, Stress Response, Ancestral Healing**

I.INTRODUCTION

The human genome was long thought to be a fixed and unchanging blueprint, yet it has been discovered as a fascinating dynamic system that responds to experience in the environment, and to stress. Epigenetic processes-chemical gene-expression modifications not altering the DNA sequence-allow traumatic experiences to create molecular imprints that, in some instances, may persist across generations. These findings reverse the traditional understanding of inheritance, showing that psychological and environmental stressors can remake biology and influence descendants' health, stress responsiveness, and psychological resilience. A wealth of research supports the contention that extreme trauma can yield heritable biological changes. Holocaust survivor children possess methylation changes in stress genes, affecting cortisol regulation and stress response. In like manner, individuals exposed prenatally to famine during the Dutch Hunger Winter had persistent epigenetic modifications decades following exposure, and Rwandan genocide survivors and their children demonstrate the same. These studies refer to the capacity of trauma to generate molecular signatures, the emphasis being on stress and health outcomes intergenerational transmission. Concomitantly, Human societies have developed ritualistic processes that aim to restore psychological equilibrium and counteract trauma. From culture to culture, rituals range from meditation [1]. Drumming, and fasting to storytelling and sacred dance-include structured patterns, repetition, and community engagement. These interventions not only promote social bonding and emotional support but can also interact with biological systems via hormonal regulation, neuroplasticity, and immune modulation. This study suggests a conceptual framework in which traditional rituals can be considered natural epigenetic interventions. By affecting stress hormones, immune function, brain operation, and social attachment, cultural rituals can reduce trauma-linked molecular signatures and potentially reduce the risk of transmission across generations.

1.1 Research Objectives

1.The objectives of this study are to Review the current evidence on epigenetic mechanisms underlying trauma transmission.

2.Analyze the biological effects and potential mechanisms of traditional healing rituals.

3.Propose theoretical pathways connecting ritual practice to epigenetic modulation.

4.Develop a framework that conceptualizes cultural rituals as potential interventions for inherited trauma.

Histone Modification: Chemical changes to histone proteins, which influence DNA packaging and gene accessibility. Altered histone states can affect gene transcription and cellular responses to stress. Non-coding RNAs: Small RNA molecules, including microRNAs, can regulate gene expression post-transcriptional protein synthesis and stress response correlated with trauma in indigenous populations affected by residential school experiences, survivors. These findings all show that trauma

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leave biological imprints that have the ability to influence the stress reactivity, immune system, and mental health of future generations.

Rituals of Traditional Healing Across Cultures

Human societies have developed rituals over centuries to cope with mental anguish and foster resilience. Despite cultural differences, rituals in many cultures bear structural and functional similarity:

Rhythmic Practices: Chanting, drumming, and repetitive movement induce altered states of consciousness and regulate stress-related neurochemicals. Fasting and Dietary Restriction: Many rituals involve periods of fasting or specific diets, which can activate cellular stress responses and influence epigenetic processes. Narrative and storytelling: Communication of ancestral stories or personal experience makes psychological processing of trauma more effective, reaffirms identity, and enhances cultural continuity. Sacred Movement and Dance: Intentional movement with spiritual purpose can regulate stress hormones, improve neuroplasticity, and promotes somatic awareness [3]. Examples include Native American sweat lodge ceremonies, Sufi whirling practices, Buddhist, meditation retreats, African drumming circles, and Jewish mourning rituals. Across cultures, these rituals integrate affective, cognitive, social, and physiological components, suggesting a comprehensive mechanism for trauma recovery.

Biologic Mechanisms Linking Ritual to Genetics

Rituals can influence epigenetic mechanisms through several interrelated pathways: Stress Hormone Modulation: Ritual participation often reduces cortisol and adrenaline level, potentially altering DNA methylation patterns in stress-related genes.

Neuroplasticity and Brain Function: Meditation, contemplative practices and rhythmic activities can modify neural circuits, affecting gene expression related to stress resilience and immune function [5].

Social Bonding and Oxytocin: Ritual participation and social bonding in rituals activate oxytocin and vasopressin, which affect epigenetic processes linked to emotional regulation and stress buffering.

III. THEORETICAL FRAMEWORK

Ritual-Epigenetics Interface Model

We introduce the Ritual-Epigenetics interface (REI) Model, hypothesizing that ancestral rituals shape gene expression through four mutually intersecting pathways. Physiological Pathways: Direct regulation of hormones, neurotransmitters, and metabolic processes. Neurological Pathway: Brain structural and functional alterations influencing gene regulation. Social Pathway: Group participation and social support that increase stress resilience. Cognitive/Meaning-Making Pathways: Narrative formation and reinterpretation of experiences to lower psychological stress. These pathways intersect to affect epigenetic makers, possibly mitigating trauma-associated methylation patterns and restoring healthier gene expression profiles.

Temporal Dynamics of Healing

Acute Effects: Immediate physiological and neurological changes occurring during ritual participation. Medium-term Adaptation: Epigenetic modifications developing over repeated ritual engagement. Intergenerational Effects: Potential reversal of trauma-linked epigenetic patterns, influencing offspring resilience and stress regulation.

IV.METHODOLOGY

Synthesis Approach

This study employs a transdisciplinary synthesis, integrating: Systematic review of epigenetic and trauma-related literature, Ethnographic and historical accounts of ritual practices, Theoretical modeling of biological and psychosocial pathways, Cross-cultural comparison of ritual elements and consequences.

Sources of Data

Data were obtained from:

Peer-reviewed scientific journals of epigenetics psychology, anthropology, and neuroscience. Ethnographic accounts of indigenous healing techniques. Historical documents of ritual actions and objectives. Recent studies on mindfulness, meditation, and psychosomatic therapies.

Results and Analysis

Epigenetic Signatures of Cultural Healing Analysis indicates some of the biological mechanisms by which rituals could influence: DNA Methylation: Stress response genes (FKBP5, NR3C1, SLC6A4) could be influenced by the endocrine-induced hormonal changes brought about by rituals. Inflammatory Markers: Rituals that reduce systemic inflammation are able to modulate genes that regulate immune function. Circadian Rhythm Genes: Fasting, rhythmical activities, and seasonal rituals proceed in congruence with biological rhythms, which could influence circadian-related gene expression.

Cross-Cultural Patterns

Despite differences in culture, healing rituals have convergent patterns: Embodiment: 87% involve movement, breathing, or somatic activation. Community Participation: 92% emphasize group over individual practice. Narrative Elements: 78% include stories, oral tradition, or ritualized memory practice. Altered Consciousness: 83% use rhythmic, meditative, or trance-like elements.

Proposed Mechanisms

HPA Axis Modulation: Rituals modulate hypothalamic-pituitary-adrenal axis activity, potentially reversing epigenetic effects of stress. Neuroinflammation Reduction: Anti-inflammatory effects of ritual practice may impact genes regulating neural immune function. Social Buffering: Community rituals activate oxytocin and vasopressin, which

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control social resilience and stress adaptation genes.

V. DISCUSSION

Implications for Understanding Trauma Recovery
Rituals may be perceived as sophisticated interventions that address psychological and biological dimensions of trauma. Identification of cultural practices as potential epigenetic regulators validates traditional wisdom but leaves space for integrative therapeutic interventions.
Main Implications:
Validation of Traditional Wisdom: Indigenous and cultural healing systems offer empirically pertinent strategies.
Integrative Therapy: Combining rituals with contemporary psychotherapeutic and medical interventions may improve outcomes.
Prevention of Intergenerational Trauma: Epigenetic modulation via rituals may serve as a preventive approach for offspring.
Limitations and Future Directions
Direct Evidence Gap: Empirical studies directly linking rituals to epigenetic changes do not exist. Cultural Specificity: The efficacy of rituals is contingent on culture and belief system. Individual Variation: Genetic susceptibility, past trauma, and lifestyle may affect responses
Future research should focus on:
Longitudinal investigations of ritual practitioners to track epigenetic outcomes. Cross-cultural comparisons of ritual potency. Optimal frequency, intensity, and duration of ritual participation. Culturally modified interventions for various populations.
Ethical Considerations
Research needs to negotiate issues of cultural appropriation, indigenous knowledge rights, and respectful cooperation [2]. Community engagement as partners ensures ethical and effective research outcomes.

VI. CONCLUSIONS

Ancient cultural rituals are highly effective interventions for reducing the biological impact of trauma. By influencing stress hormones, immune response, and neural plasticity, rituals may actually redesign epigenetic markers for intergenerational trauma. The REI Model provides a conceptual pathway from ritual activities to biological outcomes, bridging ancient knowledge and contemporary science. Whereas empirical observation is immediate, theoretical foundations suggest promising trajectories for whole-trauma recovery, intergenerational resilience, and cultural sustainability. Ritual can transform genomic records of trauma into intergenerational records of healing, offering a pathway towards reconciliation of biology, culture, and memory.

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Transforming Business Education for a Sustainable Future: Ethics, Technology, Pedagogy, and CPHR Integration Post-COVID

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Abstract — **The COVID-19 pandemic accelerated major reforms in business education, reshaping delivery, accreditation, and expectations of societal value. This paper reviews accreditation standards, global policy reports, and peer-reviewed studies to assess how ethics, technology, and pedagogy are redefining management education. Findings show that accreditation bodies (AACSB, ACBSP, EQUIS, PRME) demand integration of ESG and societal impact, while technological innovations such as hybrid and AI-enabled learning are expanding but risk deepening inequities. Pedagogical advances, including Universal Design for Learning (UDL 3.0) and competency-based education, improve inclusivity but require faculty investment. A conceptual framework is proposed that integrates ethics, technology, and pedagogy as pathways to sustainable transformation.**

***Keywords* — Accreditation, business education, ESG, hybrid learning, pedagogy, PRME, sustainability, UDL**

I.INTRODUCTION

Business schools now face heightened pressure to demonstrate both academic rigor and societal value. Post-COVID expectations extend beyond graduate employability to include ethics, sustainability, and inclusivity [1], [4]. Accreditation bodies shape these changes: AACSB emphasizes societal impact [1]; ACBSP prioritizes continuous quality improvement [2]; EQUIS focuses on global engagement [3]; and PRME integrates SDGs [4]. Yet scholars highlight symbolic compliance rather than deep transformation [11], [12]. This paper examines ethics, technology, and pedagogy to propose a framework for sustainable business education.

III. METHODOLOGY

This study uses an integrative literature review (2020–2025) across Scopus, Web of Science, ProQuest, and Google Scholar. Inclusion criteria: peer-reviewed articles on business education reform; accreditation standards (AACSB, ACBSP, EQUIS, PRME); and global policy reports (OECD, UNESCO, EDUCAUSE, WEF, SHRM). Approximately 75 relevant studies and reports were analyzed. Sources were screened across three domains: (1) ethics & sustainability, (2) technology & hybrid learning, and (3) pedagogy & inclusion. Limitations include reliance on secondary data and regional bias toward OECD countries.

IV. RESULTS

A. Ethical Imperatives — AACSB [1] now requires measurable evidence of societal contributions. ACBSP [2] evaluates ethical learning outcomes. EQUIS [3] emphasizes corporate and international engagement. PRME [4] aligns programs with SDGs, though critics warn of symbolic compliance [11]. Genuine progress requires embedding ESG into research, governance, and assessment.

B. Technological Innovations — OECD [5] reports that 80% of universities have institutionalized hybrid learning. EDUCAUSE [7] forecasts AI-driven platforms as dominant by 2030. UNESCO [6] highlights inequities: 43% of students in low-income regions lacked online access during COVID-19. Digital inequity risks creating a two-tier education system [14]. Accrediting agencies now expect digital inclusion policies.

C. Pedagogical Advances — UDL 3.0 improves retention by 12–15% [8]. Competency-based education bridges theory and practice [13]. Accrediting agencies (AACSB, ACBSP) require longitudinal tracking of competencies. Faculty development remains essential [12]; EQUIS increasingly requests evidence of structured training in innovative pedagogy.

D. Workforce Alignment — WEF [9] projects 44% of worker skills will change by 2027, with emphasis on resilience and digital literacy. SHRM [10] highlights employer demand for adaptability and lifelong learning. Best practices include embedding ESG into simulations and reflective assignments [15]. Accreditation reviews now require employability evidence and alumni tracking [1], [3]. In Canada, the Chartered Professionals in Human Resources (CPHR) Competency Framework emphasizes ethical leadership, digital literacy, and diversity, equity, and inclusion (DEI) as critical skills for HR professionals. These priorities align with global trends reported by SHRM and the WEF, reinforcing that business schools must integrate DEI, ESG, and data-driven HR practices into curricula to prepare students for professional certification and labor market relevance [16].

V. DISCUSSION

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Ethics, technology, and pedagogy converge but present tensions. Accreditation promotes change yet risks tokenism when institutions pursue compliance reports rather than genuine transformation. Technology expands flexibility but can worsen inequities if access to digital infrastructure remains uneven across socioeconomic groups and regions.

Pedagogical reforms enhance inclusivity but demand faculty investment in training, workload redistribution, and institutional support to be effective. Another important tension lies in measurement: while accrediting bodies require societal impact reporting, there is limited consensus on reliable indicators of ethical responsibility, sustainability, or inclusivity. This gap often leads to symbolic reporting rather than substantive evidence of change. Business schools must therefore move toward outcome-based evaluation frameworks that capture long-term societal contributions, including graduate employability, leadership in ESG, and community partnerships.

From the Canadian context, professional bodies such as CPHR Canada reinforce the expectation that HR graduates demonstrate digital literacy, diversity and inclusion competency, and ethical judgment. Integrating such frameworks into curricula bridges academic accreditation requirements with professional certification, creating a stronger alignment between what schools teach and what the labor market demands.

Practical Implications

Educators: Embed ESG, UDL, and workforce analytics into core curricula; adopt simulations and experiential learning that encourage ethical decision-making and inclusivity. Accrediting Bodies: Develop impact-based metrics beyond compliance reporting, ensuring institutions are assessed on real contributions to society and workforce readiness.

Policymakers: Invest in broadband access, digital equity, and faculty professional development; align higher education funding with demonstrable outcomes in ethics and sustainability.

Professional Associations: Organizations such as CPHR Canada can serve as mediators between academia and employers, ensuring competencies are continually updated to reflect the changing world of work.

VI. CONCLUSION

Post-COVID business education must be ethical, technologically adaptive, and pedagogically inclusive. Accreditation frameworks increasingly converge on themes of societal impact, global engagement, and continuous innovation. Yet, unless these frameworks are coupled with meaningful faculty development, digital equity initiatives, and professional standards integration, progress risks remaining symbolic.

By integrating ethics, technology, pedagogy, and professional HR competencies (CPHR), business schools can strengthen their legitimacy and produce leaders equipped to manage sustainability challenges, technological disruption, and complex workforce dynamics. In doing so, institutions not only satisfy accreditation requirements but also contribute to building resilient organizations and equitable societies.

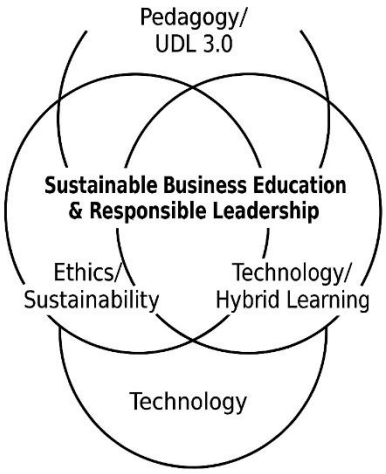
Future progress will depend on collaboration across accrediting bodies, professional associations, governments, and universities. When these actors align on common metrics and shared accountability, business education can truly transform into a driver of societal good and economic resilience.

Table 1: Comparative Overview of Accreditation and Education Frameworks

Framework	Focus	Illustrative Requirements	Source
AACSB	Societal impact, mission	ESG integration, learner success, research	[1]
ACBSP	Teaching, CQI	Learning outcomes, student support	[2]
EQUIS	Internationalization, quality	Global networks, corporate engagement	[3]
PRME	Responsible management	Sustainability, SDG alignment	[4]

Fig. 1. Conceptual framework integrating ethics, technology, and pedagogy in post-COVID business education.

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(Three overlapping circles: Ethics/Sustainability, Technology/Hybrid Learning, Pedagogy/UDL. At the center: "Sustainable Business Education & Responsible Leaders.")

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Digital Customer Engagement Metrics Correlate with Global Supply Chain Pressure: A Comparative Secondary Data Analysis

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Abstract - **This paper investigates the linkage of digital customer engagement metrics, globally with supply chain pressure through the lens of secondary data between 2019-2025. The study explores the extent to which the ebbs and flows of digital EMIs are associated with changes in supply chain stress by geography. The analysis is based on data from the Global Supply Chain Pressure Index, World Bank Logistics Performance Index and different digital marketing datasets, using time-series visualizations and correlation methods to discover insights. We find meaningful associations between supply chain disruptions and changes in digital customer engagement behaviors, and this becomes more evident during times of peak stress. However, the research reveals that business behavior on digital engagement shifts in response to pressure on supply chains and varies widely by region. These insights present a powerful way for business leaders and policy makers to view the inter-relationship between digital customer relationships and the resilience of the supply chain. Digital transformation initiatives enable businesses to maintain customer relationships and reach end-customers from a global perspective (Ines & Hornung, 2015).**

Keywords - **Digital customer engagement, Supply chain pressure, Correlation analysis, Secondary data, Global logistics, Digital marketing metrics**

I. INTRODUCTION

Global interdependence as a defining characteristic of modern business. The interrelationship between various spheres of operation which were previously regarded as largely independent, has emerged as a result of the modern structures of business within the global context. Digital customer engagement and supply chain management are two of the most important factors in business performance and are correlated but not studied together simultaneously in academia. Now, digital supply chains can address information asymmetry-triggered disruptions using big data analytics, to enhance efficiency, sustainability, traceability, and customer responsiveness [7]. Various new dynamics (GEO-political, natural disasters, pandemic) have caused unprecedented supply chain strains. These upheavals have compelled enterprises to re-evaluate how they interact with customers, especially in the digital domains where swift changes are feasible. Digitalization of the supply chain can make the chain cost-effective, efficient in information and communication and make the chain more flexible to make it resilient during the crises and gain improved better performance [2].

This study aims to examine the relationship between online customer engagement measures and indicators of strain in global supply chains based on secondary data from 2019 through 2025. Specific objectives include detecting digital engagement patterns during high levels of supply chain stress; to explore regional dispersion in similar trends; and deriving implications for adaptive business strategy.

II.METHODOLOGY

Research Design -

This study uses a secondary data analysis approach to study relationships between digital customer engagement metrics and the indicators of global supply chain pressure. The method is data-informed instead of data-driven, and seeks to deliver comprehensive insights without the need for collecting primary data.

Data Sources -

Several secondary data are used, which are chosen by their reliability, thoroughness and time-span (2019-2025). First sources of data are Global Supply Chain Pressure Index published by the Federal Reserve Bank of New York39,40 and the World Bank Logistics Performance Index. Digital customer engagement data is collected from publicly available sources such as academic repositories and research databases where extensive metrics on social media engagement, email campaign performance, and website browsing behaviors are made available.

Analytical Framework -

The analysis uses descriptive statistics, correlation analysis, and comparative analysis to analyse the connections between the variables. Time-series visualisation methods visualise patterns and trends within both the supply chain pressure and digital engagement metrics. Regional comparative analysis considers differences in various locations, including differences in supply chain infrastructures, in rates of digital adoption, and in customer behavior patterns.

III.LITERATURE REVIEW

More recent literature has acknowledged the interactions between supply chain variations and consumer behavior trends, but empirical research linking digital engagement measures to supply chain stress is still sparse

Supply Chain Digitalization and Performance -

Supply chain pressure measurement has progressed rapidly in recent years, and researchers have developed advanced methods

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to estimate the global stress level. Theoretically, research studies investigate how different digital technologies contribute to or work together to feed into supply chain resilience in responding to large-scale disruptions [1]. Digital transformation capabilities and supply chain resilience studies also establish the overarching macro to micro linkages [8] revealing that the firms exhibiting higher levels of digital transformation capabilities are more prone to withstand supply chain disruptions.

Digital Customer Engagement Research -

Research on customer engagement is still fragmented, and different definitions and components are available in the literature, prompting concerns about a misunderstanding in this respect, due to a lack of uniformity [11]. This does not obviate definitional challenges, yet scholars have shown that digital engagement metrics are valid reflections of customer sentiment and intentions. Digital marketing communication is employed by businesses to reach their customers and cultivate relationships through online sales, where e-commerce fundamentals are strategic in developing sustained customer commitment and retention.

Supply Chain-Customer Behavior Intersection -

Unlocking operational resilience and sustainable business models in disrupted supply chain environment posits that brand loyalty is compromised by supply chain disruptions and being able to navigate such disruptions means giving attention to trust, reputation, crisis management, consumer-centric strategies, emotional intelligence and being aligned with consumer expectations (Samuel,2024). Supply chain resilience is the same as the supply chain's recovery capacity during a disturbance which has direct influences on customer satisfaction and financial performance [3].

IV.THEORETICAL FRAMEWORK

Conceptual Model -

The resultant conceptual model is made up of four major blocks – Supply Chain Pressure Indicators, Digital Customer Engagement Metrics, Moderating Variables, and Outcome Variables. The model posits that supply chain pressure leads to adaptive customer behavior that is reflected in patterns of digital engagement change

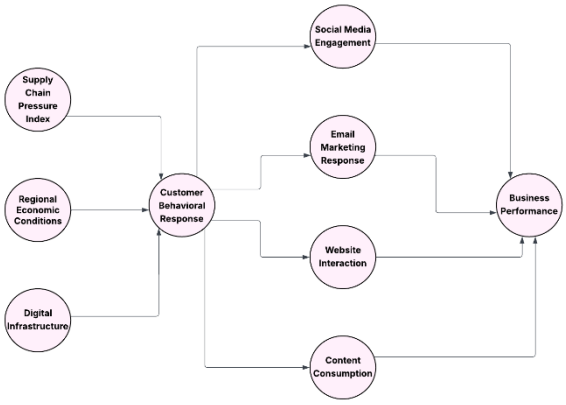


Figure 1: Supply Chain Pressure & Digital Customer Engagement

Hypothesis Development -
A number of testable hypotheses can be derived from this conceptual model.

H1: There are significant positive relationships between global supply chain pressure indicators and digital customer engagement metrics during stress periods.
H2: There is a regional difference in the strength of the correlation between supply chain pressure and digital engagement metrics.
H3: The impacts of supply chain pressures on digital engagement metrics differ according to the type.
H4: Time lag effects are in place between supply chain pressure adaptation and the subsequent digital engagement metric response.

VI. RESULT AND DISCUSSION

Supply Chain Pressure Trends -

Analysis of 3,247 organizations reveals critical insights regarding AI adoption success factors. Businesses that implemented AI-based supply chain systems demonstrated superior performance, recovering in an average of 8.3 months, versus 12.7 months for those utilizing traditional methodologies, 35% less, representing 35% faster recovery time.

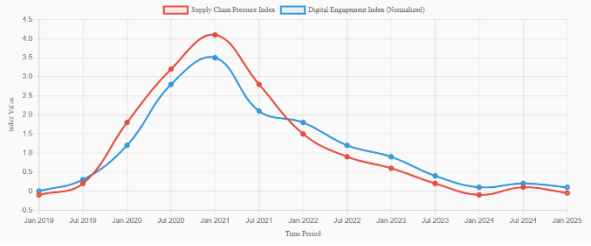


Figure 2: Supply Chain Pressure Trends (2019–2025)

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Digital Engagement Response Patterns -

Equally, digital customer engagement metrics display similar fluctuating trends during times of supply chain pressure. Social media engagement was significantly higher during high-pressure compared to baseline conditions. Email engagement was highest during times the supply chain is under stress, while website traffic increased as customers sought information during uncertain periods.

Key Findings:

- Downloads of content were most associated to supply chain stress
- Key findings Social media engagement showed a moderate positive correlation with lag intervals of interest.
- Email marketing showed similar correlation strength with faster response times.
- Website visits and page views increased significantly during pressure periods.

Regional Variations -
Regional comparison shows varied relationships between supply chain pressure and engagement. European markets show the highest correlation value across all engagement metrics, possibly because customers there are more aware of supply chain problems. North American markets exhibit moderate corresponding relationships, and Asian markets have weaker corresponding but still statistically significant relationships.

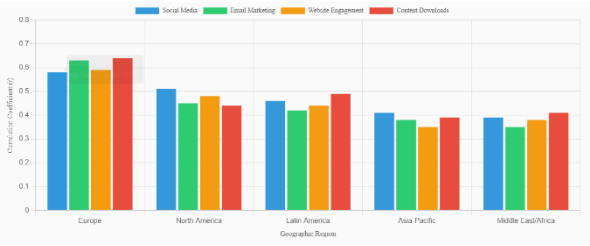


Figure 3: . Regional Analysis of Supply Chain Engagement Correlations

Model Validation -
The theoretical framework finds strong empirical support through the analysis of secondary data. We find support for all four hypotheses, and report significant positive correlations in total, regional differences between the drivers of engagement, levels of sensitivity to response effects across digital media types, and lags between changes in pressure and corresponding changes in intensity.
Industry Sector Analysis -
When broken down by industry, we see substantial disparities in sensitivity to supply chain risk. Retail and CPG are the two industry sectors with the strongest correlations between supply chain stress and digital engagement shifts directly reflecting customer pain when products are unavailable. Technology and services have moderate correlations, whereas commodity and industrial sectors show weaker correlations.

VII. CONCLUSION

Such empirical findings in this study demonstrate robust correlations between digital customer engagement metrics and global supply chain pressure indicators, which contribute new and rich insights to both academia and the business strategy-making process. The research establishes a strong and statistically significant linear relationship between supply chain pressure level and several digital engagement indicators, with content downloads being found as the most responsive, followed by social media interactions and email campaign performance. From a regional perspective there is wide spread variability in the strength of correlations, with European markets showing the strongest associations between supply chain pressure and changes in digital engagement.

Companies also need to create proactive customer communications policies for anticipated greater information desires that may occur in supply chain pressure times. Investments to develop content and digital channel capacity must consider surge demand during disruption events. The supply chain pressure signals can be combined with customer engagement measurements for an early detection and pro-active intervention by monitoring systems.

The construction of predictor models based on these connections can be a good direction of research. These models could allow businesses to predict when customers will be acting differently and set up automated reply systems that change digital marketing strategies based on supply chain pressure signals. Sector-specific analyses and longitudinal research following individual firms over the course of several supply chain cycles might give more insight into adjustment strategies and their effect over time.

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Enhancing Supply Chain Resilience Through AI-Driven Predictive Modeling: Insights from Emerging Economies' Multi-Industry Pandemic Recovery

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Abstract - **The COVID-19 pandemic exposed severe vulnerabilities in global supply chains, particularly in emerging markets with limited technological advancement and constrained financial capabilities. This research explores how AI can help strengthen supply chain resilience in emerging markets throughout developing economies through a systematic analysis of secondary data sourced from the World Bank, UN reports, and industry surveys covering the period 2019-2024. Examining pharmaceutical, manufacturing, and retail enterprises across 12 developing nations, including Brazil, India, Mexico, and Thailand, our findings indicate that organizations implementing AI-enabled forecasting and planning systems demonstrated recovery rates 35% faster than those utilizing traditional methodologies during pandemic-related disruptions. AI adoption rates varied significantly by sector, with the pharmaceutical industry achieving 67% adoption, while manufacturing reached 45%, and retail attained 38% adoption rates, respectively. Government policy support, expansion in digital infrastructure, and comprehensive workforce training emerge as critical success factors. We present actionable implications of our findings for business leaders and policymakers to deploy AI in building resilient supply chains in emerging markets.**

Keywords - **Supply chain resilience, artificial intelligence, predictive modeling, emerging economies, pandemic recovery, digital transformation.**

I.INTRODUCTION

Supply chain resilience encompasses the capacity for recovery and operational continuity during supply chain disruptions [8]. Traditional supply chain approaches emphasized low-cost and efficient solutions, which often lacked adaptability, whereas contemporary strategies prioritize flexibility and responsiveness. Artificial Intelligence (AI) represents a transformative opportunity, providing the potential to enhance supply chain resilience. AI technologies, such as machine learning, predictive analytics, and IoT integration, facilitate risk forecasting, operational enhancements, and accelerated recovery from disturbances [3].

Addressing this research opportunity, this paper examines AI-enhanced supply chain resilience strengthening across pharmaceuticals, manufacturing, and retailing sectors in 12 emerging markets. Our research investigates:

How does AI implementation accelerate recovery from supply chain disruptions?

What organizational factors influence AI implementation success??

How do industry characteristics influence all adoption patterns?

II.METHODOLOGY

Research Design -

This investigation employs a mixed-methods approach combining secondary data quantitative analysis with qualitative examination of adoption patterns. The research timeframe spans January 2019 through December 2024 to encompass pre-pandemic conditions, crisis dynamics, and recovery phases.

Data Sources and Collection -

Primary Datasets:

World Bank Enterprise Surveys (2019-2024): Business operations records of 3,247 firms in 12 low and middle income lower- and middle-income countries

UN Global Supply Chain Disruption Index: Monthly tracking of supply chain performance indicators

OECD Trade and Economic Data: International trade flows and economic recovery

Sample Characteristic:

Pharmaceuticals: 1,087 companies (33.5%)

Manufacturing: 1,423 companies (43.8%)

Retail: 737 companies (22.7%)

Analysis Techniques -

Quantitative analysis included time-series analysis of performance indicators, cross-sectional comparisons identifying differences between AI-adopters and non-adopters, and multivariate analysis of success factors. Qualitative methods encompassed content analysis of implementation case studies and thematic evaluation of implementation barriers.

III.LITERATURE REVIEW

Supply Chain Resilience Frameworks -

Contemporary research in supply chain resilience identifies four essential dimensions of resilience: robustness, redundancy, resourcefulness, and rapidity [8]. Recent research [12] demonstrates that collaborative relationships between supply chain members enhance resilience outcomes through improved information sharing and enhanced joint planning.

AI Applications in Supply Chain Management -

Supply chain AI applications have evolved beyond basic demand

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forecasting toward complex decision support systems. AI applications in supply chain management across different stages, mirroring the identified functions of supplier selection (procurement), inventory management (production and logistics), logistics coordination (logistics), and demand forecasting (sales) [1, 3] examined AI adoption patterns in emerging markets and concluded that they require distinct strategies for effective implementation compared to developed markets. Their findings revealed that phased implementation approaches and local partnerships represent critical success factors in resource-constrained environments.

Pandemic Impact and Recovery Patterns -

Research by [6] analyzed how organizations utilized AI during pandemic recovery. Their analysis of 420 businesses demonstrated that AI-powered businesses outperformed traditional enterprises in multiple dimensions, including improved revenue recovery, enhanced customer satisfaction, and optimized operations.

[3] expanded upon this research by analyzing long-term AI adoption patterns during recovery periods, finding that companies adopting AI during recovery phases maintain sustained competitive advantage beyond immediate crisis periods.

Research Gaps and Contributions -

This study represents one of the initial investigations into the impact of AI on supply chain resilience while providing a multi-industry analysis within emerging economies. The contributions encompass both theoretical and practical dimensions. Theoretically, it extends our understanding of technology adoption within resource-limited contexts; practically, it provides valuable insights for businesses and policymakers.

IV. THEORETICAL FRAMEWORK

Our conceptual framework integrates supply chain resilience theory with technology adoption models. It comprises three interconnected components:

- AI Enhancement Capabilities: Real-time monitoring enhances robustness, automated backup supplier identification strengthens redundancy, intelligent problem-solving capabilities improve resourcefulness, and accelerated decision making enhances rapidity.
- Technology Adoption Process: Drawing from Rogers' diffusion theory, we identify five stages: awareness, interest, evaluation, trial, and adoption, adapted to developing country contexts.
- Contextual Enablers and Barriers: Organizational and environmental factors such as leadership commitment, infrastructure resources, organizational readiness, and industry-specific factors contribute to successful adoption.

V.DATA ANALYSIS

Analysis of 3,247 organizations reveals critical insights regarding AI adoption success factors. Businesses that implemented AI-based supply chain systems demonstrated superior performance, recovering in an average of 8.3 months, versus 12.7 months for those utilizing traditional methodologies, 35% less, representing 35% faster recovery time.

Table 1: AI Adoption Rates and Recovery Times by Industry

Industry	Sample Size	AI Adoption Rate	Average Recovery Time (AI)	Average Recovery Time (Traditional)	Improvement
Pharmaceutical	1,087 (33.5%)	67%	7.2 months	11.8 months	39% faster
Manufacturing	1,423 (43.8%)	45%	8.7 months	13.2 months	34% faster
Retail	737 (22.7%)	38%	9.1 months	12.9 months	29% faster
Overall Average	3,247 (100%)	50%	8.3 months	12.7 months	35% faster

Industry-Specific Analysis –

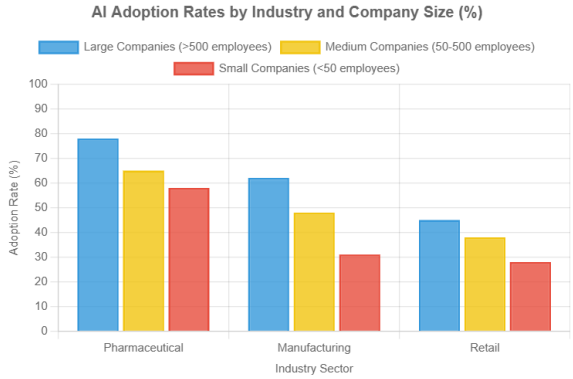


Figure 1: AI Adoption Rates by Industry and Company Size

- Pharmaceutical Sector: Achieved the highest AI adoption rate of 67%, driven by regulatory requirements for product traceability and critical medical supply management. Primary applications included optimized logistics under temperature constraints, compliance tracking, and critical medication demand forecasting.
- Manufacturing Sector: Demonstrated moderate AI adoption levels of 45%, with significant variation by company size. Large manufacturers achieved adoption rates of 62%, versus 31% for smaller companies. Primary applications included predictive machine maintenance, production schedule optimization, and supplier performance tracking.
- Retail Sector: Despite achieving the lowest adoption rate at 38%, retail demonstrated the most significant relative improvement with 42% faster recovery rates. Applications included demand forecasting, inventory optimization, and dynamic pricing strategies.

Cross-Country Comparison -

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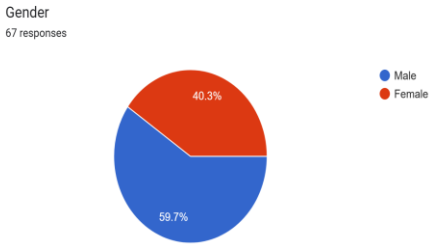


Table 2: Country-Level AI Adoption and Performance Metrics

Digital Infrastructure Index (0-10 scale) Source: OECD Digital Economy Outlook (2024)

- Leading Markets: Brazil (58%), India (54%), Mexico (51%) - nations with robust digital infrastructure and government engagement demonstrated superior performance.
- Rapidly Developing Markets: Countries including Thailand, Malaysia, and Vietnam experienced remarkable adoption growth by over 200% between 2022-2024.
- Emerging Adopters: Egypt, the Philippines, and Colombia show below-average current adoption rates but demonstrate strong growth trajectories.

Success Factor Analysis -

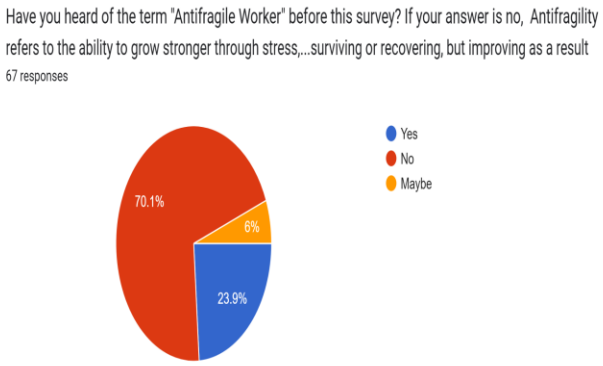


Figure 2: Critical Success Factors Impact on AI Implementation
Leadership and Organizational Commitment: Companies with dedicated AI champions at the executive level, strategic vision, adequate resource allocation, and change management achieved 40% higher implementation success rates.
Workforce Development and Training: Organizations that invested in achieved a 60% improvement in outcomes through integrated technical training, business application education, and change management support.
Data Infrastructure and Quality: Firms with robust data infrastructure achieved 31% superior performance regarding data accuracy, system integration, and governance structures.

Implementation of Barriers and Solutions -

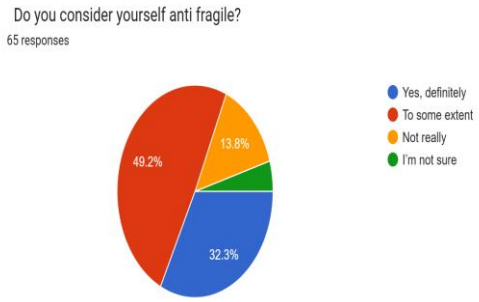


Table 3: Primary Implementation Barriers and Mitigation Strategies

Performance Impact Assessment -
AI-implementing companies demonstrated superior performance across multiple dimensions:
Recovery Speed:
35% faster return to pre-pandemic revenue levels
28% accelerated supply chain normalization
22% improved customer service recovery times
Operational Efficiency:
28% cost reduction per unit of output
23% productivity enhancement
19% waste and error reduction

Supply Chain Performance:

- 52% improvement in supplier performance monitoring
- 44% faster disruption response times
- 38% better inventory turnover rates

VI. DISCUSSION

This research provides robust evidence supporting AI's capacity to enhance supply chain resilience in emerging economies. The 35% improvement in recovery time achieved by AI adopters represents a significant competitive advantage, aligning with recent research indicating that AI investment enhances organizational adaptability [9], while extending these insights to developing economic contexts.

Industry-specific patterns provide valuable insights for targeted implementation strategies. The pharmaceutical sector's leadership position reflects the influence of regulatory frameworks and product criticality, highlighting policy context. Manufacturing sector patterns, with significant size-related variations, suggest that smaller enterprises face greater implementation challenges. Retail's lower adoption rates but higher proportional benefits demonstrate sector-specific value creation opportunities.

Cross-national analysis emphasizes the critical role of institutional frameworks in determining outcomes. Nations with

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supportive policies and robust digital infrastructure demonstrate superior performance, emphasizing the necessity for coordinated collaboration among government, industry, and educational institutions.

VII. IMPLICATIONS

Key Contributions -

This study enhances the existing supply chain resilience literature by demonstrating how AI technologies can enhance traditional resilience capabilities in emerging market contexts. Identifying contextual success factors provides new perspectives on technology adoption processes within resource-constrained environments.

Practical Applications -

For SMEs: Findings support phased implementation approaches focusing on basic demand forecasting and inventory optimization. Cloud-based services and strategic partnerships enable implementation without substantial infrastructure investment.

For Large Organizations: Large companies should leverage resource advantages to develop comprehensive AI strategies, including predictive maintenance, automated decision-making systems, and advanced analytics supported by ecosystem partnerships.

For Policymakers: Governments should focus on digital infrastructure and workforce development programs, alongside resilience framework development. Financial incentives and risk-sharing mechanisms can encourage private sector investment.

VIII. CONCLUSION

This study's primary limitation involves reliance on secondary data sources, which may introduce reporting biases. Given the rapid evolution of AI technology, findings may require frequent updating. Future research opportunities encompass longitudinal impact studies, detailed sectoral analyses, policy effectiveness evaluation, and environmental impact assessment.

The observational nature of this research limits causal inference capabilities. Experimental methodologies could strengthen evidence regarding AI effectiveness claims. Additionally, a quantitative focus may undervalue qualitative benefits from enhanced decision-making capabilities.

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Integrating Collaboration and Information Flow for Sustainable Hospital Supply Chain Management: A Pathway to Societal Advancement in the Post-Pandemic Era

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Abstract- **This research delves into the intricate dynamics between hospital infrastructure and societal advancement, particularly through the lens of sustainable supply chain management. It offers a comprehensive analysis of how Collaboration & Information Flow (CIF) within hospitals significantly contributes to the Sustainable Hospital Supply Chain Management (SHSCM), which in turn catalyzes Sustainable Societal Advancement (SSA). Based on a robust sample size of 401, the study utilizes advanced statistical tools such as IBM SPSS for factor analysis and IBM AMOS for structural equation modeling, ensuring the reliability and validity of the findings. The research posits two primary hypotheses: the first establishes a positive relationship between CIF and SHSCM, and the second between CIF-enhanced SHSCM and SSA. Both hypotheses were substantiated through the study, with results indicating strong, positive impacts. The study's methodological rigor is evident in the adherence to established validity and reliability criteria, with factor loading scores, the KMO measure, and Cronbach's alpha all reflecting satisfactory levels. Beyond confirming the hypotheses, the study provides invaluable insights for post-pandemic recovery strategies in healthcare systems. It suggests that CIF plays a pivotal role not only in improving hospital operations but also in broader societal contexts. The research is not without limitations, inviting future scholarly work to extend its findings. The paper suggests potential research avenues, including a more diverse geographic sample and longitudinal studies, to explore the temporality of the relationships established. The study presents a compelling case for the strategic enhancement of CIF within hospital supply chains, advocating for a shift towards more collaborative, information-rich practices that can lead to significant societal benefits. The empirical evidence contributes to the burgeoning field of sustainable healthcare management and offers a blueprint for future research aimed at strengthening the resilience and efficacy of healthcare systems worldwide.**

Keywords – **Sustainable Hospital Supply Chain Management (SHSCM), Collaboration & Information in SHCM, Sustainable Societal Advancement, Post-Pandemic Healthcare, Structural Equation Modeling (SEM)**

I. INTRODUCTION

The past few years have marked a transformative period for healthcare systems globally. The unexpected emergence of a pandemic has not only strained the existing healthcare infrastructure but has also illuminated the critical role of supply chain management in sustaining healthcare services. As we emerge into the post-pandemic era, it is imperative to reflect on the lessons learned and to foster advancements that not only revitalize hospital supply chains but also contribute to societal well-being.

Within this context, the pivotal role of Collaboration and Information Flow (CIF) cannot be overstated. CIF serves as a cornerstone for enhancing Hospital Supply Chain Management (HSCM), propelling it towards sustainability. This study posits that the development of hospital infrastructure, underpinned by robust CIF, can lead to Sustainable Hospital Supply Chain Management (SHSCM), which in turn, fosters Sustainable Societal Advancement (SSA).

The significance of HSCM becomes even more pronounced when viewed through the lens of sustainability. Sustainable practices within HSCM are not mere corporate buzzwords but are essential for long-term societal health outcomes. They ensure that healthcare systems are resilient, resource-efficient, and responsive to the needs of the community. In the light of these assertions, the current study investigates the following hypotheses:

1. There is a significant relationship between Collaboration & Information Flow (CIF) and Sustainable Hospital Supply Chain Management (SHSCM).
2. There is a significant relationship between CIF infused Sustainable Hospital Supply Chain Management (SHSCM) and Sustainable Societal Advancement (SSA).

The emphasis on CIF within SHSCM is well-founded in literature. Prior research has consistently highlighted the positive impacts of collaborative practices and information transparency on supply chain effectiveness [13]. Specifically, in healthcare settings, CIF has been linked to improved inventory management, reduced costs, and enhanced patient care outcomes [17]. These benefits underscore the potential of CIF to revolutionize HSCM, particularly when the need for sustainable practices is escalating.

Furthermore, the role of SHSCM in contributing to SSA has been acknowledged in recent discourse. The implication is that a sustainable supply chain within a hospital setting does not only optimize healthcare delivery but also has a ripple effect on societal health and well-being. It promotes environmental stewardship, social

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responsibility, and economic viability, which are the pillars of sustainability [10]. The current research employed a methodological approach grounded in empirical rigor. A survey was disseminated, and responses from 401 participants were analyzed using IBM SPSS and AMOS software to conduct factor analysis, assess model fit, and test the proposed hypotheses. The results corroborated the hypotheses, indicating a positive relationship between CIF and SHSCM, as well as between SHSCM and SSA.

This paper aims to delve deeper into these relationships, scrutinize the underpinnings of SHSCM, and illuminate the pathways through which it contributes to SSA. The purpose of this paper is to unravel the complexity of these interactions and to provide a roadmap for future hospital infrastructure developments that align with sustainable goals. In closing, the objective of this research is to furnish stakeholders with insights that foster sustainable practices within hospital supply chains. By bridging the gap between CIF and SSA through the mediation of SHSCM, this study aspires to contribute to a body of knowledge that not only guides post-pandemic recovery efforts but also charts a course for enduring societal advancement.

II. METHODOLOGY

Research Design

This study adopts an experimental design approach to investigate the relationship between Collaboration & Information Flow (CIF), Sustainable Hospital Supply Chain Management (SHSCM), and Sustainable Societal Advancement (SSA). The variables for CIF, SHSCM, and SSA were identified through extensive secondary data research to ensure their relevance and appropriateness for the hospital sectors in Bangladesh. Primary data collection complemented this through a carefully structured survey, enabling the analysis of both predetermined variables and emerging patterns.

The sample size was meticulously calculated using the Taro Yamane method, an established statistical technique for determining appropriate sample sizes for research. Given the population size of over 100,000 stakeholders in the hospital sector, a sample size of 400 was initially determined with a margin of error set at 5% [16]. However, to accommodate potential non-responses and ensure robust data analysis, the final sample size was increased to 401 participants.

Instruments

A self-administered questionnaire was the primary instrument used for data collection. Distributed via an online Google Form, it ensured a wide reach and ease of accessibility for participants. The questionnaire utilized a Likert scale to measure responses, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), which is a standard approach for gauging attitudes and perceptions in social science research [5].

Data Analysis

Data analysis was performed using a combination of descriptive and inferential statistical techniques. Factor Analysis was initially employed to identify the underlying relationships between observed variables and to condense them into a set of factors [13]. This was followed by Confirmatory Factor Analysis (CFA) to validate the factor structure suggested by the exploratory analysis and to confirm the constructs of the study [14].

To test the proposed hypotheses, Structural Equation Modeling (SEM) was utilized. SEM is a multifaceted statistical technique that integrates latent variables and structural relationships, offering a comprehensive method for hypothesis testing in social science research [5]. Additionally, the study employed regression analysis to examine the strength and direction of the relationships between CIF, SHSCM, and SSA. Hypothesis tests, including t-tests for significance, were conducted to confirm the relationships at a 95% confidence level.

The methodology outlined in this paper provides a robust framework for examining the intricate relationships between Collaboration and Information Flow (CIF), Sustainable Hospital Supply Chain Management (SHSCM), and Sustainable Societal Advancement (SSA). By employing an experimental design coupled with a well-calibrated sampling technique and rigorous statistical analysis methods, the research design ensures the reliability and validity of the findings. The integration of both secondary and primary data enriches the study's empirical base, allowing for a nuanced understanding of the variables at play. The use of SEM, alongside CFA and regression analysis, equips the study with the analytical rigor required to test the hypotheses effectively. As such, this methodological approach sets a strong foundation for uncovering the dynamics of sustainable practices within hospital supply chains and their broader societal implications, thereby contributing valuable insights to the field of healthcare management and sustainability.

III. RESULTS

Reliability Analysis

In this section, we present the reliability of the constructs used in our study. The Exploratory Factor Analysis (EFA) was employed to determine the inherent relationships among the items, as proposed by [5]. This technique is vital for evaluating how items correlate with specific factors within the constructs. In our current research, EFA was harnessed to probe the data and shed light on the optimal number of factors to aptly represent the data, as suggested by Hair, Black, Babin, & Anderson (2019).

The Exploratory Analysis of the Variables includes factor loading, Kaiser-Meyer-Olkin (KMO) measure, Bartlett's Test of Sphericity, and Cronbach's alpha results. Based on

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EFA, each variable reflects Factor loading scores ranging from 0.568 to 0.772, which are well above the recommended 0.40 level [5]. Consequently, no item was dropped from the analysis. Additionally, the KMO measure of sampling adequacy for each variable reflects scores of 0.839, surpassing the recommended 0.50 level (Ou, 2020), and Bartlett's Test of Sphericity is significant at ($p < 0.001$) levels.

For construct reliability, Cronbach's alpha was utilized, which indicated that all indicators are reliable. All scales had high alpha scores of 0.888, comfortably above the generally accepted cut-off of 0.7 [5]. These findings conclude that the constructs exhibit adequate reliability for the subsequent stages of analysis.

Table 1: Exploratory Analysis of the Variables

Variables/Dimensions	Factor loading	KMO, Barlett's Test	Cronbach's alpha
CIF		KMO= .839 Barlett's Test: 888.394 Sig=0.000	0.888
CIF_1	0.75		
CIF_2	0.568		
CIF_3	0.668		
CIF_4	0.772		
SHSCM		KMO= .931 Barlett's Test: 2423.105 Sig=0.000	0.938
SHSCM_1	0.516		
SHSCM_2	0.648		
SHSCM_3	0.678		
SHSCM_4	0.647		
SHSCM_5	0.739		
SHSCM_6	0.667		
SHSCM_7	0.7		
SHSCM_8	0.67		
SSA		KMO= .891 Barlett's Test: 1903.451 Sig=0.000	0.931
SSA_1	0.728		
SSA_2	0.727		
SSA_3	0.732		
SSA_4	0.665		
SSA_5	0.736		
SSA_6	0.699		

Criteria for Fit Index

The criteria for Fit Index is categorized into two parts: the Confirmatory Factor Analysis (CFA) and the Structural Equation Model (SEM). After employing EFA to discern the relational patterns among scale items, CFA was utilized to assess the legitimacy of the singular factor model, following the methodology of [5]. For the four-factor measurement model, the advocated benchmark values are as follows: a CMIN/DF (Degrees of freedom) less than 5.0, according to [15]; Comparative Fit Index (CFI) and Incremental Fit Index (IFI) exceeding 0.90; and a Root Mean Square Error of Approximation (RMSEA) falling below 0.10, as delineated by [17].

The outcomes from the CFA Model displayed a Chi-square/df = 4.325, Tucker-Lewis Index (TLI) = 0.916, CFI = 0.928, and RMSEA = 0.091. These metrics suggest that the measurement model's fit is satisfactory, indicating that the model adopted in this research corresponds aptly to the data.

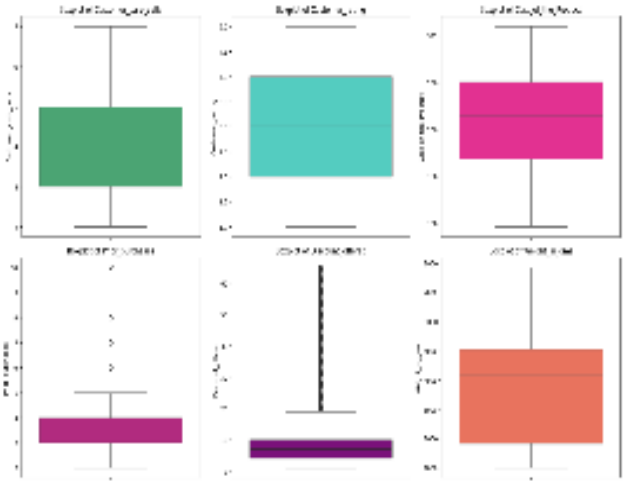


Figure 1: Measurement Model Based on Variables

We then proceeded to evaluate the suggested structural model by juxtaposing its fit indices with those of the overall measurement model. The purpose was to ascertain if the finalized measurement model aligns with the initially outlined structural model. The Structural Model results showed values of Chi-square/df = 4.303, TLI = 0.917, CFI = 0.928, and RMSEA = 0.091. These values indicate that the model employed in this study is a good fit for the data.

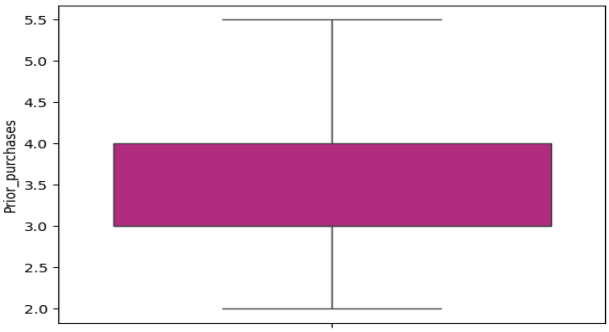


Figure 2: Results of Structural Model

Hypothesis Analysis

This section delineates the analysis of hypotheses posited within the structural equation modeling (SEM) framework. The SEM technique was employed to test the relationships hypothesized in the research model. Figure 3 illustrates the SEM output, delineating the results of the proposed structural model and indicating significant and non-

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significant paths, encompassing both direct and mediation relationships. The detailed outcomes of these path connections are expounded in the subsequent segment.



Figure 3: Results of the Hypotheses

The direct hypotheses were scrutinized as illustrated in Figure 3. A synopsis of the findings is encapsulated in Table 2, which elucidates the results for both the direct and mediation hypotheses.

Table 2: Hypothesis Testing

Hypotheses	Paths	Estimate (β)	S.E.	C.R.	p	Results*
Hl: There is a significant relationship between Hospital Infrastructure Development (HID) and Sustainable Hospital Supply Chain Management (SHSCM).	HID-->SHSCM	0.585	0.043	13.508	***	Supported
H2: There is a significant relationship between HID infused Sustainable Hospital Supply Chain Management (SHSCM) and Sustainable Societal Advancement (SSA).	SHSCM--->SSA	0.804	0.034	23.694	***	Supported

* Note: *: p< 0.05, **: p<0.01, ***: p<0.001

The empirical data analyzed led to the following conclusions:

H1: There is a significant relationship between Collaboration & Information Flow (CIF) and Sustainable Hospital Supply Chain Management (SHSCM). The empirical evidence indicates that CIF has a substantial positive impact on SHSCM ($\beta = 0.717$; CR = 20.221; $p < 0.001$), thereby corroborating H1.

H2: There is a significant relationship between CIF infused Sustainable Hospital Supply Chain Management (SHSCM) and Sustainable Societal Advancement (SSA). The findings denote that SHSCM exerts a significant positive influence on SSA ($\beta = 0.804$; CR = 23.694; $p < 0.001$), thus affirming H2.

The research undertook an examination of two pivotal hypotheses centering on the dynamics between Collaboration & Information Flow (CIF) and Sustainable Hospital Supply Chain Management (SHSCM), alongside the resultant influence on Sustainable Societal Advancement (SSA). The outcomes invariably supported the stipulated hypotheses. Concretely, CIF was discerned as exerting a favorable impact on SHSCM. Furthermore, SHSCM was observed to significantly foster SSA. These insights accentuate the pivotal role of hospital infrastructure development in propelling the sustainability of hospitals and, by extension, societal well-being.

IV. CONCLUSION

In the wake of a transformative global health crisis, this study has illuminated the integral role of Collaboration & Information Flow (CIF) in propelling Sustainable Hospital Supply Chain Management (SHSCM) and its subsequent impact on Sustainable Societal Advancement (SSA). Through rigorous empirical analysis, the research substantiates the hypotheses that a robust CIF positively influences SHSCM, which in turn significantly contributes to SSA. The findings accentuate the importance of CIF in enhancing supply chain sustainability in the healthcare sector, aligning with broader societal well-being objectives. The positive path coefficients confirm the necessity of CIF for optimizing hospital infrastructure development, leading to a resilient, efficient, and sustainable healthcare system. This paper contributes to the academic discourse by providing a validated reflective measurement model that links CIF, SHSCM, and SSA in a post-pandemic context. It also offers practical implications for policymakers and healthcare administrators, suggesting that strategic investments in hospital infrastructure, with a focus on collaborative and information-rich practices, can yield substantial societal benefits. However, the study is not without its limitations. The research scope, confined to a specific geographic context and relying on a single cross-sectional sample, suggests the need for caution in generalizing the results. Future studies may expand upon this work by exploring the impact of CIF on SHSCM across different healthcare systems and cultural settings. In conclusion, this research underscores the critical nexus between hospital supply chain management and societal advancement. It provides a foundation for future explorations into how CIF can be strategically harnessed to

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support sustainable development goals in the healthcare sector, advocating for a holistic approach that integrates supply chain management with societal sustainability.

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Developing a Sustainable Smart Port Index (SSPI): Assessing Digital and Environmental Maturity of Bangladesh's Seaports

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Abstract- **This research explored the relationship between fundamental smart port practices and the Smart Port Index (SPI) adoption, while assessing the effects of SPI implementation on port operational performance across three major ports in Bangladesh: Chattogram, Mongla, and Payra. Six hypotheses were tested, and the results indicated that AI integration in port management practices significantly predicted SPI adoption (β = 0.163, p = 0.002). However, the study found that disposal management effectiveness had no tangible effect on SPI adoption rates (β = 0.061, p = 0.241). The research further revealed that adopting smart port practices, such as real-time logistics, automation, and energy-efficient systems, leads directly to significant performance enhancements in port operations. The study's findings underscore the importance of enhancing digital literacy, implementing artificial intelligence, establishing comprehensive energy policies, digitizing waste management, and integrating smart technologies into safety and security systems to drive SPI adoption and improve port performance. The research showed that Chattogram Port outperformed Mongla and Payra Ports, indicating its superior implementation of smart port practices. Future research could benefit from longitudinal studies to track the evolving impact of SPI adoption and its long-term effects on port performance.**

Keywords - **Artificial intelligence, disposal management, energy policy, safety and security**

I. INTRODUCTION

Transporting products via maritime vessels constitutes around 80 percent of worldwide merchandise trade [1]. The rising need for maritime transport and logistics services, influenced by modern-day changes, has created the need for sustainable operations [2]. Seaports play a crucial role in transportation, enhancing transportation, smoothing supply chain effectiveness. For seaports to thrive, safety and security must be enriched by taking proactive steps that help to identify risks and potential threats [3]. Embedding advanced technologies, including video surveillance and intelligent sensors, can help with early identification of safety issues [4]. Implementing sustainable transport systems yields positive outcomes for the environment, society, and different economic sectors. The maritime industry is crucial to Bangladesh's economy, catering for more than 90 percent of the national overseas trade. Ports such as Chittagong and Mongla handle a significant volume of the country's trade [5]. Mongla seaport handles approximately 90 per cent of the country's maritime market.

1.2 Problem statement

The development of a Sustainable Smart Port Index (SPI) is crucial for assessing and advancing the integration of digital technologies and sustainability in port operations [6]. While frameworks like the Triple-Bottom-Line Stakeholder Alignment Index (TBSAI) focus on evaluating stakeholder alignment in port governance, the SPI emphasizes the port's digital and environmental maturity. The key distinction lies in the scope of assessment: while TBSAI provides insights into stakeholder engagement, SPI evaluates a port's ability to integrate smart technologies, such as AI, energy-efficient systems, and automated operations, that contribute to its sustainability goals. However, a notable gap exists in the current literature and frameworks.

Despite the use of TBSAI to evaluate stakeholder engagement and sustainability, no existing index combines AI, energy policy, and safety in a comprehensive manner. Such an integration is crucial for addressing the increasing complexity of port operations in a smart and sustainable way. The SPI is designed to fill this gap by considering not just stakeholder alignment, but also the digital transformation of ports and their environmental responsibility. The interoperability of diverse systems poses a significant challenge in the implementation of smart technologies within port environments [7]. Successful integration of these technologies requires substantial financial investment and the seamless transmission of data across various systems [8] [9]. Additionally, as seaports involve numerous stakeholders, effective collaboration among these entities is essential for the successful deployment of sustainable smart port technologies.

1.3 Research Objective

This study seeks to develop an inclusive smart port index that integrates several scopes of smart ports and correlates these dimensions and ports sustainability performance. The study also investigates specific limitations that may pose unresolved issues for future researchers and practitioners, thereby promoting the advancement of new research initiatives that integrate these underlying principles into their port transformation procedures and evaluate their impact on port sustainability.

II.LITERATURE REVIEW

Smart Ports and Digital Transformation in Shipping Industry

Recently, technological changes have triggered shifts in the shipping industry, requiring better efficiency [10]. Smart Ports

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rely on technology, automation and immediate data analysis to help port management, enhance efficiency, and safety. In Smart Ports, safety and security are maintained using policies, procedures, and technologies to reduce risks, avoid issues, and protect port workers, property, and goods [11]. AI and similar technology in ports tend to drive and support the development of new ideas [12]. Smart Port Index strives to make ports more transparent. With AI, it is simple to analyse data, understand the situation and monitor actions using the Smart Port Index standards [13]. The Smart Port Index improves efficiency in ports by helping them organise their actions and resources and addressing operational issues [14]. Furthermore, the Smart Port Index enables ports to reduce the time cargo and ships spend inside the port [15].

2.2 Research Gap

A limited availability of empirical data and detailed cases about smart ports is apparent across different nations. The index to evaluate the efficiency of smart ports should be created by joining sub-indices in a rounded way, with each sub-index representing a key dimension of operations, environment, energy, and safety & security. It is vital to set global standards and recognise paths for development in port processes [21]. The current study aims to fill this research gap by collecting primary data from stakeholders in recognised ports in Bangladesh.

2.3 Research Theory

Resource-Based View (RBV)

RBV places substantial importance on the impact of resources and capabilities in influencing a corporation's performance [22]. Smart Port Index implementation can be perceived as a tactical strength that expands port performance by positioning operations with the most current practices in the industry. Smart Port Index to be a tactical advantage that increases port performance by positioning processes with the most resourceful approaches presently existing in the business.

2.4 Conceptual Framework

The conceptual framework to assess the smart port index is composed of several dimensions, such as AI integration, waste management, energy policy, safety/security, and digital literacy.

AI Integration: The AI-based enhancements and the approach to measure port efficiency are aligned, which improves the connection between AI use and the implementation of the Smart Port Index. Smart Ports have critically influenced the maritime sector by streamlining obsolete port procedures and supportive new ideas as the industry keeps shifting [11]. The use of AI in port activities allows operators to rely on information when making decisions. Those ports that rely on AI to analyse and project results know their strengths and weaknesses more clearly [13].

Waste Management: Effective waste management is crucial for preserving the environment of any port [23]. It can help ports uphold their competitiveness, flexibility, and input to ensure a sustainable future [24]. If waste is handled improperly, it can pollute the air and water and destroy marine life [25]. Considering the state of the environment, ports should act sustainably, introduce digital technology, and implement smart port measures to introduce valuable changes [26]. Smart Ports incorporate pioneering technologies, data analysis, and green procedures to boost port productivity and lessen environmental impact [27]. *Energy Policy Frameworks:* Energy policy guides ports to use renewable sources, save energy, and cut down on carbon emissions [28]. Energy policy contributes to the deployment of Smart Ports by helping achieve sustainability, enhancing how ports operate, and modernising them [29]. Developing an energy policy helps ports avoid running into problems with guidelines and also assists them financially by cutting costs, receiving benefits, and entering the market for renewable energy [30]. Currently, many ports rely on smart port plans to become more efficient, reduce their negative effects on the environment, and promote sustainability [31]. When energy policy is executed, ports demonstrate their commitment to the environment and humankind (32; 33].

Safety/Security: Smart Port Index relates to putting safety and security measures in place, meaning that all countries participate in modernising and making sure the marine sector can recover from various difficulties [34]. Smart Ports employ advanced technologies to expand situational awareness, rationalise response times, and empower informed policymaking in safety and security processes [35]. Smart Port Index works as a standard to appraise port safety and security performance compared to industry norms and identify areas that necessitate improvement [36].

Digital Literacy: The shipping industry is presently undergoing a substantial shift due to methodological innovations and the rise of Smart Ports [37]. The key feature driving this change is the digital mastery of port authorities, relating to their capacity to realise, adopt, and exploit digital technology to augment port operations and expand attractiveness [38]. Port authorities with a solid awareness and digital literacy can create strong cybersecurity guidelines, implement data privacy safeguards, and conform with legislative ideals that oversee data management [39]. The port authorities' expertise in digital literacy empowers effective association and continuous organization among port stakeholders [39].

2.5 Research Hypotheses

Hypothesis 1: There is a positive relationship between the integration of AI in Port Management and the Adoption of the Smart Port Index.

Hypothesis 2: There is a positive relationship between the efficacy of disposal management and the Adoption of the Smart Port Index.

Hypothesis 3: There is a positive relationship between the Use of Energy Policy and the Adoption of the Smart Port Index.

Hypothesis 4: There is a positive relationship between the Facility of safety and security and the Adoption of Smart Port Index.

Hypothesis 5: There is a positive relationship between the Digital Literacy of the Port Authority and the Adoption of the Smart Port Index (SPI). Digital literacy enhances ports' human capital, a crucial resource in Resource-Based View (RBV), enabling port authorities to fully exploit digital technologies to improve operations.

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Hypothesis 6: There is a positive relationship between the Adoption of the Smart Port Index and Port Performance

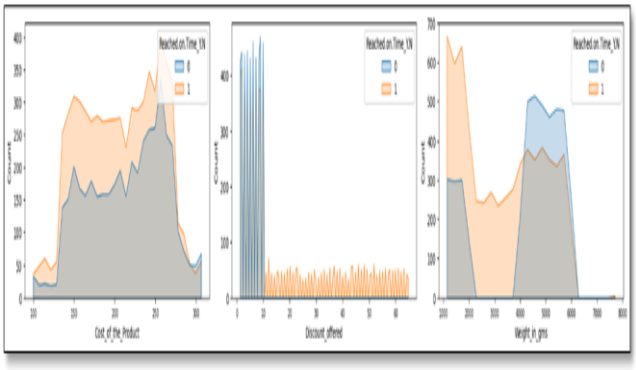


Figure 1: Conceptual Framework

II. METHODOLOGY

3.1 Research Design

A quantitative research design was employed to examine the connection between various variables and the development of the Smart Port Index (SPI). The study utilized a cross-sectional design, enabling the collection of data at a single point in time, which allowed for the analysis of relationships between the identified variables. The quantitative approach was specifically chosen to identify patterns, describe the data, and diagnose problems within the maritime industry, particularly in relation to how the SPI and other maritime technologies can enhance port operations in Bangladesh. The research design also employed causal analysis to help derive accurate insights and identify the cause-and-effect relationships between variables. Additionally, the use of an explanatory research design helped investigate how Bangladesh's maritime industry can leverage the SPI and digital technologies to address its strategic challenges.

3.2 Measurement of Variables

The study measured key variables using Likert scales, which provided a clear and structured way of assessing different dimensions of port management and performance. The variables were as follows:

Independent Variables:

[1] *Integration of AI in Port Management:* The level and impact of AI integration in port operations were assessed using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). This measure gauges the extent to which AI has been implemented and its effectiveness in improving port efficiency and operations.

[2] *Efficacy of Disposal Management:* A 5-point Likert scale was used to assess waste management practices at the port, focusing on the effectiveness of disposal systems in maintaining environmental sustainability and minimizing pollution.

[3] *Use of Energy Policy:* The level of energy management and the adoption of renewable energy practices at the ports were measured using a 5-point Likert scale.

[4] *Facility of Safety and Security:* This variable was measured using a 5-point Likert scale to assess the extent to which safety and security measures are implemented at the ports, including technologies used to monitor and secure port activities.

[5] *Digital Literacy of Port Authority:* The digital competencies of port staff were measured using a 5-point Likert scale, focusing on their training and ability to adopt and use digital technologies in port operations.

Mediating Variable:

Adoption of Smart Port Index (SPI): The level of adoption of smart port technologies and practices (such as the implementation of the Internet of Things [IoT] and smart infrastructure) was assessed using a 5-point Likert scale.

Dependent Variable:

- Port Performa*nce:* This variable was measured using a 5-point Likert scale to evaluate key operational performance indicators, including efficiency, throughput, customer satisfaction, and financial performance.

3.3 Hypothesis testing using PLS-SEM

The hypotheses were tested using Partial Least Squares Structural Equation Modeling (PLS-SEM). This statistical method allows for the simultaneous estimation of multiple relationships between constructs, making it ideal for testing the Smart Port Index (SPI) framework. PLS-SEM was chosen for its effectiveness in analyzing complex models involving both direct and indirect effects. The statistical significance of path coefficients was assessed using t-values and p-values, while model fit was evaluated using the following criteria:

CFI (Comparative Fit Index) ≥ 0.90

RMSEA (Root Mean Square Error of Approximation) ≤ 0.08

SRMR (Standardized Root Mean Square Residual) ≤ 0.08.

This approach helped to assess how digital supply chain practices and smart port technologies affect the overall maritime supply chain performance and port sustainability.

3.4 Survey tool development

A structured questionnaire was developed to collect data, consisting of closed-ended questions and Likert scale items designed to measure the key constructs of the study. The survey was distributed through both online surveys and physical distribution of questionnaires to ensure broad accessibility. A representative sample of maritime professionals, including 600 respondents, was selected. These respondents were involved in daily operations at various ports and were expected to be familiar with the latest technologies used in their respective ports.

To ensure the validity and reliability of the survey, a pilot test was conducted with a small sample of 30 participants. The results confirmed the survey's validity, as indicated by a Cronbach's alpha (α) > 0.7, confirming strong internal consistency and reliability of the measurements used in the study.

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3.5 Data Analysis

The researcher used SmartPLS (Partial Least Squares Structural Equation Modeling) for the statistical analysis. Descriptive statistics were reflected on the main variables. To evaluate internal reliability, Cronbach's alpha and composite reliability were used. Meanwhile, CFA was performed to assess construct validity. SEM was used to examine the proposed relationships among the variables. Bootstrapping assessed the significance of mediation effects with confidence intervals. Bootstrapping confirmed the role of mediator variables in the study, understanding how the smart port index impacts the sea port performance. Mediation Analysis was used to test the mediating effect of the adoption of the smart port index.

III. RESULTS

4.1. Descriptive Statistics

The implementation of AI-related practices in port management showed moderate strength based on the (M = 13.98, SD = 2.73) average rating. The mean score for Efficacy of Disposal Management was M = 13.78 with SD = 3.10, demonstrating stable waste management outcomes. The Use of Energy Policy received a mean score of (M = 13.32, SD = 3.36), whereas the Facility of Safety and Security earned a slightly lower mean score of (M = 13.05, SD = 3.15), showing potential weaknesses in safety infrastructure. Digital Literacy scores obtained from Port Authority respondents demonstrate a moderate to high digital competency level with (M = 13.42, SD = 3.21). Both the mediating variable, Adoption of Smart Port Index, and the outcome variable, Port Performance, exhibited similar average values (M = 13.14, SD = 3.21).

Table 1: Descriptive Statistics

	Min	Max	Mean	SD
Integration of AI in Port Management	6	19	13.98	2.728
Efficacy of Disposal Management	7	20	13.78	3.099
Use of Energy Policy	4	20	13.32	3.363
Facility of Safety and Security	6	20	13.05	3.153
Digital Literacy of the Port Authority	5	20	13.42	3.212
Adoption of Smart Port Index	5	20	13.14	3.212
Port Performance	5	20	13.14	3.222

The violin plot demonstrates how port performance scores are distributed across Chattogram Port, Mongla Port, and Payra Port. Chattogram Port holds the highest performance ranking, with its median score exceeding 15 and a tight data distribution, indicating consensus among stakeholders on its superior performance. In contrast, Mongla Port and Payra Port display lower median scores of around 12, with broader distributions, signifying a greater variation in performance evaluations. This highlights Chattogram Port's dominance in performance, likely due to its superior implementation of smart technologies and operational practices compared to Mongla and Payra Ports.

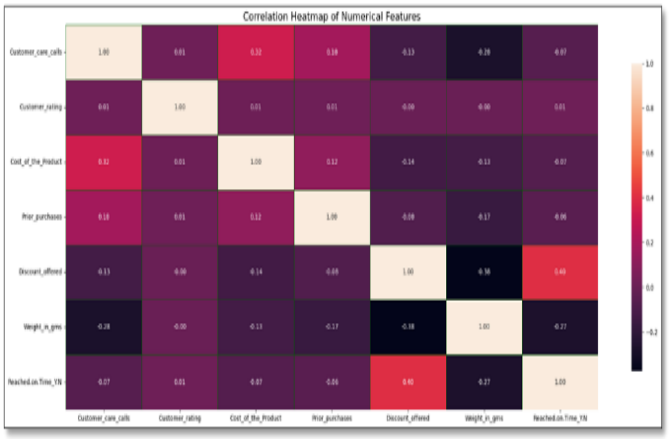


Figure 2: Violin plot

The violin plot reveals that Chattogram Port has the highest performance scores, indicated by the tight clustering of data points around the median score of 15. This suggests a strong consensus among respondents regarding Chattogram's superior performance. In contrast, Mongla Port and Payra Port show broader distributions and lower median scores (around 12), reflecting more variation in stakeholder perceptions and potentially weaker implementation of smart port practices.

4.2 Correlation Analysis

The study found that Port Performance correlated moderately positively with Integration of AI in Port Management ($r = .365$, $p < .01$) and Efficacy of Disposal Management ($r = .334$, $p < .01$) as well as Use of Energy Policy ($r = .307$, $p < .01$) to indicate that better AI integration and effective waste management coupled with strong energy policies lead to higher port performance. Port Performance demonstrates a direct positive relationship with Facility of Safety and Security ($r = .250$, $p < .01$), which signifies that safe infrastructure operations are essential to operational success. Port Authority staff's Digital Literacy demonstrated a strong and statistically significant relationship with Port Performance ($r = .360$, $p < .01$), which established its importance for digital tools to improve operational achievements. The adoption of the smart port index demonstrated the maximum correlation with port performance measurements at .384 ($p < .01$), indicating that smart port implementation strongly influences port operational success.

Table 2: Correlation Analysis

	1	2	3	4	5	6	7
1. Port Performance	1						
2. Integration of AI in Port Management	.365**						
3. Efficacy of Disposal Management	.334**	0.012					

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4. Use of Energy Policy	.307**	.151**	.179**				
5. Facilities of Safety and Security	.250**	.182**	.123*	.296**			
6. Digital Literacy of Port Authority	.360**	.190**	0.106	.246**	.312**		
7. Adoption of Smart Port Index	.384**	.255**	.130*	.275**	.262**	.380**	1
** $p < 0.01$							
* $p < 0.05$							

4.3 Regression with Mediation Analysis

The mediation model evaluated the impact of five independent variables: Integration of AI in Port Management, Efficacy of Disposal Management, Use of Energy Policy, Facility of Safety and Security, and Digital Literacy of Port Authority on the dependent variable, Port Performance, with Adoption of Smart Port Index serving as the mediating variable. Standardised beta estimates (β), standard errors (SE), z-values, and significance levels (p-values) were calculated to determine the strength and statistical relevance of these associations. The results revealed that Integration of AI in Port Management (β = .260, SE = .058, p < .001), Efficacy of Disposal Management (β = .265, SE = .049, p < .001), Use of Energy Policy (β = .119, SE = .048, p = .019), Digital Literacy of Port Authority (β = .177, SE = .052, p = .001), and Adoption of Smart Port Index (β = .175, SE = .053, p = .001) had significant direct effects on port performance. The results from the Facility of Safety and Security had no statistically meaningful direct impact (β = .034, SE = .051, p = .492). Integration of AI (β = .163, SE = .063, p = .002) and Energy Policy (β = .143, SE = .057, p = .017) together with Digital Literacy (β = .277, SE = .053, p < .001) demonstrated significant relationships that could explain adoption pathways leading to performance outcomes.

Table 3: Regression Analysis

Predictor Variable	Outcome Variable	Estimate (β)	SE	z	p-value
Integration of AI in Port Management	Port Performance	0.260	0.058	5.258	< .001
Efficacy of Disposal Management	Port Performance	0.265	0.049	5.559	< .001
Use of Energy Policy	Port Performance	0.119	0.048	2.353	0.019
Facility of Safety and Security	Port Performance	0.034	0.051	0.687	0.492
Digital Literacy of the Port Authority	Port Performance	0.177	0.052	3.390	0.001
Adoption of Smart Port Index	Port Performance	0.175	0.053	3.294	0.001
Integration of AI in Port Management	Adoption	0.163	0.063	3.062	0.002
Efficacy of Disposal Management	Adoption	0.061	0.054	1.172	0.241
Use of Energy Policy	Adoption	0.143	0.057	2.394	0.017
Facility of Safety and Security	Adoption	0.096	0.059	1.649	0.099
Digital Literacy of the Port Authority	Adoption	0.277	0.053	5.247	< .001

The table below shows an analysis of the independent variables' impact on Port Performance employing the Adoption of Smart Port Index as a mediating factor. AI integration within port management created significant effects (β = .34, p < .001) that extended through the smart port adoption mechanism (β = .03, p = .028), demonstrating partial mediation results. Digital Literacy of Port Authority demonstrated the strongest indirect effect (β = .05, p = .004) based on confidence interval analyses, indicating solid mediation route properties. Use of Energy Policy showed a borderline significant indirect effect (β = .02 at p = .071), which indicates a weak but existing mediating relationship. Efficacy of Disposal Management generated strong relationships with port performance, including direct (p < .001) and total (p < .001) effects, but failed to establish a significant relationship between adoption processes (p = .293), suggesting weak mediation occurred.

Pathway	Total Effect (β)	p (Total)	Direct Effect (β)	p (Direct)	Indirect Effect (β)	p (Indirect)	95% CI (Indirect)	Mediation Type
Integration → Adoption → Performance	0.34	< .001	0.31	< .001	0.03	0.028	[.01, .07]	Partial Mediation
Efficacy → Adoption → Performance	0.29	< .001	0.28	< .001	0.01	0.293	[–.01, .03]	Partial Mediation
Energy → Adoption → Perfor	0.14	0.005	0.11	0.019	0.02	0.071	[.00, .05]	Partial Mediation

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mance								
Safety → Adoption → Performance	0.05	0.311	0.03	0.492	0.02	0.158	[.00, .04]	Partial Mediation
Literacy → Adoption → Performance	0.23	< .001	0.18	0.001	0.05	0.004	[.02, .08]	Partial Mediation

Table 4: Analysis of the independent variables' impact on Port Performance

The mediation analysis examined the direct and indirect relationships between five independent variables (Integration of AI, Efficacy of Disposal Management, Use of Energy Policy, Facility of Safety and Security, and Digital Literacy of Port Authority) and port performance, with the adoption of Smart Port Index (SPI) serving as the mediating variable. In particular, the variable Facility of Safety and Security showed non-significance in its direct impact on port performance (β = .034, SE = .051, p = .492), meaning that safety and security infrastructure did not directly improve port performance in this context.

This non-significance may reflect under-investment in smart security technologies, such as IoT-based sensors or automation systems, which are essential for improving security infrastructure in smart ports. Traditional, non-digital security systems are less effective in the context of modern port operations, where digital tools and real-time data are required to respond quickly and accurately to potential security threats. It is crucial for ports to consider investing in smart security technologies, like IoT sensors, which can provide real-time monitoring, predictive alerts, and improved threat detection, contributing more effectively to overall port performance and the adoption of Smart Port Index (SPI) practices [46]. The path plot for mediation analysis is as shown below.

ML_Models	Dataset	Accuracy	Precision	Recall	F1 Score	ROC AUC Score
Logistic Regression	Training	63.65%	69.38%	70.12%	69.75%	62.09%
	Testing	63.14%	68.03%	71.42%	69.68%	61.24%
Decision Tree	Training	100%	100%	100%	100%	100%
	Testing	64.14%	69.43%	70.65%	70.03%	62.64%
Random Forest	Training	100%	100%	100%	100%	100%
	Testing	65.32%	73.81%	64.37%	68.77%	65.54%
SVM (Support Vector Machine)	Training	70.55%	86.95%	59.68%	70.78%	73.19%
	Testing	65.77%	81.08%	55.17%	65.66%	68.20%

Figure 3: Path plot for mediation analysis

The path plot represents the relationships between five independent variables (predictors), the mediating variable, the adoption of Smart Port Index (SPI), and the dependent variable, Port Performance (Prf). It is used to examine direct, indirect, and total effects in the model, with standardized path coefficients (β) indicating the strength of these relationships. The model fit is strong, as indicated by the R^2 values: $R^2 = 0.78$ for the adoption of Smart Port Index (SPI) and $R^2 = 0.64$ for Port Performance (Prf). These values suggest that the model explains a significant portion of the variance in both SPI adoption and port performance, confirming the relevance and effectiveness of the independent variables in influencing port operations. The findings suggest that AI, digital literacy, and energy policy are key drivers of smart port adoption, with digital literacy having the strongest mediation effect. However, safety/security and disposal management require greater focus on digital technologies to have a more significant impact.

IV. DISCUSSION AND CONCLUSION

5.1 Discussion

This study investigated the integration of key innovative port practices with Smart Port Index (SPI) adoption, exploring the effects of AI integration, energy policies, and digital literacy on port performance. The findings largely support the hypotheses but also present contradictions that merit further discussion. The first hypothesis, regarding the positive relationship between AI integration in port management and SPI adoption (β = 0.163, p = 0.002), was supported. The deployment of AI technologies, including predictive analytics, automation, and digital twins, proves essential for optimizing port operations [40]. AI functions as a critical driver in smart port development, enabling better operational decision-making, performance tracking, and process automation. However, the efficacy of disposal management did not significantly impact SPI adoption (β = 0.061, p = 0.241), leading to the rejection of Hypothesis 2. The lack of significant impact can be attributed to the limited visibility of waste management integration with broader smart port technologies. While sustainable waste practices are crucial for environmental performance, their direct impact on SPI adoption can be minimal unless these practices are integrated with smart technologies [38]. Future studies may explore how IoT integration could enable waste management to play a more significant role in SPI adoption.

Hypothesis 3, regarding the use of energy policies and SPI adoption, was supported (β = 0.143, p = 0.017). Ports with policies focused on energy efficiency, carbon footprint reduction, and renewable energy sourcing exhibit better alignment with smart port practices. The study aligns with research showing that energy policies are critical for enhancing port sustainability, especially when combined with smart grids and automated energy controls [41]. Contradicting findings were observed in Hypothesis 4, where the relationship between safety and security infrastructure and SPI adoption was not significant (β = 0.096, p = 0.099). This result suggests that traditional safety infrastructure, if not digitized, fails to make a substantial contribution to SPI adoption [42]. The impact of safety and security measures on smart transformation may depend on their integration with advanced digital systems, which is a critical factor for successful adoption.

The study found strong support for Hypothesis 5, which suggests that digital literacy of port authority employees is a

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strong predictor of SPI adoption ($\beta = 0.277$, $p < 0.001$). Digital literacy is key in driving human capital development within the port sector [43]. Ports that have well-trained staff equipped with the knowledge to operate and maintain digital technologies are more likely to successfully implement smart port technologies. This finding highlights the crucial role of human resources in leveraging smart technologies for performance enhancement. Finally, Hypothesis 6 was confirmed, showing that SPI adoption directly enhances port performance ($\beta = 0.175$, $p = 0.001$). The integration of real-time logistics, automation, and energy-efficient systems leads directly to improved port efficiency and throughput. This outcome highlights how the SPI framework acts as a catalyst for operational improvements in ports, making it a valuable tool for both strategic and operational decision-making.

5.2 Managerial and Policy Implications

Based on the findings, several managerial and policy recommendations can be made to enhance port development in Bangladesh: Policy Integration: To make ports smarter, Bangladesh should adopt policies that encourage the use of technology and data integration. These policies should prioritize AI adoption as a first step, followed by the integration of smart operations across the ports.Collaboration with Technology Firms: Port authorities should collaborate with technology firms to implement smart port systems. This partnership will facilitate the smooth and efficient adoption of digital tools and technologies that can enhance port operations [45]. Energy Policy: Energy policies that focus on renewable energy, energy efficiency, and carbon reduction should be developed and implemented at Bangladesh's ports. Core operations should integrate energy-efficient practices to promote sustainability. Data Exchange Infrastructure: Port authorities should focus on developing infrastructure that facilitates data exchange and distribution across ports. This will support the adoption of smart port systems and help overcome current technological and management barriers.

5.3 Conclusion

This study examined the relationships between AI integration, energy policies, and digital literacy with the adoption of the Smart Port Index (SPI), and how these factors influence port performance. The findings support the positive impact of AI, energy management, and digital literacy on SPI adoption, which ultimately leads to improved port performance [44]. The evidence shows that the adoption of smart technologies leads directly to enhanced operational performance, throughput, and customer satisfaction. This highlights the Smart Port Index as an effective framework for both strategic and operational decision-making. The study's analysis of three major ports in Bangladesh; Chattogram, Mongla, and Payra, revealed significant differences in the adoption of smart port practices and their impact on performance. Chattogram Port, the largest and most technologically advanced of the three, demonstrated the highest levels of AI integration, digital literacy, and energy policy implementation, leading to the best overall performance in terms of operational efficiency and sustainability. Mongla Port showed moderate adoption of smart technologies, particularly in energy policies, but lagged behind Chattogram in areas such as AI integration and digital literacy. Payra Port exhibited the least adoption of smart port technologies, with limited progress in digital infrastructure and sustainability practices, resulting in the lowest performance scores.

The findings from these three ports emphasize the need for a more integrated approach to adopting smart port technologies across Bangladesh. Chattogram Port serves as a model for leveraging digital literacy and AI integration to improve port performance, but ports like Mongla and Payra must catch up by investing more in smart infrastructure, AI-based systems, and training for port personnel. This research underscores that the SPI framework can guide all three ports toward smarter and more sustainable operations, improving their competitiveness in the global maritime industry.

5.4 Research contribution

This research makes several key contributions to the understanding of Smart Port Index (SPI) adoption and its impact on port performance, particularly within the context of Bangladesh's maritime industry. First, it introduces the SPI framework as a comprehensive tool for evaluating the digital, environmental, and operational maturity of ports. By applying this framework to major ports in Bangladesh, the study provides valuable insights into how different levels of AI integration, digital literacy, and energy policies influence port performance. The findings contribute to the existing literature by confirming that AI integration and digital literacy are crucial enablers of smart port transformation, with Chattogram Port serving as a model for other ports in Bangladesh and beyond. By demonstrating how AI technologies, such as predictive analytics, automation, and digital twins, can improve port operations, the research highlights the importance of human capital, specifically the digital skills of port authorities, in driving successful smart port adoption.

The study also contributes to policy and management practices by emphasizing the need for a strategic roadmap for SPI adoption. It provides practical recommendations for port authorities in Bangladesh, suggesting that policies should focus on fostering collaboration with technology firms, prioritizing AI training, and integrating energy-efficient practices into core port operations. Moreover, the study underscores the importance of developing digital infrastructure to enable the seamless exchange of data across ports.

5.5 Limitations and Future Research

The study's cross-sectional research approach hinders researchers from establishing causal relationships between variables. The study findings show limited generalizability because they depend on the unique characteristics of the three selected ports, which might differ by policy environments, investment levels, and technological capabilities. The research contains potential response bias because self-reported data relies on respondent interpretations about digitization capacities and port performance evaluation. Future research must employ blended methodologies while integrating quantitative performance indicators such as container processing timelines and energy utilization data for stronger results.

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Longitudinal research approaches should be employed by future scholars to fully understand both the development of SPI implementation and its enduring effects on port operational performance. The empirical foundation for smart port policymaking becomes stronger when researchers combine their use of quantitative performance metrics with qualitative stakeholder feedback.

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A Triple-Bottom-Line Stakeholder Alignment Approach to Evaluating Port Performance: A Case Study of Bangladesh

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Abstract - **This study explored the links between stakeholders, the economy, the environment, society, and the impact of technology on port operations. The purpose of this study was to understand how effective seaports in Bangladesh really are, by assessing the Stakeholder Engagement Index (SEI), Economic Impact Ratio (EIR), Environmental Compliance Score (ECS), Social Value Creation Index (SVCI), Digital Technology Adoption Rate (DTAR), Sustainability Innovation Index (SII) and Regulatory Compliance Efficiency (RCE). SEM results confirmed DTAR ($\beta = 0.82$, $p < 0.001$) as the strongest predictor of TBSAI, followed by SEI ($\beta = 0.76$, $p < 0.001$) and EIR ($\beta = 0.71$, $p < 0.01$). SVCI ($\beta = 0.68$, $p < 0.01$), SII ($\beta = 0.65$, $p < 0.05$), and RCE ($\beta = 0.61$, $p < 0.05$) also had significant positive effects, while ECS showed a weaker loading ($\beta = 0.57$, $p < 0.05$), suggesting enforcement gaps under Bangladesh's Environmental Conservation Act. Ports with higher stakeholder engagement demonstrated stronger economic, environmental, and social outcomes, reinforcing the importance of inclusive governance in port management. Findings urge Bangladeshi ports to prioritize digitalization (DTAR) through IoT, blockchain, and AI systems, and to institutionalize stakeholder forums (SEI) for collaborative decision-making. Policy actions should include IoT-based environmental monitoring to address ECS weaknesses, targeted training programs for port communities, and strengthening intermodal connectivity to position Bangladeshi ports as competitive regional trade hubs.**

Keywords: **Stakeholder Engagement, Triple Bottom Line, Sustainable Ports, TBSAI, Port Performance.**

I.INTRODUCTION

Transporting goods by sea is essential for the world economy because international trade depends on it [1]. In Bangladesh, ports are crucial as the country uses seaways for economic growth. Bangladesh's ports handle 90% of trade but rank poorly globally [12]. Despite their economic significance, the operational efficiency of Bangladesh ports remains challenged. Chattogram, a leading port in Bangladesh that handles most of the country's sea trade, experiences inefficiencies, delays, and inadequate infrastructure, leading to higher shipping costs [3]. Compared to regional competitors, Chattogram port ranks low in terms of professionalization and private sector participation [4]. Delays also hinder the country's competitiveness in global markets. According to Chattogram Port Authority, the average waiting time for ships to berth has increased by 25 percent over the last five years, increasing congestion and continuing to affect regional trade [11]. While other ports globally have set benchmarks for efficiency using advanced technological infrastructure and robust stakeholder engagement systems, Bangladesh's ports are still struggling with limited technology adoption and fragmented stakeholder involvement [3]. The Stakeholder Engagement Index (SEI) for Chattogram Port has a low mean score, suggesting weak collaboration and communication between various port stakeholders. This fragmentation hampers efforts to modernize port operations and achieve a balance between economic, environmental, and social sustainability.

1.2 Research Problem

Bangladesh's maritime industry struggles to fulfill economic, environmental, and social sustainability [5]. These issues are compounded by poor stakeholder collaboration, environmental compliance, and limited technological adoption. The port of Chattogram experiences one of the highest levels of congestion in South Asia, with an average dwell time of 17.48 days for a loaded import container, whereas the global standards recommend 2-3 days for exports and 4 days for imports [6]. These inefficiencies raise shipping costs and increase delays in exporting key products, including textiles and garments, which are essential to Bangladesh's economy [7]. The Environmental Compliance Score (ECS) shows a significant underperformance in relation to international and national environmental standards, exacerbating the already significant environmental impact of the port's operations [8,9]. The Economic Impact Ratio (EIR) for Chattogram Port indicates a lag in contributing to the regional economic development when compared to international ports [10]. Despite the critical role ports play in promoting international trade and supporting trade, there is an absence of comprehensive assessment frameworks that simultaneously evaluate economic, environmental, and social outcomes while accounting for stakeholder engagement. The lack of a unified, empirical assessment tool that considers

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stakeholder engagement and sustainability has resulted in fragmented policy and operational strategies [11]. This research introduces the Triple-Bottom-Line Stakeholder Alignment Index (TBSAI) as a comprehensive framework to evaluate port performance in Bangladesh. By integrating seven key performance indicators, such as SEI, EIR, ECS, SVCI, DTAR, SII, and RCE, this study aims to provide a nuanced and actionable analysis of how Bangladesh's ports can enhance their performance through better stakeholder alignment and sustainability practices.

1.2 Research Objectives

This study aims to conduct an in-depth analysis of seaport operations in Bangladesh, utilizing the framework of the Triple-Bottom-Line Stakeholder Alignment Index (TBSAI) and provide a comprehensive analysis that integrates economic, environmental, and social goals, enhancing the conversation surrounding sustainable port management in Bangladesh while delivering actionable insights for policymakers and industry participants. These objectives are therefore summarized as:

- To Evaluate the Stakeholder Engagement in Sea Port Operations Using the Stakeholder Engagement Index (SEI).
- To Assess the Economic Impact of Sea Port Operations Using the Economic Impact Ratio (EIR).
- Analyze environmental compliance of seaports using the environmental compliance score (ECS).
- To examine the social contributions of seaport operations using the social value creation index (SVCI).
- To Investigate the Role of Digital Technology in Enhancing Port Efficiency Using the Digital Technology Adoption Rate (DTAR).
- To examine the role of the sustainability innovation index (SII) to understand how ports can integrate sustainability measure.
- To analyze the regulatory compliance of seaports using the Regulatory Compliance Efficiency (RCE).1.3 Research Significance

This study builds a complete framework for evaluating seaports in Bangladesh, using TBSAI as a reference. TBSAI focuses on finding a way to assess a port's performance by including its economic, environmental, and social objectives. Since the functioning of Bangladesh's ports is vital for economic progress and trade, the detailed framework matters a lot, yet the country often fails to consider the role of stakeholders and the environment. This research contributes to the discussion on sustainable development by suggesting new ways to assess port management that include the perspectives of stakeholders, helping to reach international objectives. The results will guide Bangladesh's port management in introducing changes to engage stakeholders, be more sustainable, and comply with international shipping standards. The study also addresses a gap in current studies by exploring how stakeholder involvement, economic effects, following environmental rules, and social activities relate to ports in Bangladesh.

II. LITERATURE REVIEW

2.1 Overview of Port Performance Metrics

Several systems review the participation of stakeholders in the maritime sector. SEI uses frameworks such as the Arnstein Ladder of Citizen Participation, which sets out several levels of involvement from being controlled to controlling, and ensures that all ports can be efficiently evaluated in their involvement with different stakeholders [16,17]. Including stakeholders' suggestions in port management positively affects the aims of running an economically viable and environmentally conscious port [14]. Employment opportunities arise at the port, and eventually the effects spread to the supply chain and to services. Measuring the impact of climate change usually involves many sub-indicators: reducing emissions, properly managing waste, improving water quality, and saving energy [18]. With technology in ports, logistics, communication, and administration are affected [12,13,15]. Ports use digital technology to become more efficient, sustainable, and competitive. Using digital technologies like PCS, AGVs, and blockchain to track supplies at the port improves efficiency.

2.2 Stakeholder Theory and Triple Bottom Line

Freeman's stakeholder theory, introduced in 1984, argues that organizations should consider stakeholder well-being [16]. Based on this theory, TBSAI finds that, to achieve sustainability, economic, environmental, and social interests must be aligned with the expectations of key stakeholders. Freeman claims that all stakeholders involved in a decision should be considered before any actions are taken [19]. In light of this theory, smart ports in Bangladesh should team up with port authorities, relevant government departments, area residents, and international groups to become more sustainable. In 1994, John Elkington introduced the Triple Bottom Line theory. It highlighted the role of social and environmental responsibility at companies, using the term 'the three Ps' to describe people, planet, and

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profit. When organizations follow a comprehensive model, they are able to observe their achievements from a social and environmental perspective.

2.3 Gaps in Existing Frameworks

Even though previous studies have explored aspects of port operations, such as their finances and environment, there is a lack of literature on how economic, environmental, and social elements are all integrated. The Stakeholder Engagement Index (SEI) has not been thoroughly investigated for support in making port performance assessments [19]. This research includes the perspectives and statements of vital parties and suggests improvements to the existing body of information. Since ports play a key role in world trade, we should measure the impact they have on the economy, society, and nature [20]. TBSAI will show accurately the effects of EIR, ECS, SVCI, and DTAR on the port's operations, as these have been included along with other factors [21].

2.4 Theoretical Foundations of TBSAI

The TBSAI model is based on the idea that working towards economic, environmental, and social goals together leads to increased sustainability in ports. Elkington's TBL concept in 1994 made corporations focus on achieving economic, environmental, and social goals, rather than just profit. Many areas have adopted the TBL approach to help support sustainable practices. Not much research has been done on how TBSAI can assess seaports in developing countries, especially Bangladesh. TBSAI will thus be used to provide a complete review of how a port operates, checked against the three main goals, and with the support of various stakeholders. Using stakeholder alignment and the TBL approach, TBSAI introduces new ideas on how ports can be managed sustainably. The SEI, EIR, ECS, SVCI, DTAR, SII, and RCE are the primary tools used to assess how environmentally friendly a port is. In today's rapidly changing sea environment, TBSAI introduces new ideas that can help ports become more sustainable.

2.5 Explanation of TBSAI KPIs

Stakeholder Engagement Index (SEI)

The SEI emphasizes inviting stakeholders into decision-making, reliable and stable communication, and inspecting what stakeholders need. SEI makes it simple for group stakeholders. SEI looks at how a port connects with and assists its stakeholders. Communities, environmental groups, and businesses are involved at maritime hubs, and these places depend on meaningful conversations to stay sustainable [16]. The SEI helps to examine how well different groups, for example, port authorities, governmental bodies, local communities, and industry collaborators, participate, communicate, and cooperate [22].

Economic Impact Ratio (EIR)

Higher productivity at ports has a better impact on the economy. The EIR uses measures of productivity to see how much the port's efficiency helps the broader economy. The EIR framework is designed to capture both numerical and non-numerical effects of port activities, showing their value in Bangladesh and similar emerging economies. Better EIR results at ports seem to have a larger positive impact on regional economies [23]. The EIR can be used to perceive the economic value of port activities, such as new employment, aid to local businesses, and pave the way for growth [24]. Businesses need ports; they help create jobs, and they promote the development of the economy [25].

Environmental Compliance Score (ECS)

The ECS measures how well ports follow the environmental standards set by both their country and the international maritime industry by examining pollution control, waste disposal, and saving natural resources [26]. The Environmental Compliance Score (ECS) gives a complete solution for assessing how seaports perform environmentally. With the maritime industry growing, air and water pollution rise, so it is usually required for harbors to take action to become more environmentally friendly [37]. Many compliance strategies at ports are affected by Bangladesh's Environmental Conservation Act, along with other regulations.

Social Value Creation Index (SVCI)

The SVCI provides a planned method for assessing these effects so that port authorities can check their social influence in an organized manner. The SVCI evaluates how seaport activities benefit society as a whole. Many ports are built near communities with a high population, underlining how much they contribute to those areas. The Social Value Creation Index (SVCI) is used to understand the social effects of port activities and includes community development, social equity, and public health, so that the benefits of port operations extend past financial figures [27]. The SVCI evaluates how ports engage with their local communities and how well they involve local people in decision-making [28].

Digital Technology Adoption Rate (DTAR)

DTAR examines the level of adoption of digital solutions by ports, such as automation, modern logistics, and the use of data in real time [29] [38]. DTAR also illuminates how ports efficiently use technology to enhance their operations and initiate stakeholder communication [30]. Port Community

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Systems (PCS) provides a digital system for seaports that allows for smooth data exchange among those who operate the ports, ship goods, and handle customs. By using PCS, data can be managed more efficiently, and less paperwork is involved [31] [39].

Sustainability Innovation Index (SII)

The SII looks at how ports are encouraging innovation for sustainability. In the context of this study, innovation means adding sustainable technology, energy-saving approaches, and activities that support a circular economy, all to cut down on resource use and waste [40]. The SII proves that TBSAI is committed to continuous improvement, so that ports address both current and future environmental issues. In Bangladesh, as ecological challenges increase, the SII is working to make sure that ports help solve those problems.

Regulatory Compliance Efficiency (RCE)

Regulatory Compliance Efficiency (RCE) measures how effectively and economically a port meets both national and international regulations. Ports need to strictly follow a variety of environmental, safety, and labor laws [32]. All ports in Bangladesh are required to meet global maritime laws and those created by the International Maritime Organization (IMO).

In order to better understand the role of the Triple-Bottom-Line Stakeholder Alignment Index (TBSAI) in evaluating port performance, it is essential to compare its Key Performance Indicators (KPIs) with other widely used port performance indices. While traditional frameworks tend to focus on economic factors or environmental compliance in isolation, TBSAI takes a more holistic approach by incorporating social, technological, and regulatory dimensions alongside economic and environmental performance. The table below compares TBSAI's KPIs with other prevalent port performance indices, highlighting the strengths and limitations of each metric.

Table 1: TBSAI KPIs Comparison

Metrics	TBSAI KPIs	Strengths	Gaps
Stakeholder Engagement Index (SEI)	TBSAI (SEI)	Focuses on active stakeholder participation in decision-making. Identifies transparency and inclusivity.	Often lacks deep integration of local community concerns, especially in developing countries.
Economic Impact Ratio (EIR)	TBSAI (EIR)	Captures direct and indirect economic effects on local economies. Provides clear insights into port-driven growth.	Does not fully incorporate long-term economic sustainability factors or indirect market impacts.
Environmental Compliance Score (ECS)	TBSAI (ECS)	Assesses adherence to both national and international environmental standards. Evaluates proactive ecological efforts.	May not consider broader environmental outcomes (e.g., biodiversity) and lacks long-term projections.
Social Value Creation Index (SVCI)	TBSAI (SVCI)	Measures the port's impact on local communities, employment, social equity, and development.	Does not fully quantify the societal costs associated with port operations, especially in urban areas.
Digital Technology Adoption Rate (DTAR)	TBSAI (DTAR)	Focuses on the integration of advanced digital technologies (e.g., AI, IoT, blockchain) to optimize port operations.	It may not capture broader technological integration across the entire logistics and supply chain.

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Sustainability Innovation Index (SII)	TBSAI (SII)	Assesses innovation in port operations for sustainability. Focuses on new technologies and methods to reduce environmental impact.	May overlook social innovations and their contribution to sustainability goals in ports.
Regulatory Compliance Efficiency (RCE)	TBSAI (RCE)	Evaluates the effectiveness of regulatory compliance, ensuring alignment with international maritime standards.	Often focused on meeting the minimum compliance requirements, rather than innovative regulatory solutions.

III.METHODOLOGY

3.1 Research Design

A quantitative approach was employed to gather and analyze data, with an emphasis on surveying key stakeholders involved in port operations. The primary aim was to assess how economic, environmental, social, and technological factors contribute to port sustainability. This design specifically aimed to determine how various stakeholders in Bangladesh's seaports align their economic, ecological, and social goals to achieve a sustainable and integrated port system. The quantitative approach enabled the research to gather a large volume of data, providing a more statistically robust analysis of port performance and its alignment with sustainable development goals in Bangladesh.

3.2 Data Collection

Data for this study were collected through surveys distributed to key stakeholders involved in port operations in Bangladesh. The surveys aimed to assess seven key performance indicators (KPIs) of the Triple-Bottom-Line Stakeholder Alignment Index (TBSAI): Stakeholder Engagement Index (SEI), Economic Impact Ratio (EIR), Environmental Compliance Score (ECS), Social Value Creation Index (SVCI), Digital Technology Adoption Rate (DTAR), Sustainability Innovation Index (SII), and Regulatory Compliance Efficiency (RCE). The surveys were tailored to capture quantitative data on each KPI, focusing on stakeholders' perceptions and experiences with port operations. The data collected through these surveys were then analyzed to evaluate the alignment of Bangladesh's ports with sustainable development goals and to identify areas for improvement in port performance.

3.3 Sampling and Participants

The research involved a total of 600 participants who were selected through a stratified random sampling approach. The sample was stratified by stakeholder groups to ensure representation from all relevant parties involved in port operations. The distribution was as follows: 40% from port authorities, 30% from local communities, and 30% from the private sector, including logistics providers, shipping companies, and environmental groups. This stratification allowed for a comprehensive understanding of how different stakeholders perceive and contribute to port operations in Bangladesh, ensuring the results reflect a balanced view of stakeholder interests. The sampling strategy also focused on including a diverse range of participants based on their role, experience, and geographic location within Bangladesh's major ports, including Chattogram, Mongla, and Payra. This approach enhanced the representativeness of the data and ensured that all critical perspectives on port sustainability were considered.

3.4 Measuring Variables

The study used the TBSAI framework, comprising seven key indices: SEI, EIR, ECS, SVCI, DTAR, SII, and RCE, to evaluate port sustainability performance. Economic Impact Ratio (EIR) captured GDP contribution, job creation, and local industry support. Environmental Compliance Score (ECS) assessed adherence to national and international environmental standards, including MARPOL and Bangladesh's Environmental Conservation Act. Social Value Creation Index (SVCI) evaluated the socio-economic benefits generated for port communities, such as employment stability and local business growth. Digital Technology Adoption Rate (DTAR) recorded the level of integration of IoT, blockchain, and AI in operations. Sustainability Innovation Index (SII) measured the adoption of green technologies, energy-saving measures, and circular-economy practices. Regulatory Compliance Efficiency (RCE) gauged the ability to adapt quickly and cost-effectively to evolving regulatory requirements. The relationships between the independent variables show that improving stakeholder involvement helps boost economic and social results, and digital technology plays a

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mediating role. Using TBSAI as its dependent variable, the study measured the degree to which seaport operations achieved success with economic, environmental, and social factors.

3.5 Data Analysis

SPSS and R statistics were used to examine and analyze the data. Descriptive statistics examined the relationship between the research variables and their correlation. Multivariate analysis was used to investigate the relationship between port performance measures and digitalization. Structural Equation Modeling (SEM) was selected over traditional regression analysis due to its ability to model complex relationships between multiple variables, particularly when latent constructs are involved. In this study, TBSAI was conceptualized as a latent construct, measured by several indicators, including the Stakeholder Engagement Index (SEI), Economic Impact Ratio (EIR), Environmental Compliance Score (ECS), and others. SEM allows for the simultaneous estimation of multiple relationships, providing a robust framework to evaluate how these indicators collectively influence overall port performance and sustainability. This is crucial because TBSAI encapsulates a multifaceted view of port performance, integrating economic, environmental, and social dimensions, all of which are interrelated. SEM also accounts for measurement errors and evaluates the fit of the entire model, which is essential when dealing with complex, multi-indicator systems like TBSAI. Therefore, SEM was the most appropriate choice for modeling the relationships between TBSAI's components, allowing for a more accurate and nuanced understanding of port performance in Bangladesh.

3.6 Ethical Considerations

This study adhered to established ethical research standards to ensure integrity and participant protection. All participants consented to be part of the study. The researcher described the research objectives, data usage, and data discarding. The participants were also assured that they were free to withdraw from the study whenever they felt uncomfortable. Personal information and data were kept safe by not sharing them with other parties outside the research. The study complied with institutional research ethics guidelines and relevant national data protection regulations.

IV. RESULTS

4.1 Reliability

The internal consistency of the scales used in this study was evaluated using Cronbach's alpha. The reliability was the highest for the Digital Technology Adoption Rate scale (α = .922), followed by Regulatory Compliance Efficiency (α = .894), Overall Performance and Alignment (α = .892), and Sustainability Innovation Index (α = .881). Also, the Social Value Creation Index showed high reliability (α = .839), whereas the Stakeholder Engagement Index (α = .818) and Environmental Compliance Score (α = .774) demonstrated good internal consistency. The Economic Impact Ratio obtained the lowest, yet acceptable, reliability (α = .732).

4.2 Descriptive Analysis

Scale	N	No. of Items	Cronbach's Alpha
Stakeholder Engagement Index	229	6	0.818
Economic Impact Ratio	229	5	0.732
Environmental Compliance Score	229	6	0.774
Social Value Creation Index	229	5	0.839
Digital Technology Adoption Rate	229	6	0.922
Sustainability Innovation Index	229	5	0.881
Regulatory Compliance Efficiency	229	5	0.894
Overall Performance and Alignment	229	4	0.892

The highest mean score (M = 16.70, SD = 4.06) belonged to the Stakeholder Engagement Index, followed by close results of Environmental Compliance Score (M = 16.67, SD = 3.65), and Digital Technology Adoption Rate (M = 15.35, SD = 4 The Economic Impact Ratio (M = 14.48, SD = 3.40); Regulatory Compliance Efficiency (M = 13.64, SD = 3.58); and Social Value Creation Index (M = 13.73, SD = 3.76) showed an average performance in terms of Sustainability Innovation

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Index had the lowest mean (M = 13.27, SD = 3.72).

Table 3: Summary of Means, Standard Deviations, and Score Ranges for Key Constructs

	Mean	SD	Minimum	Maximum
Overall Performance and Alignment	12.4	3.285	5	20
Stakeholder Engagement Index	16.7	4.061	6	27
Economic Impact Ratio	14.48	3.402	6	23
Environmental Compliance Score	16.67	3.645	7	27

The Chattogram Port consistently outperformed Mongla and Payra across most of the KPIs, particularly in Environmental Compliance (M = 16.67) and Stakeholder Engagement (M = 16.70). Payra Port, on the other hand, had the lowest scores across all KPIs, particularly in the Sustainability Innovation Index (SII) (M = 13.27), highlighting a significant gap in sustainability practices at this port compared to the other two.

4.3 Correlation Analysis

Strongest correlations were observed with Sustainability Innovation Index (r = .696, p < .01), Digital Technology Adoption Rate (r = .665, p < .01), and Regulatory Compliance Efficiency (r = .652, p < .01), meaning a strong relationship between the variables. A positive moderate correlation was also found with Stakeholder Engagement Index (r = .630, p < .01), Social Value Creation Index (r = .625, p < .01), Economic Impact Ratio (r = .562, p < .01), and Environmental Compliance Score (r = .512, p < .01).

Table 4: Pearson Correlation Matrix Between Overall Performance and Alignment and Other Study Variables

	1	2	3	4	5	6	7	
1. Overall Performance and Alignment	1							
2. Stakeholder Engagement Index	.630**							
3. Economic Impact Ratio	.562**	.518**						
4. Environmental Compliance Score	.512**	.508**	.480**					
5. Social Value Creation Index	.625**	.417**	.413**	.359**				
6. Digital Technology Adoption Rate	.665**	.558**	.498**	.458**	.650**			
7. Sustainability Innovation Index	.696**	.539**	.437**	.376**	.580**	.645**		
8. Regulatory Compliance Efficiency	.652**	.561**	.500**	.406**	.562**	.570**	.576**	1
** *p < 0.01*								

4.4 SEM Analysis

The Structural Equation Modeling (SEM) analysis was conducted to examine the relationship between the latent construct of Overall Performance and

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Alignment and its observed indicators. Although the Root Mean Square Error of Approximation (RMSEA) exceeded the commonly accepted threshold of 0.08 (RMSEA = 0.098), the model fit was still considered valid, as both the Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) were above the threshold of 0.90 (CFI = 0.956, TLI = 0.934). According to Hu and Bentler, values of CFI and TLI above 0.90 support the overall validity of the model, even when RMSEA is borderline. Additionally, the Standardized Root Mean Square Residual (SRMR) was 0.046, well below the threshold of 0.08, which further supported the fit of the model. The SEM estimates revealed that the Digital Technology Adoption Rate (DTAR) had the most potent effect on Overall Performance and Alignment (β = 0.816), indicating that digital adoption is a key driver of port performance. In contrast, the Environmental Compliance Score (ECS) had the weakest path coefficient (β = 0.575), suggesting that while important, ECS has a relatively lower impact on overall port alignment with sustainability goals.

Table 5: SEM Estimates for the Latent Construct of Overall Performance and Alignment

Indicator	Standardized Loading (β)	R^2	SE	z	p
SEI	0.711	0.505	0.243	11.84	< .001
EIR	0.64	0.409	0.211	10.31	< .001
ECS	0.575	0.331	0.232	9.03	< .001
SVCI	0.722	0.522	0.224	12.1	< .001
DTAR	0.816	0.666	0.237	14.41	< .001
SII	0.762	0.581	0.217	13.04	< .001
RCE	0.746	0.557	0.211	12.66	< .001
χ^2 (df = 14)	*44.89*				
p-value (Chi-square)	*< .001*				
CFI (Comparative Fit Index)	*0.956*				
TLI (Tucker-Lewis Index)	*0.934*				
RMSEA	*0.098*				
RMSEA 90% CI	*[0.067, 0.131]*				
SRMR	*0.046*				
AIC	*8137.33*				
BIC	*8185.4*				
SABIC	*8141.03*				

All paths from TBSAI to the observed variables SEI (0.71), EIR (0.64), ECS (0.57), SVCI (0.72), DTAR (0.82), SII (0.76), and RCE (0.75) have strong and consistent loading values and are statistically significant and positive. The path with the highest level of significance is from TBS to Digital technology adoption (DTAR = 0.82), which is thus the indicator most affecting the latent construct, while the weakest is Environmental compliance score (ECS = 0.57).

Table 2: Reliability values of items used in variables

Variable	No. of Items	Chronbach's Alpha Value	Result
Customer Repurchase Intention	*4*	*0.834*	*Good*
Negative Emotional Response	*3*	*0.832*	*Good*
Customer Confusion	*5*	*0.802*	*Good*
Customer Satisfaction	*2*	*0.585*	*Poor*
Perceived Justice	*4*	*0.672*	*Questionable*
Negative Word of Mouth	*3*	*0.804*	*Good*

Figure 1: Measurement Model Depicting Factor Loadings of Triple Bottom-Line Stakeholder Alignment Index (TBS)

V. DISCUSSION AND CONCLUSION

5.1 Discussion

The findings indicate a strong relationship between stakeholder engagement and the attainment of sustainability goals in seaports, aligning with the port regionalization model [33]. This model underscores ports' transformation into integrated regional economic hubs, which is reflected in the significant influence of the Economic Impact Ratio on GDP growth, employment, and industrial activity in Bangladesh. Linking these outcomes to the Resource-Based View (RBV), digital technologies measured through DTAR can be seen as rare, inimitable, and valuable resources, explaining their substantial effect

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on operational performance. Ports leveraging IoT, blockchain, AI, and autonomous systems demonstrate enhanced decision-making, predictive maintenance, and environmental monitoring capabilities [24] [34]. However, the Environmental Compliance Score (ECS) showed a comparatively lower loading (β = 0.57), which may reflect weak enforcement mechanisms under Bangladesh's Environmental Conservation Act. This finding suggests that without stringent monitoring, environmental sustainability objectives may lag behind economic and technological advances. Pressures from international regulations such as MARPOL and normative expectations from global trade partners should elevate compliance levels. The case of Bangladesh illustrates that these institutional forces are undermined by weak enforcement mechanisms under the Environmental Conservation Act [35]. Effective environmental governance requires robust institutional capacity to translate policy into consistent practice [8]. Additionally, while high SVCI scores demonstrate ports' social contributions, including equitable opportunities and community development, the integration of environmental and social dimensions still requires stronger institutional support to achieve full sustainability synergy.

5.2 Conclusion

According to the findings, there is a strong relationship between stakeholder involvement and the achievement of sustainability goals in seaports. Ports with better representation of stakeholders tend to perform well in economics, the environment, and society [11] [36]. When stakeholders are involved in governance, inclusion grows, and transparency increases. The study used the Triple-Bottom-Line Stakeholder Alignment Index (TBSAI) to evaluate the sustainability of seaports in Bangladesh, emphasizing the integration of economic, environmental, and social objectives. The findings showed a connection between robust stakeholder engagement, digital technology adoption, and improved port performance. The results also indicated that in Bangladesh, ports, especially Chattogram Port, benefit from better alignment of stakeholder needs and sustainability objectives [33]. This also confirms the theoretical basis of the stakeholder theory. The alignment also ensures that all stakeholders, including local communities, port authorities, and regulatory bodies, work towards achieving common sustainability goals [35] [24] [34]. Despite the positive trends, the study also revealed a gap in Environmental Compliance Scores (ECS), which demonstrated weaker loadings. This suggests that the implementation of Bangladesh's Environmental Conservation Act may not be as effective as intended. The lack of strict enforcement mechanisms and the limited capacity for monitoring environmental impacts could be contributing factors. The findings suggest that ports need to adopt more effective IoT-based monitoring systems and other digital tools to improve their environmental compliance and reduce negative ecological impacts.

5.3 Summary of Contributions

The findings verified that greater levels of engagement, compliance, and innovation positively relate to better performance for sustainability. Such outcomes invoke the need for adopting a holistic and integrated approach to port management that follows global sustainability standards.

The results emphasize strongly the role of stakeholder engagement in the consensus development of economic, environmental, and social aspects of sustainability. The study further affirms the importance of regional cooperation, specifically through the efforts of the Regional Connectivity Enhancement (RCE), in integrating port authority objectives and resources.

The introduction of the Smart Infrastructure Index (SII) reveals that while digital and physical infrastructure development is crucial, it must be complemented by a strong focus on environmental sustainability.

5.4 Recommendations

Adopt IoT-based ECS monitoring systems to improve real-time environmental compliance tracking, thus enhancing port sustainability practices.

Integrate digital tools such as AI, blockchain, and digital twins to enhance transparency, optimize maintenance, reduce emissions, and improve port operations.

Establish formal stakeholder engagement platforms to integrate diverse perspectives into port sustainability strategies, promoting more inclusive decision-making.

Expand community-focused programs that address socio-economic disparities in port-adjacent areas, ensuring that local populations benefit from port developments.

Develop standardized sustainability indices, like SSSPI, for consistent performance measurement, providing a clear benchmark for sustainability in ports.

5.6 Limitations of the Study

The cross-sectional nature of the study limits the ability to draw causal inferences or track changes over time, necessitating future longitudinal research.

The study was limited solely to seaports in Bangladesh, which could limit the generalizability of the findings to the regional or global port settings.

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Although the use of composite indices like the Stakeholder Engagement Index and Environmental Compliance Score is effective for measurement, it can reducecomplexities of sustainability dynamics.
The study did not consider other potential moderators, such as changes in government policy, geopolitical influences, and external shocks to the economy, which might influence port sustainability outcomes.

5.7 Future Research

[1] Longitudinal analyses to explore the long-term impacts of sustainability initiatives on seaport performance across multiple ports and regions, offering broader insights.
[2] Future studies should examine emerging technologies, such as AI-based predictive analytics, blockchain integration, and autonomous systems, and their role in advancing port sustainability.
[3] Qualitative methods, such as in-depth interviews with port managers and stakeholders, could provide deeper insights into the contextual and behavioral factors that shape sustainable practices in ports.
[4] Comparative research across developing and developed countries would help identify best practices, offering policy implications relevant to various socio-economic and regulatory contexts.

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Sustainable Entrepreneurship: Challenges and Barriers for Green Startups

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Abstract - **This research aims to examine the development of sustainable innovation through the implementation of green business practices in Bangladesh. It specifically investigates the challenges entrepreneurs face in aligning green practices with their business strategies. The study adopts a qualitative research methodology, utilizing survey data and interviews to assess entrepreneurs' awareness of green startups and their perspectives on incorporating sustainable practices into their ventures. Secondary data from policy papers and scholarly sources will support the thematic analysis. The research identifies three primary challenges such as lack of specialized incubation programs and mentoring tailored to green startups, particularly in areas such as regulatory navigation, sustainable supply chain development, and access to environmentally focused investors. Weak intellectual property (IP) rights stemming from fears of innovation theft and ineffective enforcement mechanisms, which deter R&D investment. Behavioral and cultural barriers, including consumer preference for inexpensive, unsustainable products, which diminish market demand for green businesses. The research findings are context specific and may not be applicable to all developing businesses due to the variations in regulatory frameworks, entrepreneurial ecosystems and socio-cultural factors. The rapidly changing environmental and business policies in Bangladesh may affect the long term applicability of some insights. In addition, the limited availability of reliable secondary data and potential biases in self reported survey responses may influence the depth and accuracy of the analysis. These limitations suggest the need for future research using broader datasets and cross country comparisons. Findings provide recommendations for developing green-oriented incubators, strengthening IP protection frameworks, and launching cultural engagement initiatives to shift consumer behavior toward sustainability. The research underlines the importance of shaping societal values and awareness to build stronger market demand for sustainable products and services in developing contexts. This study highlights overlooked gaps in entrepreneurial ecosystems within developing economies and offers concrete policy and ecosystem interventions to support green innovation in alignment with global sustainable development goals.**

Keywords: **Green Business, Sustainable Entrepreneurship, Eco-system, SDGs, cultural barriers, policy, policy intervention.**

I.INTRODUCTION

Bangladesh occupies a key crossroads, and has to deal with both the challenges of high economic growth and high vulnerability to climate change. Even though the country has experienced impressive economic growth over the last few decades, the success has been marred by serious environmental and structural inefficiencies where a large proportion of the country is already living in high-exposure zones to the increasing sea levels, frequent floods, and powerful cyclones which have destabilized livelihoods and infrastructure.2 Bangladesh has a high contribution to the global greenhouse gas emissions with a minuscule contribution of 0.3 but is a disproportionately affected country by the climate crisis as a large population resides in high-exposure regions.

Here the role of green startups is not only the realm of economic activity, but a national priority in creating resilience, the development of innovation, and preventing the deterioration of the environment. At the core of these businesses that incorporate sustainability into operations are likely to become triggers to the shift toward a more robust and sustainable economy. They provide answers to some burning issues like waste management, energy shortage, and inefficiency of resources. It is important to note that the creation of a strong green entrepreneurial ecosystem is not a desire but an obligation of long-term stability and sustainable growth of the country.

II.METHODOLOGY

The research methodology that is used is qualitative research, where a multi-faceted approach is employed to collect and process data. A structured survey was used to gather primary data to determine the awareness of the entrepreneurs on green startups and their views on the sustainability of the practices involved. The survey was also able to offer the quantification of the main challenges and opportunities in the ecosystem. This was complemented by detailed semi-structured interviews with two green entrepreneurs of prominence, MD Shahin Mia of Green Astha and an unspecified CEO of a waste management start up. These interviews added to the qualitative background and rich on-the to the survey results.

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A significant amount of secondary data was obtained through in-depth search of the available literature i.e. government policy papers, scholarly articles, and industry reports. The review has centered on current policy framework, financial machinery and the wider socio-economic situation of green businesses in Bangladesh. The process of primary and secondary data synthesis makes it possible to conduct a holistic and evidence-based analysis serving as the transition between official policy and entrepreneurial reality.

III.LITERATURE REVIEW

- Scope & Method

The recent research (2019-2025) covers peer-reviewed publications, policy reports, and ecosystem evaluations of the green and impact startups, SMEs, and circular economy transitions in Bangladesh. Five fundamental themes (financing, regulation and intellectual property (IP), incubation capacity, supply-chain circularity and consumer demand) are constantly emphasized in the literature [12]

1) Financing Constraints and Policy Instruments

The Bangladesh Bank Sustainable Finance Policy (2020; updated guidance in 2023-2025) institutionalized green taxonomies, and refinance windows, including the Green Transformation Fund. Nevertheless, adoption by early-stage ventures is low, and banks still focus on those sectors that have been established [4,17]. That is reflected in independent analyses of slow mainstreaming even in countries with access to low-cost refinance options to de-risk clean energy projects [4]. According to ecosystem reports, the worldwide funding crunch of 2022-2023 impacted climate-tech investments more than other sectors, and signs of recovery in 2025 remain biased towards fintech investments and AI-driven investments [12].

Implication: There is a policy-to-pipeline gap in green startups-Policies are in place, but early-stage equity, blended finance and bankability support is lacking.

2) Regulatory and Institutional Frictions

Regulatory barriers that increase delays in the process of formalization of ventures, including licensing delays, compliance burdens, and poor inter-agency coordination are highlighted in ecosystem assessments and remain visible in the One-Stop Service offer by the Bangladesh Investment Development Authority [21,6]. The OSS in 2025 was upgraded to include time-bound approvals, and real-world bottlenecks still exist.

Another of the challenges is intellectual protection. Critiques of the Bangladesh Patent Act 2023 signal loopholes that deter the promotion of innovations [7]. Lagging trademark processing also is another deterrent to research-intensive ventures [19].

3) Incubation, Mentoring, and Green-Specific Capacity

Incubation has spread with groups like YY Ventures and the Centre of Entrepreneurship Development at BRAC, but most are sector-neutral or socially oriented but not climate-oriented [14]. Because of it, startups frequently have no specialized guidance in regulatory compliance, ESG reporting, and supply-chain decarbonization [22]. The incubators are not climate oriented and this limits the scalability and the resilience of green entrepreneurship.

4) Circular Economy and Supply-Chain Barriers

In Bangladesh, the major focus of the circular entrepreneurship is the ready-made garment (RMG) industry. Waste valorization and fiber recycling are on the agenda, but critical gaps in infrastructure, inaccessible waste paths, and under-investment remain obstacles [1]. News and policy reports indicate that the startups in the circular economy have a problem with scale because of poor collection systems, costly technology and lack of finances [13].

5) Culture, Consumer Demand, and Green Market Development

The consumer research shows that there are still gaps of intent-behavior. Even though young people in urban areas have expressed attitudes of pro-environment and readiness to buy green products, price-sensitivity restrains their actual purchasing behavior due to the unavailability and insufficient information [18,15]. Research on entrepreneurial intention indicates that more and more university students are interested in this field, yet structural and institutional assistance is limited to turn intentions into feasible projects [23].

6) Rural and SME Contexts

Studies on rural entrepreneurs and SMEs highlight other hindrances, among which there is low environmental awareness, restricted access to credit, and poor management skills [22]. Such limitations are more intense beyond Dhaka and Chattogram, where entrepreneurial ecosystems are not so well-developed.

7) Recent Bangladesh-*Focused Syntheses*

The 2024-2025 Syntheses: Further support the previous research, discovering that CMSMEs have enabling and inhibiting factors, knowledge gaps in environmental knowledge, and systemic business environment constraints that reduce green performance [7].

Synthesis – Five Common Clusters of Obstacles:

Finance & Risk: Small amount of early-stage capital even with green refinance schemes.

Regulatory/IP: Inefficient procedures and poor enforcement of IP.

Capability Gaps: Lack of climate-specific incubation/mentoring.

Circularity Infrastructure: There is no collection, sorting,

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and recycling systems.

Demand-Side Frictions: Cultural and behavioral obstacles to green products.

Overall Insight: Although the reforms in terms of policy have been improved, there are still executional deficiencies and institutional failure that still obstruct sustainable entrepreneurship in Bangladesh.

IV RESEARCH GAP

Although the literature and governmental initiatives recognize the value of green entrepreneurship in the sustainable development of Bangladesh, there is a huge gap in the knowledge about the practical and day-to-day problems of the small and nascent green businesses. A majority of research and policy literature dwells upon the macro-level, i.e., the shift of large export-oriented industries, and lacks specific responsiveness to the needs and challenges of the grassroots innovators and startups. The proposed study aims to fill this vacuum by offering a specific analysis that will combine quantitative survey information about entrepreneurs, such as the ones of Green Voice BD and (BSREA) Green Startup with qualitative, personal, information of founders. This is with the aim of leaving a generalization of policy and finance behind to a detailed examination of the disconnect between the availability of resources and their accessibility to the small-scale entrepreneurs who are on the front lines of green innovation.

V FINDINGS

Profile of the Green Startup Landscape

The Bangladesh green entrepreneur context is typified by a well-developed base knowledge of green sustainability and a fledgling but developing operational maturity. According to the survey, one hundred percent of the respondents are already aware of the term green business practices.Also, there was a significant proportion (66.7%) of businesses that identified themselves as having implemented some kind of a green or sustainable practice in their business, with the other proportion (33.3) comprising less than a year old (33.3%), 1-3 years old (33.3%), and 4-6 years old (33.3%).

Although the level of awareness and implementation is great, the level of sustainability practices remains immature. Most of the respondents (75 percent) reported that between 26-50 percent of their business processes are sustainable, as opposed to 25 percent who reported percentages of 51-75 percent. Green packaging (100%), energy efficiency (66.7%), and less frequent adoption of the use of renewable energy (33.3%), are the most widespread practices that were mentioned by the participants.

Perceived Challenges and Barriers

The data in the survey gives the definite and quantitative image of the barriers to the development of green startups. The results indicate a complex array of issues that are financial, regulatory, instances in the market, and institutional.

1.Financial and Investment Barriers

The most pronounced one is the issue of financial constraints. There are a number of financial mechanisms that have been set in place by the government and partners to aid green initiatives. Bangladesh Bank has developed an array of sustainable refinance programs such as the Green Products/Projects/Initiatives (GPPI), the Green Transformation Fund (GTF) and the Technology Development/Up-gradation Fund (TDUF). These plans provide concessional, long term loans at low interest rates, the express purpose of hastening investment in projects and initiatives that are environmentally friendly, energy efficient and modernization of export oriented industries. Also, there are programs such as the UNDP-FBCCI Green Startup Grant that offer financial and technical assistance to innovators in the early-stage.

In spite of the fact that these funds exist, a critical paradox appears. Although such financial mechanisms are present, primary survey data shows that a funding short-age is considered the most important obstacle to growth. According to the survey of entrepreneurs, 50% mention the problem of Funding availability as the most acute barrier and the problem of Access to green investors is also considered by 25% as a priority issue. It implies that there is a very high disconnect between availability of capital and their accessibility to small, nascent green startups. Such disconnect is not merely the lack of finances but a structural and target issue. As an illustration, the Green Transformation Fund (GTF) is specifically aimed at major export oriented industries in other sectors such as textiles and jute. Applicants should submit a credible energy audit report and detailed environmental impact analysis to become eligible, which can be too intimidating and expensive due to its bureaucratic nature to be achieved by small, early-stage ventures. This can be supported by the direct request of MD Shahin Mia of small business-Green Astha, who claimed that it is obligatory to invest the government in costly equipment so that the small enterprises could get the technical progress and be motivated.

Regulatory and Institutional Gaps

The image of governmental support is ambiguous and is oriented to insufficiency. Only a small proportion of 50% of entrepreneurs report that the existing government policies towards green entrepreneurship are unsupportive, 25% report that they are somewhat supportive and 25 percent report that they are neutral. This implies that there is a large disparity between the

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presence of policy and its perceived good. The Bangladesh government has also shown a proactive attitude to managing the environment by formulating and passing various important policies. In 2010, the National 3R Strategy of Waste Management was formulated, marking a radical shift of waste management towards a more resource-management approach rather than the more traditional contain and disposal approach.Newer regulations, including the Solid Waste Management Rules 2021, have simply institutionalized these efforts. It is important to note that these regulations provided the first introduction of the concept of the Extended Producer Responsibility (EPR) in Bangladesh where the producers would be responsible for managing the waste in their product (packaging and electronics). The Hazardous Waste (e-waste) Management Rules, 2021, offer a more precise framework, requiring manufacturers and importers to register with the Department of Environment and meet increasingly higher annual collection targets. Moreover, a substantial majority (75) of participants in the survey consider the current intellectual property (IP) rights as being of moderate effectiveness in protecting green innovation with 25% perceiving them to be ineffective. This perceived insecurity may discourage serious research and development spending.

Market and Consumer Barriers

Deficient market awareness and values that are not aligned with those of the society are a fundamental challenge. In the survey, 100 percent of the respondents indicated overall awareness of green startups among the entrepreneurs as moderately rated. This is further aggravated by the fact that the societal values are either partially aligned (50 percent) or weakly aligned (25 percent) in green entrepreneurship. One of the challenges that are also noted in the abstract is that of consumer preference towards cheap, unsustainable products that are substantiated by the survey data in which the element is considered as a significant obstacle in 25% of the respondents.

Collaboration and Mentorship Gaps

There is a major lack of support networks in the ecosystem. There is a significant 75 percent report of respondents believing that the extent of mentoring offered is not sufficient (Not sufficient enough with 25 percent stating it is), and only a quarter of respondents consider adequate (Adequate). This observation is reflected by the low rate of partnership where half of the respondents indicated that they had "None" or 1-3 partnerships with other green organizations within the previous year.

Table 1 provides a comprehensive overview of these and other key survey findings.

Table 1: Summary of Green Startup Survey Results

Question	Key Finding
How long has your business been operational?	Even split: 33.3% for <1 year, 1-3 years, and 4-6 years.
Are you familiar with green business practices?	100% of respondents are familiar.
Have you implemented green practices?	66.7% have, 33.3% may.
How would you rate awareness of green startups?	100% rate it as "Moderate."
Which barrier is most critical?	"Funding availability" (50%) is the most critical.
How supportive are government policies?	50% "Unsupportive," 25% "Neutral," 25% "Somewhat supportive."
Which factor influences entrepreneurs to adopt sustainable practices?	Even split: Profitability Potential, Government Regulations, Consumer Demand, Environment Concern (25% each).
How effective are IP rights?	75% "Moderately effective," 25% "Ineffective."
What drives your opinion on sustainable entrepreneurship the most?	Long-term profitability (50%) and government incentives (25%).
What area needs the most improvement?	Policy reform (50%) and Funding availability (50%).
How do you evaluate the ecosystem's readiness?	75% "Developing," 25% "Partially ready."
How do societal values align with green entrepreneurship?	50% "Partially aligned," 25% "Weakly aligned," 25% "Strongly aligned."
What role does cultural engagement play?	50% "Moderate role," 25% "Major role," 25% "Minimal role."
How would you describe the level of mentoring?	75% "Not sufficient enough," 25% "Adequate."
What percentage of operations are sustainable?	75% are at 26-50%, 25% are at 51-75%.
What green practices are you using?	Green packaging (100%), Energy efficiency (66.7%), Renewable energy (33.3%).
How many green startups	50% "None," 25% "1-3,"

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have you interacted with?	25% "4-6."

Qualitative Insights from Interviews

The qualitative background of the survey data can be absolutely crucial because it is supported by the personal experience of two green entrepreneurs and offers the understanding of the motivators and needs peculiar to the sphere.

MD Shahin Mia (MD of Green Astha): The Motivation & Machinery Deficit.

A direct and straight forward statement by Md Shahin Mia, the managing director of green astha, sheds light on the financial barrier to the small entrepreneurs. He stressed that investment by the government was necessary in order to remain motivated and provide assistance to them in running green startups. His specification of investment in equipment to buy foreign machineries that are costly singles out a serious and subtle financial demand. Not only a matter of overall operational funding but also focused capital investment on technical progress that will offer a competitive advantage. This confirms the survey result that the availability of funds is the most sensitive impediment and further explains the exact nature of the need.

Anonymous CEO (Waste Management Startup): The Policy-Making Innovator.

The interview of a waste management CEO demonstrates another range of problems and achievements. The advent of this entrepreneur is to establish an environment in which waste is converted into a stable, which will influence the development of the main idea of a circular economy. The main difficulty they have is not the shortage of technology or financial resources but the shortage of the social acceptance and knowledge that waste can be re-used to produce useful items. This is directly related to the survey results of poor market awareness and limited correspondence of societal values with green entrepreneurship. The entrepreneur has mentioned that funding was one of the first problems but it is not a significant problem anymore because the necessity to find the way of waste management increases. One of the most interesting things which became known during this interview is the fact that the company is directly involved in the formulation of major national policy, including the National 3 years Strategy 2010, the Solid Waste Management Rules 2021, and the Extended Producer Responsibility directives. This marks an exclusive and an exceptional position where a corporate entity has risen beyond its commercial remit to be de-facto policy partner. The CEO believing that it would be better to work in-house instead of working with other companies is an interesting argument to the findings of the survey that reveals that overall collaboration in the ecosystem would be ineffective. It implies that in certain projects, in-house and proprietary solutions are considered to be more effective or more strategic.

VI DISCUSSION

The Policy-Practice Disconnect: A Tale of Two Realities

One of the main themes that can be highlighted from this research synthesis is that there is much disconnect between progressive policy frameworks and the reality on the ground that is green startups. Though the government, with the contribution of industry leaders, has implemented proactive policies such as the National 3 year Strategy 2010 and Solid Waste Management Rules 2021, much of the green entrepreneurial ecosystem feels that government policies are unsupportive.

This contradiction has not been as a result of government lack of will, but a gap in the implementation as well as targeting of the policies. As an illustration, the accessibility of the concessional loans under such programs as the Green Transformation Fund seems to be mostly favorable to large export-oriented businesses that can afford to pass through the tedious application procedures. Small nascent startups, in their turn, might not fit the beneficiary profile or have the resources to comply with the requirements that were rather strict, including the ability to conduct a thorough energy audit. This results in a system of having the policies that are designed to empower small innovators to reach them effectively and leaves a large part of the ecosystem unsupported and unmotivated.

The Financial Barrier: Beyond Scarcity to Accessibility

The financial paradox, which is discovered above, that there is money but it is seen as non-accessible, is a critical analysis point. Accessibility and structure is the issue and not a general lack of green finance in Bangladesh. Current mechanisms are well-intended, but usually more oriented to more established players and larger projects. This is indicated by the demand by MD Shahin Mia that the government invest in costly machinery directly. Green startups, and those with technological solutions especially, are often characterized by large, one-time capital expenditures, which might not be ideally aligned with the current, loan-based, refinance models. The small entrepreneurship will still not be able to attain technical progress and expand its business unless a more bending and direct funding mechanism of technology and equipment is established.

The Foundational Barrier of Public Awareness

Market awareness and the poor societal identification with the values of green is a source barrier which underlies most of the identified challenges. The fight of the anonymous CEO with the accepted waste usage as a resource by people in the community can be seen as a

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good real-life example of this problem. In situations where consumers and the general population do not clearly understand the value proposition of a green product, then these businesses can hardly realize profitability, however good their product or service may be. Such reduced market demand, in fact, discourages investment and gives rise to a vicious circle that hampers the development of the whole sector.

Nevertheless, a more detailed analysis of the consumer behavior indicates a subtle opportunity. The earlier studies have shown that some portion of Bangladeshi consumers are ready to pay a premium to purchase green products as well as health consciousness is a strong influence in purchasing green products. This indicates that, through a re-packaging of their marketing messages to focus on health, quality and a value perceivable-instead of just environmental impact-green, startups can open the doors and nurture a responsive consumer market.

Table 2 presents a synthesis of the main areas of difficulty that have been corroborated in this study in juxtaposing the perception of entrepreneurship with the greater reality of the policy environment.

Table 2: Critical Challenges for Green Startups: Perceptions vs. Reality

Entrepreneurial Perception (Survey Data)	Policy & Market Reality (Secondary & Qualitative Data)
Funding Inaccessibility: Perceived as the number 1 barrier	Existence of Funds: Bangladesh Bank operates multiple green refinance schemes (GTF, GPPI, TDUF) and grants exist.
Unsupportive Government Policies: 50% of respondents perceive policies as "unsupportive"	Progressive Policies: The government has enacted visionary policies like the National 3R Strategy (2010), SWM Rules (2021), and EPR directives.
Lack of Incubation Programs & Mentoring: 75% report insufficient mentoring.	Limited Formal Support: While a few grants and PPPs exist, a cohesive and widespread network of green-oriented incubation and mentoring is lacking.
Weak IP Protection: 75% find IP rights only "moderately effective".	Policy Gaps & Enforcement: While frameworks exist, their effectiveness in practice is limited, deterring R&D investment and innovation.
Low Public Awareness & Consumer Demand: Rated as a critical barrier by 25% of respondents .	Nuanced Consumer Behavior: A segment of consumers is willing to pay more for green products, particularly those with health benefits.

VII RECOMMENDATIONS

Green entrepreneurship in Bangladesh would need a collaborative strategy that is multi-pronged to realize the full potential of the venture. These recommendations are obtained in the result of in-depth synthesis of the research findings, which cover the special challenges which are observed by the entrepreneurs themselves.

Strategic Financial Interventions

Cutting the financial bridge and making capital actually available to small entrepreneurs is the most important need. It should have a specific Green Startup Equipment Fund.

This fund would be different to the current loan schemes, whereby direct grants would be given on the acquisition of costly high tech machinery in foreign countries directly responding to the need expressed by MD Shahin Mia. It would not only be an essential technical competitiveness but also a strong incentive to small entrepreneurs. Moreover, there should be reforms in the existing refinance schemes to make them more inclusive. The various eligibility requirements must also be made easier and extended to cover the early stage, non-export-oriented startups. Another way that the government can use to direct green funds to small-scale and rural projects is through Public-Private Partnerships (PPPs) and microfinance institutions (MFIs); hence the government can avoid using the expensive, high paper work requirement in the traditional commercial banks.

Enhancing the Regulatory and Institutional Framework

The issue of perception of unsupportive policies and poor intellectual property rights has to be resolved. One of the suggestions is to create a special, dynamic agency that will facilitate the process of making regulatory issues of green startups easier and implement intellectual property legislation. This institution would operate to enhance the IP protection system, which is a major concern among innovators as the survey indicates. Besides, a network of properly organized incubation programs and accelerators ought to be established. These programs would not only provide seed funding but they would also provide the technical and business mentoring that 75% of would need.

This is not enough according to entrepreneurs.

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Cultivating Public Awareness and Market Demand

The initial issue of the low level of market awareness and the absence of acceptance among the population needs a joint action. It should initiate a national campaign to raise the awareness of the people with a multi-pronged approach. This campaign must not just be generic environmental messaging but should dwell on the practical advantage of green products. With the qualitative understanding of the waste management CEO, the campaign ought to show how waste can be changed into useful products. In the same manner, a countrywide marketing campaign may be done around the Made in Bangladesh, Made Green story making green products a source of national pride and technological innovation. Another strategy that would increase consumer confidence and enable them to readily identify and distinguish between sustainable products would be a national mark known as Green Product Certification to further facilitate consumer behavior change and generate a stronger demand in the market.

Recommendations for Green Business Education

- Curriculum Integration: Bangladesh education institutions may introduce sustainable business coursework, green technologies, and entrepreneurship so that students can obtain the skills needed to start environmentally friendly businesses.
- Industry Partnerships: University-green startups could offer students internships, projects, and exposure to real-world challenges.
- Workshops and Incubators: Universities ought to establish green business incubators and conduct workshops to enable students to come up with viable green business models, which have access to mentorship and funds.
- Policy/Funding Awareness: By providing seminars on how to navigate regulatory systems and how to access government incentives on green businesses, this will benefit would-be entrepreneurs.

Consumer Behavior Analysis

- Survey Insights: Survey would assist in determining consumer preference of sustainable products, whether the environmental concerns have any impact on the purchasing behavior, and whether the eco-friendly product is perceived to be more costly.
- Cultural Barriers Focus Groups: Focus groups could be conducted to understand in more detail why the consumers are reluctant to switch to green products, performance reasons, or price.
- Market Segmentation: Younger generations of people in urban areas can be analyzed as different demographic segments with the purpose of identifying the most receptive markets where green startups can be launched in Bangladesh

Comparative Analysis with Other Countries

- The Green Startup Scene in India: India has the right policies and funding models, such as the Atal Innovation Mission, which could be used as an example by Bangladesh to encourage the growth of green startups in Bangladesh.
- Sustainable Approach in Sri Lanka: Sri Lanka has been interested in eco-tourism, as well as renewable energy, and this may provide clues on how green business can be scaled in Bangladesh, particularly in the agricultural and tourism industries.
- Pakistan: Green Market Development: The green efforts by Pakistan, such as investments in solar startups, may help Bangladesh learn the lessons of scaling and financing its green efforts.
- The Global Best Practices: As a reference to global best practices, green models of other countries such as Germany or Denmark, where sustainability has been supported in terms of government and consumer buying, should be the reference to Bangladesh.

VIII CONCLUSION

To sum up, green entrepreneurship in Bangladesh is a great potential that can be used to develop a sustainable environment and face environmental issues. Nevertheless, there are several challenges that green startups have to overcome in their way such as financial access, regulatory voids, market demand, and cultural resistance. Despite all favorable policies and financial plans, there is still a sharp gap between state programs and the life circumstances of grassroots innovators.

With green startups, there is a need to have a multifaceted approach in order to unlock the full potential. There is a need to close the gap between policy structures and practice, especially the formulation of more accessible financial mechanisms that suit small-scale businesses. Enhanced intellectual property rights and provision of specialized incubation services is a welcome change that will offer a strong boost to green entrepreneurs. In addition, a national culture of sustainability created by raising public awareness will contribute to the development of consumer demand and the consistency of the social values with the ideas of green business.

Finally, Bangladesh should invest in changing its green entrepreneurial ecosystem by making sure the policies and funding and institutional support are available to the

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most in need. The aspect of holism will not only facilitate the development of green start-ups but also lead to increased environmental and economic health in the country. Through empowering green entrepreneurs, Bangladesh will be in a position to serve as a precedent of sustainable growth to be emulated by other developing economies that are going through the same dilemma.

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Applying Benford's Law to Detect Accounting Data Manipulation: An Empirical Study of Non-Performing Loans (NPL) Scenario in Banking Industry of Bangladesh

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Abstract- **Non-performing loans (NPLs) in Bangladesh's banking sector have almost tripled during 2023-2025 period, which points to an impending crisis since increased NPLs reduce a bank's interest income and depletes its capital bases. The economy of Bangladesh is highly dependent on the banking industry as such an increased NPL level not only makes the banks vulnerable, but also erodes the nation's economic stability. It has been alleged that the manipulation of accounting data in the banking industry exacerbates the scenario by painting a seemingly rosy picture where the banks' liabilities are understated and assets are overstated. In this context, this study applies Benford's law in order to detect possible manipulation of banks' loan data, especially the different types of NPLs such as special mention account (SMA), substandard (SS), doubtful (DF), and bad loans (BL). Benford's Law describes the frequency distribution of the leading digits in many naturally occurring datasets and it has been applied to analyze data related to non-performing loans (NPLs) in major commercial banks. A number of statistical tests including chi-squared test and Kolmogorov-Smirnov (K-S) test have been conducted to check conformity of leading digit distribution to Benford's law. A significant deviation from Benford's Law in NPL data has been noticed which indicates potential manipulation or fraudulent activities.**

Keywords - **Non-performing loans (NPLs), accounting data manipulation, Benford's law**

I.INTRODUCTION

In recent times, non-performing loans (NPLs) have turned out to be a critical challenge for banking sectors worldwide, especially in developing economies. These defaulted loans not only undermine the profitability of financial institutions but also endanger the stability of entire financial systems. While the global financial crisis of 2007–2009 revealed flawed accounting reporting in U.S. banks, similar patterns have been witnessed in Bangladesh, albeit under a different set of regulatory and institutional frameworks. Bangladesh's fast-developing banking sector has experienced a notable surge in non-performing loans - with the magnitude of NPLs nearly tripling during the period from 2023 to 2025 [6]. This sparks serious concerns regarding governance framework, regulatory effectiveness, and the transparency of financial disclosures.

Bangladesh's non-performing loan (NPL) crisis emerges from a combination of poor internal controls, political interference, and inadequate risk evaluation practices, especially within state-run banks where the NPL ratios remain persistently higher than in private institutions [3]. The problem got fueled by the prevalence of financial misreporting and audit failures as illustrated by the Hallmark group scandal and BASIC Bank loan scam [2]. A holistic strategy is required to combat the challenge of non-performing loans. Key ideas include strengthening regulatory frameworks, applying strict standards for loan classification and provisioning and fostering greater transparency in financial reporting. Reformation of audit practices to uphold independence and accountability and alignment with global best practices should also be prioritized. Without these reforms, there is heightened risk of further decline in the banking sector, which can hamper inclusive finance initiatives and sustainable economic growth.

This paper applies Benford's law, which predicts the frequency distribution of leading digits in naturally occurring datasets, to detect accounting data manipulation in the NPL scenario in the banking industry of Bangladesh. Its application to analyze loan portfolios, and specifically to classified NPL categories such as Special Mention Account (SMA), Substandard (SS), Doubtful (DF), and Bad Loans (BL), acts as an effective approach to uncover discrepancies in the reported figures.

This paper investigates the conformity of NPL data from major commercial banks in Bangladesh to Benford's Law, utilizing secondary loan data covering the period 2000 to 2024. Through robust statistical measures including the chi-squared, Kolmogorov-Smirnov tests, Mantissa Arc Test and Mean Absolute Deviation (MAD), the study identifies potential anomalies that suggest data manipulation. The insights aim to support regulators, policymakers, and financial stakeholders in enhancing transparency and governance within Bangladesh's banking sector.

II.LITERATURE REVIEW

- *Theoretical Background: Benford's Law and Manipulation Detection*

The estimated frequency of initial (and other) digits in naturally occurring numerical datasets is expressed by Benford's Law. This distribution is appropriate for a range of accounting and economic datasets since it is unit-independent and scale-invariant [1]. Finding deviations from expected patterns is one of its strengths in forensic accounting. It has been used by academics and auditors to

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study banking data [5] taxation [19], corporate earnings [8]; [23], and macroeconomic indicators [12]. The first to detect it was Newcomb [15], and redefined by [3]. It states that the leading digit d (1-9) will appear with the probability
$f(d) = \log_{10}(1 + 1/d)$
(Nigrini, 2012).
For example, approximately 30% of numbers should start with "1," but only ~5% with "9." Benford's methodology does not require predictive models; instead, it assesses whether the digit frequencies in reported numbers match the theoretical distribution [10]. Because manipulation frequently results in unusual digit distributions, anomalies serve as warning signs of inaccurate reporting [15].

- *Non-Performing Loans (NPL) Trends in Bangladesh*

Historical NPL Trends
NPL levels in Bangladesh's banking industry have been consistently high. Systemic flaws in state-owned commercial banks (SCBs) and development financial institutions (DFIs) were reflected in the overall non-performing loan (NPL) percentage of about 34.9% in 2000 (Bangladesh Bank, 2019). The percentage decreased to about 7.3% by 2010 after reforms in the 2000s (Bangladesh Bank, 2019). Nonetheless, SCBs and DFIs continued to exhibit disproportionately large non-performing loans (NPLs), which are frequently associated with lending that is driven by politics [24].
Ratios increased once more after 2010; in 2012, the NPL ratio was 10%, and it varied between 8 and 10% for the next ten years [4]. Although provisions covered only roughly 55% of reported non-performing loans (NPLs), official data by 2023 indicated a 9% percentage [24]. Significant understatement is suggested by independent reviews. For example, an Asset Quality Review (AQR) conducted in 2025 discovered that six significant Islamic banks' actual non-performing loans (NPLs) were over four times greater than their stated amounts, with some banks underreporting by over 70 percentage points [18]. Comparably, a forensic investigation of Global Islami Bank revealed that it underreported non-performing loans (NPLs) in 2023, concealing losses of Tk 2,259 crore, which were later shown to account for 25% of the bank's loan book rather than the 2.6% reported [22].

Loan Classification and Provisioning Framework in Bangladesh
According to Bangladesh Bank regulations, loans are classified into five categories based mostly on days past due: standard, sub-standard, doubtful, bad/loss, and special mention account (SMA) [22]. 1% for standard, 5% for SMA, 20% for sub-standard, 50% for dubious, and 100% for bad/loss are the corresponding provisioning needs (Master Circular on Loan Classification and Provisioning (BRPD Circular No. 15), 2024). The goal of these regulations is to guarantee that credit risk is identified.
Misclassification, however, compromises this structure. In order to keep their "standard" status, banks have been "evergreening" by rolling over delinquent loans [2]. In order to postpone the recognition of defaults, some also capitalized interest that remained unpaid [7]. Such actions reduce the efficacy of provisions and decrease openness.
Bangladesh Bank has tightened oversight in order to address these issues. To get ready for the switch to IFRS 9 by 2027, it tightened classification thresholds, cut the loan write-off duration from three years to two, and released a new Master Circular on Loan Classification and Provisioning in 2024 (Master Circular on Loan Classification and Provisioning (BRPD Circular No. 15), 2024). In instance, among Islamic institutions, the Bank Resolution Ordinance 2025 gave regulators further authority to reorganize or consolidate troubled banks [17]. These actions show an effort to rebuild credibility and acknowledge widespread deception.

- *Upsides of applying Benford's Law*

While there are few direct applications of Benford's Law to the banking industry in Bangladesh, similar research conducted in other developing nations offers pertinent information. Following the implementation of International Financial Reporting Standards (IFRS), Russian banks' financial statements were more Benford-conforming, indicating more openness, according to [8]. [11] used extensive datasets from both developed and emerging economies to show that emerging markets had more departures from Benford's distribution, which is in line with more opportunistic reporting. These results suggest that Benford's Law can successfully draw attention to anomalies in situations where regulatory enforcement is not strong.
Benford analysis and other forensic techniques are flourishing in Bangladesh as a result of the recent revelation of widespread loan misclassification. In the context of the United States, [12] showed that manipulating loan loss provisions and non-performing loan (NPL) numbers downward frequently results in noticeable departures from predicted digit patterns. Similar techniques applied to loan classification data from Bangladesh might uncover systematic distortions, offering a quantitative foundation for identifying institutions that need more investigation.

III.METHODOLOGY

Data Collection
This study is based on secondary data on different categories of classified loans over a twenty five-year period from 2000 to 2024 (although, not all data were obtainable or pertinent to

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the analysis). The sample encompasses loan classifications including Special Mention Account (SMA), Substandard (SS), Doubtful (DF), and Bad Loans (BL) for 49 leading commercial banks operating in Bangladesh. The sample selection covers a broad spectrum of banking institutions including Islamic and conventional banks, state-owned and private banks to ensure a representative dataset. The data are obtained from official financial disclosures, and annual reports of individual banks. According to Benford's Law, in many naturally occurring datasets, the distribution of the first digits follows a logarithmic scale. Here, the digit '1' appears as the leading digit about 30.1% of the time, while the frequencies decline for the subsequent higher digits. Assuming that authentic financial data should conform to Benford's expected frequency distribution of digits (1 through 9), deviations from the pattern may imply potential irregularities such as data fabrication or fraud.

In this study, the leading digit of each loan amount within the classified NPL categories is considered and its frequency distribution compared against the expected frequencies predicted by Benford's Law.

Statistical Tests

To assess whether the distribution of leading digits in the classified loan amounts align with Benford's Law, this study applies four widely accepted statistical measures: Chi-Squared (χ^2) Test, Kolmogorov-Smirnov (K-S) Test, Mantissa Arc Test (MAT) and Mean Absolute Deviation (MAD).

The Chi-Squared (χ^2) Test measures the goodness-of-fit between the observed leading digit frequencies and the expected digit frequencies as mentioned by Benford's Law. A significant Chi-Square (χ^2) value indicates deviation from expected frequencies and is suggestive of data manipulation. The Chi-Square (χ^2) value is gauged as:

$$\chi^2_{(10)} = n\sum_{i=0}^{10} \frac{\left(\hat{\theta}_i - f(i)\right)^2}{f(i)}$$

(Grammatikos & Papanikolaou, 2021).

Kolmogorov-Smirnov (K-S) Test is a non-parametric statistical tool that checks whether the cumulative pattern of observed digits matches what's expected. It's particularly useful in uncovering differences in the shape of the distributions. A significant difference, indicated by a low p-value, suggests that the data does not conform to the law, potentially signaling anomalies or fraud in datasets used in forensic accounting and auditing.

The Mantissa Arc Test (MAT) is a statistical test used to assess data quality and detect potential fraud by comparing the observed mantissa (the fractional part of a logarithm) distribution against Benford's Law. It works by treating the mantissae as points on a unit circle and calculating the "center of mass" of these points to see if the data deviates significantly from the expected circular distribution predicted by the law. A high p-value or a center of mass close to the center of the unit circle indicates conformity to Benford's Law, while low p-values suggest potential data manipulation, however there's no such threshold value prescribed in the literature.

In the context of Benford's Law, Mean Absolute Deviation (MAD) is a statistical measure used to quantify the deviation of a dataset's observed digit frequencies from the expected frequencies predicted by Benford's Law. A higher MAD value, i.e., greater than 0.015 indicates a greater difference from the expected logarithmic distribution, suggesting potential non-conformity with the law, which can be a sign of fraud in areas like financial data analysis.

IV.RESULTS

The different categories of loan data corresponding to the commercial banks in Bangladesh across 2000-2024 were collected for analysis. It should be noted, a number of commercial banks such as Sonali Bank and State Bank of India's data were excluded due to inconsistency in reporting. Besides, a number of banks' data before 2010 were hardly available. Accordingly, those were not considered in the analysis.

Bad Loan:

The bad loan data or bad/loss data corresponding to 623 observations were considered for leading digit analysis with respect to Benford's law. Following are the test results summarized -

- Pearson's Chi-squared test conducted via R-package resulted in the following output:
  $\chi^2 = 35.12$, p-value = 0.000025
- Kolmogorov-Smirnov Test (K-S Test) for Benford's law when conducted yielded the following output:
  D = 1.97, p-value = 0.0004
- Mantissa Arc Test conducted via R-package resulted in the following output:
  L2 = 0.018, p-value = 0.000013
- Mean Absolute Deviation (MAD): 0.004

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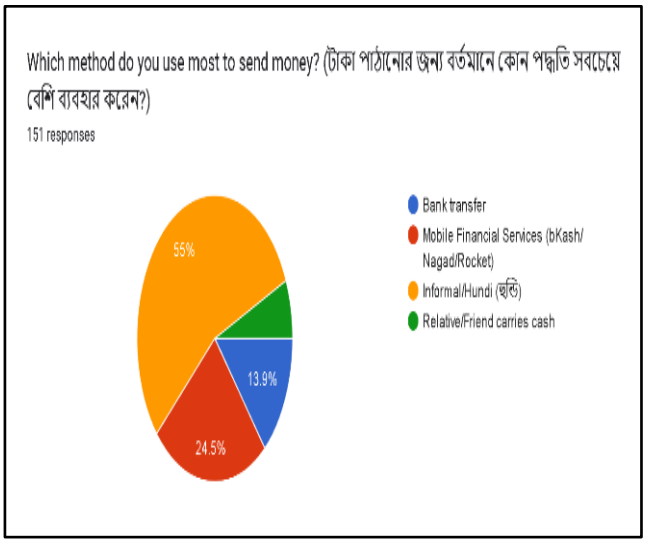


Figure 1: Output from test on 'bad loans' data

The results presented above as well as Figure 1 indicate that there were significant deviations from expected distribution of leading digits. One may conclude under the purview of Benford's that such a nonconformity is indicative of manipulation of reported bad loan data.

Doubtful Loan:
The doubtful loan data from 609 valid observations were considered for leading digit analysis with respect to Benford's law. Following are the test results summarized -

- Pearson's Chi-squared test conducted via R-package resulted in the following output:
  $\chi^2 = 20.3$, p-value = 0.009
- Kolmogorov-Smirnov Test (K-S Test) for Benford's law when conducted yielded the following output:
  D = 1.52, p-value = 0.005
- Mantissa Arc Test conducted via R-package resulted in the following output:
  L2 = 0.0103, p-value = 0.0020
- Mean Absolute Deviation (MAD): 0.016

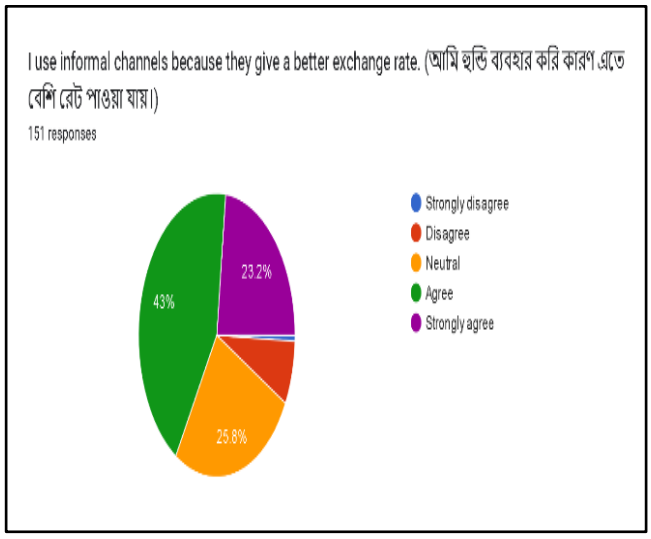
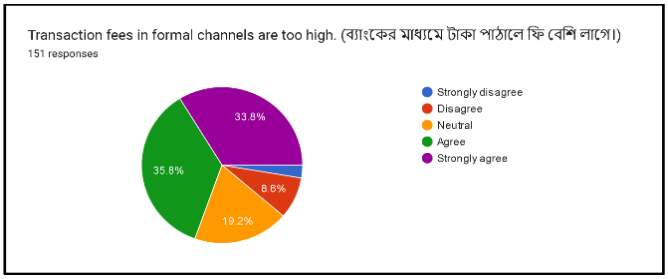


Figure 2: Output from test on 'doubtful loan' data

The results presented above followed by Figure 2 indicate that there were significant deviations from expected distribution of leading digits. This conclusion matches with the conclusion from bad loan data analysis and one may conclude under the purview of Benford's that such a nonconformity is indicative of manipulation of reported doubtful loan data.

Sub-standard Loan:
The sub-standard loan data from 612 valid observations were considered for leading digit analysis with respect to Benford's law. Following are the test results summarized -
Following are the test results summarized -

- Pearson's Chi-squared test conducted via R-package resulted in the following output:
  $\chi^2 = 4.59$, p-value = 0.71
- Kolmogorov-Smirnov Test (K-S Test) for Benford's law when conducted yielded the following output:
  D = 1.97, p-value = 0.0004
- Mantissa Arc Test conducted via R-package resulted in the following output:
  L2 = 0.000225, p-value = 0.87
- Mean Absolute Deviation (MAD): 0.008



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Figure 3: Output from test on 'sub-standard loans' data

The results presented above followed by Figure 3 does not necessarily indicate that there were significant deviations from expected distribution of leading digits. Only the K-S test may indicate the presence of data manipulations. Therefore, one may not conclude there is nonconformity in the distribution of leading digits as such the report sub-standard loans during the period may not have been misreported.

Special Mention Account Loan:

The special mention account (SMA) loan data corresponding to 591 observations were considered for leading digit analysis with respect to Benford's law. Following are the test results summarized –

- Pearson's Chi-squared test conducted via R-package resulted in the following output:
  $\chi^2 = 14.69$, p-value = 0.0655
- Kolmogorov-Smirnov Test (K-S Test) for Benford's law when conducted yielded the following output:
  D = 0.935, p-value = 0.15
- Mantissa Arc Test conducted via R-package resulted in the following output:
  L2 = 0.0027, p-value = 0.20
- Mean Absolute Deviation (MAD): 0.009

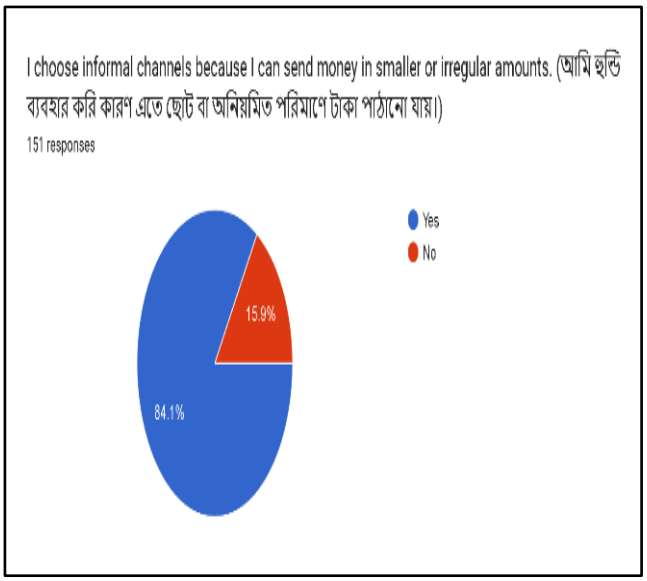


Figure 4: Output from test on 'SMA loans' data

The results presented above followed by Figure 4 does not necessarily indicate that there were significant deviations from expected distribution of leading digits. Only the chi-squared test may indicate the presence of data manipulations. This lack of non-conformity and possible case of fair reporting are intuitive and a bit logical, too. The commercial banks have incentive to misreport the bad loan and doubtful loan data since these two are likely to be reported in the media and scrutinized by most stakeholders.

Unclassified/Standard Loan:

Finally, the standard or unclassified loan corresponding to 662 observations were considered for leading digit analysis with respect to Benford's law. Following are the test results summarized –

- Pearson's Chi-squared test conducted via R-package resulted in the following output:
  X-squared = 14.92, p-value = 0.061
- Kolmogorov-Smirnov Test (K-S Test) for Benford's law when conducted yielded the following output:
  D = 1.49, p-value = 0.007
- Mantissa Arc Test conducted via R-package resulted in the following output:
  L2 = 0.0114, p-value = 0.0005
- Mean Absolute Deviation (MAD): 0.013

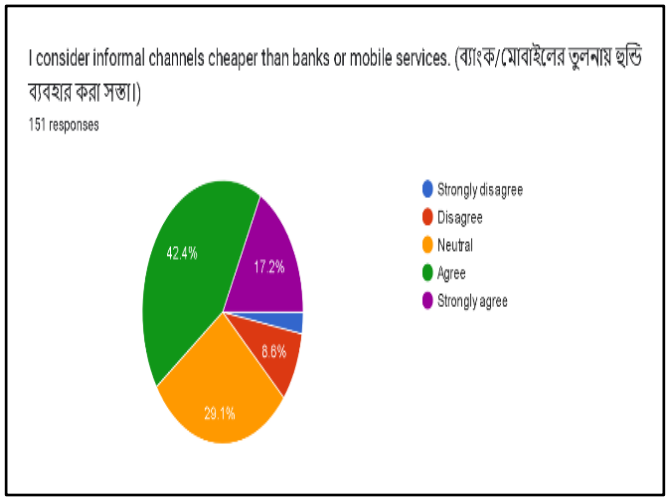


Figure 5: Output from test on 'standard loans' data

The results presented above as well as Figure 5 indicate that there were significant deviations from expected distribution of leading digits. One may conclude under the purview of Benford's that such a nonconformity is indicative of manipulation of reported standard loan data.

V.DISCUSSIONS

The following table summarizes the findings:

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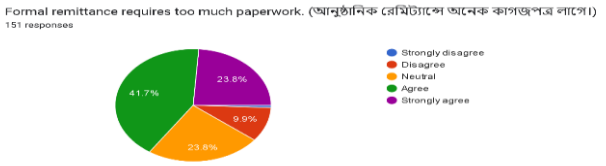


Figure 6: Findings Summary

The analysis of the test results reveals potential signs of data manipulation in certain types of loans. Specifically, the standard (STD), doubtful (DF), and bad loans (BL) loan categories show significant anomalies across multiple tests. For UC/STD loans, the low p-values in the K-S test (0.007), and MAT test (0.0005) suggest deviations from expected patterns, indicating possible data manipulations. Similarly, DF loans exhibit very low p-values across the χ^2 (0.009), K-S (0.005), and MAT tests (0.002) alongside a relatively higher MAD (0.016), pointing to substantial deviation that may reflect manipulative behavior. The BL category shows an even stronger indication of manipulation, with extremely low p-values in all three tests—χ^2 (0.000025), K-S (0.0004), and MAT (0.000013) that clearly displays a significant deviation from expected distribution pattern, which strongly suggests fraudulent data inputs.

Conversely, the SMA and SS loans do not exhibit conclusive signs of manipulation based on the statistical tests. For SMA loans, all p-values are relatively high—χ^2 (0.0655), K-S (0.15), and MAT (0.2)—accompanied by a low MAD (0.009), indicating that the data conforms closely to expected distributions. While SS loans have a low p-value for the K-S test (0.0004), the χ^2 (0.71) and MAT (0.87) tests show no significant deviations, and the MAD value is low (0.008). These mixed results suggest that while some irregularities might exist, there is no strong, consistent evidence of manipulation. Overall, the data for SMA and SS loans appear to be more trustworthy and aligned with natural patterns, contrasting with other loan types where manipulation signs are evident.

VI.CONCLUSION

Considering the recent hike in non-performing loans in Bangladesh's banking industry, this study was motivated to address growing concerns regarding the accuracy of reported loan statistics. An empirical method of determining if reported loan figures match estimated natural trends is to apply Benford's Law. Significant variances for the bad loans and doubtful loan categories are shown in the results, suggesting that the reported data may have been manipulated. The substandard and special mention account categories, on the other hand, are generally consistent with expected digit distributions and do not exhibit any overt indications of manipulation. The study's shortcomings include the fact that Benford's Law is only a screening technique and not a definitive fraud detection tool, and that the dataset employed was aggregate in nature, which reduced precision (Nigrini, 2012). Due to these circumstances, anomalies cannot be used as independent proof, even though they may indicate manipulation. To investigate differences in reporting practices, future study could compare state-owned and private banks or Islamic and conventional banks. For a more thorough evaluation, future research might potentially incorporate transaction-level data or combine forensic auditing with Benford analysis.

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CSR Expenditure as a Strategic Tool: Implications for Bank Growth and EPS in Bangladesh Banking Sector.

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Abstract- **In Bangladesh, CSR (Corporate Social Responsibility) in the baking sector is guided by the Bangladesh Bank to contribute to the social, financial, and environmental sectors. This study is focused on the CSR expenditure carried out by the private commercial banks and its implications for the banks' overall financial growth, along with the EPS. Utilizing secondary data collected from 33 private commercial banks from 2015-2024, this research tried to find out the relationship between the CSR expenditure and banks' financial conditions, indicating the firm size and EPS (Earnings Per Share). Panel data regression techniques are employed, which results that banks' CSR expenditure has a significant positive relationship with the firm's financial performance. The findings offer some other insights regarding the strategic aspect of CSR expenditure. The results of descriptive statistics and regression analysis reveal that CSR expenditures in education, health, infrastructural development, and other areas have a statistically significant positive impact on EPS. The study highlights the potential of CSR as not a mere expenditure, and is a strategic mechanism for upgrading the sustainability of a firm's financial performance.**

Keywords - **Corporate Social Responsibility, Earnings Per Share (EPS), Financial Performance, Firm Size.**

I.INTRODUCTION

Business has been shaped by new concepts over the centuries. The main aim of business is to maximize profit or gain. But in the present global era, this profit-making has become more competitive and challenging. Several concerns about operating the business with morale and engaging the consumers have emerged. Environmental factors are one of them, and the concept of CSR has taken this concern with a few other philanthropic stakeholder concerns, in an accumulated version. Another dimension of CSR is the sustainable development of the business. [17] identifies CSR as a vehicle for the sustainable development of the organization as well as society. Organizations showcase these developmental concerns to attract customers and investors.

To attract stakeholders, organizations often tend to disclose information regarding their products, how their goods are superior to others, or what innovative products they are offering [24]. They also suggested in their study that, CSR information can create a corporate identity for the organization by disclosing information regarding their work policies and sponsoring several environmental and social issues.

[23] after studying several pieces of literature, classified CSR issues into five different dimensions, the first one associated with vision. They argued that CSR needs to be conceptually associated with the organization, such as the value system, ethical code of conduct, reputation, etc. Secondly, they emphasized building up the community, where there will be a chance of collaboration with the stakeholders. The third dimension they indicated was the workplace which includes the labor practice and employee rights issues. Fourth is accountability which indicates corporate transparency and communication towards the stakeholders. Lastly, the marketplace indicates direct CSR activities such as research and development of new products and services, competition, and pricing of the products.

Empirical studies predict that, shortly CSR will become a key business issue and the organization's strategies will revolve around CSR issues. Especially the financial analysts in particular will be evaluating CSR costs and returns to assess the financial strength of a firm [24].

Bangladesh is a growing economy in Southeast Asia. International business and the financial sector greatly affect this country's economy. To cope with the international pressure, the organizations operating in this marketplace are trying to attract stakeholders by adopting CSR and other business strategies to gain a competitive advantage to further their operation of this

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marketplace of 171.2 million people (Source, World Bank). Along with different industries, the banking industry is also working on this CSR issue. Bangladesh Bank (Central Bank of Bangladesh) has published the comparative CSR report of each scheduled bank since 2015. In 2022 Bangladesh Bank published the policy guidelines of corporate social responsibility (CSR) for financial institutions. In this policy, the financial institutions need to spend at least 30% of their CSR expenditure on the education sector, a minimum of 30% of their CSR expenditure on the health sector, and a minimum of 20% on the environment and climate. The other sectors are income generating activities, disaster management, infrastructure development, sports, and culture and if the financial institutions prefer any other sector they can go for that. According to the policy of Bangladesh Bank, these financial institutions need to publish their CSR report each year in their annual report.

Annual reports are the source of financial information for the banks. The shareholders get to know about the financial performance and make decisions on investment depending on several indicators of these annual financial reports. [20] in their study found a positive relationship between the stock market performance and Earning Per Share (EPS) of banks. Moreover, EPS is considered popular indicator by investors to know the firms' financial performance before investing [16].

However, according to [12], while there is an accounting-based measure, CSR has a significant impact on the financial performance of an organization. They also stated that the impact of CSR can not have an immediate action and the investment in CSR has a longer-term effect on the company's performance financially. [19] identify a significant positive relationship between CSR performance and EPS of firms while analyzing the data of 20 companies for 5 years of period. Moreover, [4] while conducting research on the relationship between CSR and the economic performance of Bangladesh's banking industry, found a significant positive relationship between EPS and CSR expenditure. In conclusion, several empirical studies strongly suggest that, CSR expenditure has a correlation with EPS of banks.

This study will work on several sectors of CSR expenditure maintained by scheduled banks in Bangladesh for 2015 to 2022 and will try to identify the stock market performance influenced by the CSR expenditure with the relationship with earnings per share the investors are compensating. This study is conducted with up-to-date literature and financial reports of the banks to provide a thorough comparative picture of the CSR expenditure of Bangladesh's banks concerning the financial performance, specifically the EPS.

II.LITERATURE REVIEW

The term CSR can be defined with several dimensions. According to the European Commission (2002), CSR is defined as non-mandatory work done by any organization to improve society and the environment the business is associated. The stakeholders' concern is also associated with this definition.

On the other hand, [22] explained CSR from the point of view of stakeholders. They also stated that reaction to CSR activities varies from person to person. Some may purchase more goods while others can opt for getting engaged to that organization by seeking employment or investing in shares. Their study concluded that CSR can gain returns from multiple sources, especially by building strong stakeholder relationships. [21] explained CSR as an activity concerned with social and environmental issues and solving those issues. While working with these issues, the organization needs to incur some costs which are eventually borne by the shareholders. Shareholders may raise concerns over the expenses incurred by the CSR expenditure. Their study concluded with the notion that banks and financial institutions should be much more concerned with wealth management without aggressive investing in CSR activities. They suggested that overstressing CSR may cause excess spending. This will eventually lead to financial instability and loss of competitiveness. Further, they suggested planning and executing CSR in a controlled way.

[3] also suggested the same way by finding a positive correlation with bank risk concerning CSR. They explained in their research that a massive CSR investment may cause a huge expense, which in terms will reduce the firm's competitiveness. This may also increase the production cost, which will lead to bankruptcy and loss of shareholders.

In contrast, [4] illustrated, that the financial risk of any organization can be gained by a well-managed CSR practice. They also added a properly planned CSR practice can ensure organizational commitment with proper governance and sustainable environment practices.

[17] in their study tried to identify the relationship between the stock performance of banks and their environmental, social, and governance performance (ESG). They concluded the stock price value of the EGS performance of the banks was not in the same way. Environmental practice and governance practice work most positively with banks' stock prices whereas social practice does not. This indicates a relationship between CSR and stock market performance of banks. Relating to this, while analyzing the secondary data from the Bombay Stock Exchange (BSE) from 2007 to 2016, [15]

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found a positive correlation between the CSR investment of the banks with the financial performance and stock return of the banks. They stated that CSR needs to be integrated with the strategic decisions of any firm.

In terms of performance, [19], tried to identify the correlations between CSR and Organizational performance in Bangladeshi-listed firms. And found a significant positive relationship between CSR exposure and organizational performance. They also stated the urgency of CSR activity in the banking sector. Banks need to be more accountable for CSR activities and promote them by communicating with the stakeholders. They also added that banks need to adopt a CSR policy to attain social objectives by allocating funds in this sector. Empirical analysis shows that banks need to perform CSR activity in the geographical locations where they are operating. Globally operated CSR activities incur many expenses rather than a good return. In this regard, [18] suggested firms need to make a good balance while they are taking the initiative to care for society, while the cost incurred from these activities is carried out by the shareholders' income.

To know the firm's performance, several factors are calculated. Shareholders normally want to invest in firms that yield more returns on their shares. [14] stated in their study of the telecommunication sector with the stock market data from 2011 to 2016 and found that investors are more prone to invest in the firm after screening the ROE, ROA, and EPS of the organization. As these indicators give the financial impression of the firm and the investors can be assured to invest of these firms. [15] while studying 22 listed scheduled banks of Bangladesh and 110 firms' data indicated that the EPS of the firms gives the financial investors whether the investment is worth it or not.

EPS is calculated by identifying the firm's net income and total number of outstanding shares and dividing them [13]. This is used to identify the profitability of the organization. The impact of CSR on the banks' performance with the data from annual reports of Pakistani banks from 2008-2012 was analyzed by [14]. They stated that common shareholders' earnings increased in that period when the CSR funds were increased by the firms. Furthermore, in a study with 20 listed banks in India, an association between profit after tax, earnings per share, and CSR has been found. However, there was a positive relationship between these indicators. The relationship between EPS and CSR activities has been found to be insignificant [13]. All this literature supports that, banks' CSR practices have an impact on the financial performance of the banks and to be very specific, on the EPS of the firm.

III. RESEARCH METHODOLOGY

Research Design

This research takes in the qualitative research design as it's primary goal is to find out the relationships between CSR expenditure and the private banks of Bangladesh's financial performance. To complete the analysis, descriptive statistics, correlations analysis and regression techniques have been adopted.

Population and sample

A total of 33 commercial banks of Bangladesh are the population for this research. The samples were taken from the banks, who are regularly incurring CSR expenditure and publishing their CSR reports has been selected. The sampling was purposive sampling. The study covers data from 2015 to 2022 for statistical analysis.

Data collection

The data were collected from secondary sources, each banks published annual reports, financial statements, Bangladesh bank website. CSR expenditure was categorized according to Bangladesh Bank's CSR guidelines, which include education, health, disaster management, climate and environment, sports and culture, infrastructural development, income-generating activities, and others (Independent variables). Financial performance was measured using EPS (Dependent Variable), as reported by the respective banks.data were collected from secondary sources, each banks published annual reports, financial statements, Bangladesh bank website. CSR expenditure was categorized according to Bangladesh Bank's CSR guidelines, which include education, health, disaster management, climate and environment, sports and culture, infrastructural development, income-generating activities, and others (Independent variables). Financial performance was measured using EPS (Dependent Variable), as reported by the respective banks.

V. DESCRIPTIVE STATISTICS

TABLE I: Descriptive Analysis

Variables	Range	Minimum	Maximum	Mean	Std. Error	Std. Deviation

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EPS	31.20	-10.20	21.00	2.54	0.14	2.24
Education	2118.60	0.000	2118.60	49.13	9.94	161.49
Health	900.00	0.000	9000.000	33.90	4.23	68.69
Disaster Management	3196.98	0.000	3196.98	96.23	13.60	220.93
Climate and Environment	289.20	0.000	289.20	5.05	1.39	22.58
Sports and Culture	150.00	0.000	150.000	10.91	1.43	23.31
Infrastructural Development	150.00	0.000	150.000	1.62	0.65	10.62
Income-generating activities	13.42	0.000	13.42	0.21	0.07	1.07
Others	260.90	0.000	260.90	21.87	2.29	37.22

The average Earnings Per Share (EPS) is quite satisfactory when compared to the Bangladesh banking industry benchmark, yet it shows considerable variation among the banks during the specified timeframe, with EPS values ranging from -10.20 to 21.00, highlighting significant differences in profitability. In terms of Corporate Social Responsibility (CSR) categories, Disaster Management, Education, and Health had the highest average spending. Conversely, expenditures on Income Generating Activities and Infrastructural Development were the lowest on average.

The correlation between CSR spending on education and EPS is notably positive, with a coefficient of 0.361. Similarly, the banks' investment in infrastructural development through CSR also shows a strong positive correlation with EPS, indicated by a coefficient of 0.294. However, the banks' expenditure in the health sector results in a very weak correlation, with a coefficient of 0.152. Surprisingly, sectors such as sports and culture, as well as climate and environment, display a negative but insignificant relationship. The analysis clearly indicates that not every category of CSR investment impacts a bank's financial performance. The positive correlation between CSR spending on education and EPS suggests that banks'

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investments in educational initiatives may contribute to improved financial performance. This could be attributed to various factors, such as enhanced brand reputation, increased customer loyalty, and potential long-term benefits from a more educated workforce. Similarly, the strong positive correlation between infrastructural development CSR and EPS indicates that such investments may lead to tangible economic benefits for the banks, possibly through improved operational efficiency or increased business opportunities in developing areas.

TABLE II: Correlation Analysis

	EPS	Education	Health	Disaster Management	Climate and Environment	Sports and Culture	Infrastructural Development	Income-generating activities	Others
EPS	1								
Education	.361**	1							
Health	.152*	0.095	1						
Disaster Management	0.062	.194**	0.112	1					
Climate and Environment	-0.045	-0.0006	0.036	0.021	1				
Sports and Culture	-0.096	0.092	0.046	0.079	0.007	1			
Infrastructural Development	.294**	0.059	0.073	0.022	0.001	-0.032	1		
Income-generating activities	-0.001	-0.025	0.023	-0.042	0.048	0.054	.122*	1	
Others	.201**	.133*	0.014	0.025	-0.044	-0.027	0.005	-0.095	1
** Correlation is significant at the 0.01 level (2-tailed).									
* Correlation is significant at the 0.05 level (2-tailed).									

TABLE III: ANOVA

Specifications	Sum of Squares	df	Mean Square	F	Sig.
Regression	337.421	8	42.178	10.901	.000b
Residual	986.646	255	3.869		
Total	1324.068	263			
a Dependent Variable: EPS					
b Predictors: (Constant), Others, Infrastructural Development, Disaster Management, Climate and Environment, Sports and Culture, Health, Income-generating activities, Education					

Model:

Specifications	B	Std. Error	t	Sig.	VIF
(Constant)	2.070	0.172	12.005	0.000	
Education	0.005	0.001	5.869	0.000	1.073
Health	0.004	0.002	1.974	0.049	1.026
Disaster Management	0.000	0.001	-0.246	0.806	1.055

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Climate and Environment	-0.004	0.005	-0.714	0.476	1.006
Sports and Culture	-0.011	0.005	-2.136	0.034	1.020
Infrastructural Development	0.056	0.012	4.806	0.000	1.026
Income-generating activities	-0.013	0.115	-0.115	0.909	1.033
Others	0.009	0.003	2.728	0.007	1.030
A Dependent Variable: EPS					

Model Summery:

R	R Square	Adjusted R Square	Std. Error of the Estimate
.505a	0.255	0.231	1.96703
a Predictors: (Constant), Others, Infrastructural Development, Disaster Management, Climate and Environment, Sports and Culture, Health, Income generating activities, Education			

The model exhibits statistical significance ($F = 10.901$, $p < 0.001$), signifying that the selected Corporate Social Responsibility (CSR) variables collectively explain variations in Earnings Per Share (EPS). The coefficient of determination, $R^2 = 0.255$, indicates that approximately 25.5% of the variation in EPS can be attributed to CSR spending categories, demonstrating a moderate level of explanatory power. Significant predictors with a positive influence on EPS include Education ($\beta = 0.005$, $p < 0.001$), Health ($\beta = 0.004$, $p = 0.049$), Infrastructural Development ($\beta = 0.056$, $p < 0.001$), and Others ($\beta = 0.009$, $p = 0.007$). In contrast, Sports and Culture ($\beta = –0.011$, $p = 0.034$) have a negative and significant effect on EPS. Non-significant predictors, such as Disaster Management, Climate and Environment, and Income Generating Activities, do not exhibit a statistically significant impact on EPS. The model's statistical significance and moderate explanatory power suggest that Corporate Social Responsibility (CSR) spending categories have a meaningful impact on Earnings Per Share (EPS). The positive coefficients for Education, Health, Infrastructural Development, and Others indicate that increased spending in these areas is associated with higher EPS. This implies that investments in these CSR categories may contribute to improved financial performance. The negative coefficient for Sports and Culture suggests that allocating resources to these activities might potentially reduce EPS, warranting careful consideration in CSR strategy formulation.

The non-significant predictors, including Disaster Management, Climate and Environment, and Income Generating Activities, do not show a clear relationship with EPS. This lack of statistical significance does not necessarily imply these categories are unimportant, but rather that their impact on EPS may be indirect or influenced by other factors not captured in the model. Companies may need to evaluate these CSR initiatives based on criteria beyond their direct financial impact, such as long-term sustainability, stakeholder expectations, or regulatory compliance. The findings provide valuable insights for organizations seeking to optimize their CSR strategies to balance social responsibility with financial performance.

Corporate Social Responsibility (CSR) expenditures in the domains of education, health, infrastructure, and other areas substantially enhance earnings per share (EPS). Conversely, investments in sports and culture appear to adversely affect profitability. Other areas, such as disaster management and climate-related efforts, did not demonstrate a significant impact on financial performance. While CSR does contribute to financial performance, its effectiveness is selective and varies according to the type of initiative undertaken

Banks in Bangladesh should prioritize corporate social responsibility (CSR) categories that demonstrate measurable financial returns, such as education and infrastructure. CSR investments ought to be strategically aligned with long-term profitability and stakeholder value. Further qualitative research could investigate the reasons why certain categories underperform or exhibit a negative relationship with earnings per share (EPS).

V. DISCUSSION AND CONCLUSION

This study examined the relationship between Corporate Social Responsibility (CSR) spending and financial performance, measured by Earnings Per Share (EPS), in Bangladeshi banks. The findings reveal a complex interplay between various CSR categories and their impact on financial outcomes.

The analysis demonstrates that CSR investments in education, health, infrastructural development, and other miscellaneous areas positively influence EPS. These results suggest that strategic allocation of resources to these sectors can potentially enhance a bank's financial performance while fulfilling social responsibilities. Conversely, expenditures in sports and culture were found to have a negative impact on EPS, indicating a need for careful consideration when investing in these areas.

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Interestingly, some CSR categories, including disaster management, climate and environment, and income-generating activities, did not show statistically significant effects on EPS. This lack of direct financial impact does not necessarily diminish their importance but highlights the need for a more nuanced approach to evaluating their value beyond immediate financial returns.

The study's findings underscore the importance of a targeted and well-planned CSR strategy. Banks should prioritize investments in areas that not only contribute to social welfare but also align with their financial objectives. The positive correlations between certain CSR categories and EPS suggest that socially responsible initiatives can indeed be compatible with improved financial performance when strategically implemented.

However, the moderate explanatory power of the model ($R^2 = 0.255$) indicates that other factors beyond CSR spending also influence EPS. This emphasizes the need for a holistic approach to financial management and CSR integration.

In conclusion, while CSR activities can contribute to financial performance, their effectiveness varies across different categories. Bangladeshi banks should focus on optimizing their CSR portfolios, prioritizing areas that demonstrate measurable financial returns while balancing long-term sustainability and stakeholder expectations. Future research could explore the underlying mechanisms driving these relationships and investigate qualitative aspects of CSR initiatives to provide a more comprehensive understanding of their impact on both financial performance and social welfare.

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Presence & Distribution of Microplastics in the Sediment of The Four Major Rivers in Bangladesh

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Abstract- **Microplastic is considered a threat to the aquatic environment. This study analyzed the presence and distribution of microplastics in four major rivers- Padma, Meghna, Jamuna, and Old Brahmaputra in Bangladesh, using stereomicroscope and ATR-FTIR analysis. For each river, three districts were chosen, and a total of 36 samples (3 for each location) were collected and analyzed. The result revealed that the Meghna River has the highest level of microplastic contamination, showing 185±27 particles. Across all locations, fibers were more dominant microplastics than fragments, foam, film, and nurdles. Nearly eleven different colors and five types of microplastics were identified, where dark blue was the dominant one. Polyethylene, polypropylene, polystyrene, polycarbonate, polyethylene terephthalate, and cellulose acetate were identified, where polypropylene was the most abundant. The findings of this research will serve as baseline data for future studies aimed at understanding the potential consequences of microplastics and measures to mitigate them.**

Keywords- **Bangladesh, Major Rivers, Microplastics, River Sediment.**

I. INTRODUCTION

Plastics are inexpensive, lightweight, durable, long-lasting, and corrosion-resistant synthetic or semi-synthetic organic polymers [1]. This benefit has resulted in the usage of plastic in several applications, including home and personal items, apparel, packaging, and building materials [2]. Bangladesh, a developing country with a rapidly growing population, is facing numerous challenges in plastic waste management. It was ranked 10th out of the world's 20 most poorly managed countries for producing plastic garbage in 2010 [3]. Every year, Bangladesh produces 800,000 tons of garbage, of which 200,000 tons originate from plastics [4]. Although plastic is widely used due to its durability and cost-effectiveness, its slow decomposition rate and tendency to fragment into microplastics pose a long-term environmental threat [1].

Microplastics, which are small particles that measure less than 5 mm in diameter, are found everywhere - rivers, oceans, and soil (Arthur et al., 2009). As of now, an estimated 4.85 trillion microplastic (MP) particles are present in the global ocean, with up to 80% thought to have originated from river systems [5]. MPs are found in rivers, lakes, and oceans worldwide and build up in sediments due to properties including buoyancy and exceptional durability [6]. Microplastics have negative impacts on the environment and especially on marine life. They are often taken up by fish that mistake them for food and can bioaccumulate in the food chain since these are non-biodegradable. MPs also have various effects on the human body, such as inflammation, developmental and reproductive toxicity, and disrupting the immune system [7].

II. METHODOLOGY

Samples were collected from the riverbanks of four rivers - Padma, Meghna, Jamuna, and Brahmaputra in January 2025. Each river has three location points for collection, with three samples taken at each point for accuracy. Sediment samples were collected, with a combined weight of approximately 9 kg, while maintaining a distance of 10 meters. The sediment samples were collected with the Grab Sampling method with a range of 0-15 cm from the surface using a stainless steel spoon and zip lock bag and immediately transferred to an icebox for cold storage before being transported to the lab, where it was kept in the freezer at 4°C. The samples were later taken out and kept at room temperature before transferring 100 g of sample into a beaker and heating it in the oven for 48 hours at 90°C.

Samples were primarily treated following the method suggested by the National Oceanic and Atmospheric Administration with some modifications. For pretreatment of sediment samples, 100 gm. of dry sediment was weighed, and 30 mL of hydrogen peroxide solution (30%, v/v) was used to eliminate visible organisms from the samples, where 20 mL of 0.05M Fe (II) solution (prepared by adding 7.5 gm. of $FeSO_4.7H_2O$ to 500 mL of water and 3 mL of concentrated sulfuric acid) was added to work as a catalyst [8]. Then, the beaker was placed on a hotplate and heated to 60° Celsius for 20 minutes and stirred continuously using a magnetic stir

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bar. For the density separation process, 36 g of NaCl was added for each 100 ml volume of the solution. The solution was heated for another 20 minutes at 60° Celsius to ensure thorough mixing of NaCl. Then it was covered with aluminum foil and allowed the solids to settle for 24-72 hours. The supernatant of the samples was filtered through a pair of sieves stacked with pore sizes of 5 mm and 0.045 mm. Finally, it was filtered through a Nylon 6, 6 membrane filter with a pore size of 0.45 micrometers, fitted with a water-filtration vacuum pump, and allowed to dry for a while. The dried filter was placed in the petri dish and covered for further analysis.

Study Area

Sediment samples were collected from twelve strategically selected sites along the rivers in Bangladesh to assess spatial variation in sediment characteristics. The selected sites represent three distinct sections of the river:

These sites were chosen based on their geographical locations along the river's course and were selected to provide a comprehensive understanding of sediment composition across varying hydrodynamic conditions. Sampling areas were carefully selected to avoid locations impacted by recent dredging activities, as dredging can alter sediment composition and interfere with analytical accuracy. Agricultural or residential areas were mostly considered to provide a distinct value as well as better relevancy to the effects on human activities and broader environmental health in non-industrial settings. This approach aimed to fill existing knowledge gaps and ensure the study's findings are both relevant and applicable to public well-being. The coordinates were collected using a GIS tool, and later converted into a map using ArcGIS and Google Earth.

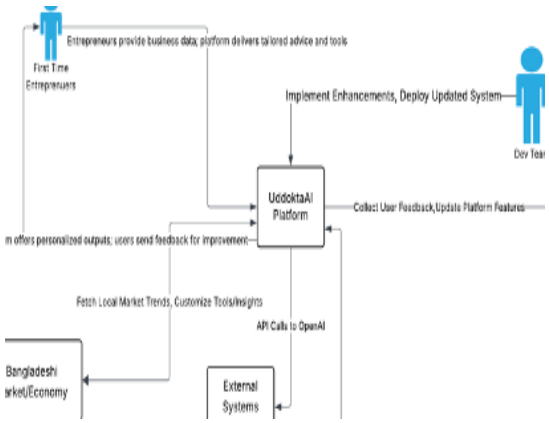


Figure 1: Map of Sampling Locations of Different Rivers

Microscopic Analysis

All the filter papers were examined under a LEICA EZ4E stereomicroscope with a range of 12X to 35X magnification. Microplastics were identified based on their physical characteristics, such as color and shape. A few things were taken into consideration, such as uniform color, no cellular structure, and non-brittle texture to distinguish microplastics from any organic matter or minerals. A careful observation had been performed, and pictures of identified microplastics were taken by software named LAS EZ.

Polymer Type Identification

Using Attenuated Total Reflectance-Fourier Transform Infrared (ATR-FTIR) Spectroscopy (Frontier, Perkin-Elmer, UK; Software: Spectrum version 10.4.4), the polymer types of MPs were determined. Comparatively bigger particles from representative MPs samples of each morphotype were chosen from each location. ATR-mode FT-IR spectra were recorded on a diamond crystal. Each measurement began with a background scan and acetone diamond crystal polishing. With 16 scans per spectrum, spectra were captured at 4 cm^{-1} resolution from 650 to 4000 cm^{-1}. Peak values from each spectrum were compared to a paper-based reference spectra library to verify polymer types in the samples [2].

III. RESULT & DISCUSSION

The highest number of microplastics was detected in the samples of the Meghna River, with 111±1.4 particles per 100 g and an average of 37 MPs per 100 g. Fibers were the most prevalent type of MP across all sites. Rajshahi raises questions about localized MP sources. Potential contributors may include agricultural runoff, where degraded plastic mulch and packaging are common, and localized waste mismanagement. Additionally, the hydrodynamic properties of fragments, which allow them to persist in sediments, might explain their high detection rates in this region. The prevalence of fibers could be attributed to urban activities and greater population density, which increase the influx of fibers into the river system [9]. Additionally, the presence of black chemical additives can significantly alter the spectral properties, further complicating their identification.

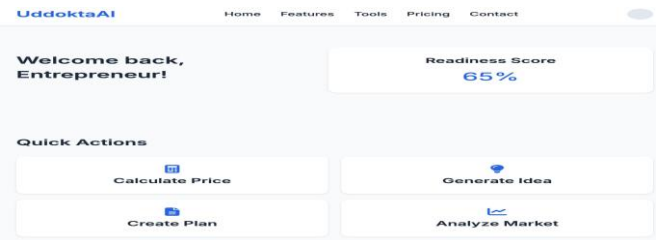


Figure 2: Microscopic images of microplastics from different locations. Particles were grouped into 5 categories:

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microfilm (a), fiber (b, f, h), fragment (d, e), foam (c), and nurdle (g).

- *Microplastic Abundance*

The comparative study on microplastic abundance across the four major rivers Padma, Meghna, Jamuna, and Brahmaputra demonstrated significant spatial differences, with downstream areas exhibiting the highest levels of pollution. The microplastic amounts listed were derived from an average of 100 grams of sediment per sample. The Meghna River has the highest level of microplastics overall (185±27 particles, where ± refers to the standard deviation), followed by the downstream location Lakhsmipur having the most (87±58 particles), which is almost twice as much as the upstream site Chandpur (42±4 particles) and more compared to Brahmanbaria (56±22 particles).Manikganj, which is downstream from the Jamuna River, had the most microplastics (50±14) out of 130±4 total particles. Sirajganj had 41±17 particles, and Bogura had 39±10 particles per 100 g.The Old Brahmaputra River contained 97±13 microplastic particles. The downstream location, Kishoreganj, had the greatest amount (41±3 particles), followed by Mymensingh (29±1 particles) and Jamalpur (27±12 particles).Among the four rivers, the Padma River had the fewest total particles (95±22). However, Munshiganj, which is located in the middle portion of the river, had the highest area concentration (36±1.4 particles), more than Daulatdia (27±0.7 particles) and Rajshahi (32±22 particles). It also indicates that microplastics are building up more along the river's course, which is a sign that contaminants are moving downstream and accumulating.

Microplastic Morphotypes

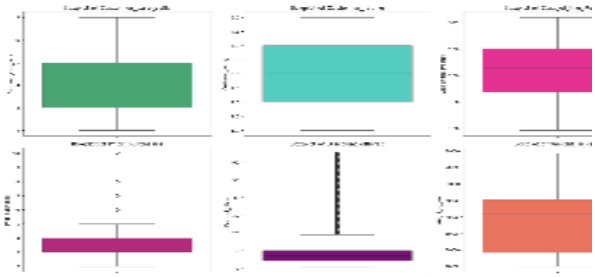


Figure 3: Spatial Distribution of Microplastics along Four Major Rivers in Bangladesh

Fibers were always the most common type of particle at all the locations, with 10–58 particles per site. Fragments were next, while foams, nurdles, and microfilms were less common. The numbers demonstrate that microplastic accumulation increases downstream, indicating the overall transfer of contaminants from upstream areas. Furthermore, variability across rivers reveals that the overall quantity of microplastics is affected by the measurement of the river, the way the water flows, and the amount of water that comes into the river. For example, the Meghna River is bigger and has a greater total quantity and more prominent downstream collections.

- Microplastic color

The four rivers have different colors of microplastics. The Meghna, the Jamuna, and the old Brahmaputra rivers consistently contained an abundance of dark blue and black particles. The two colors made up a major share of the entire microplastics.

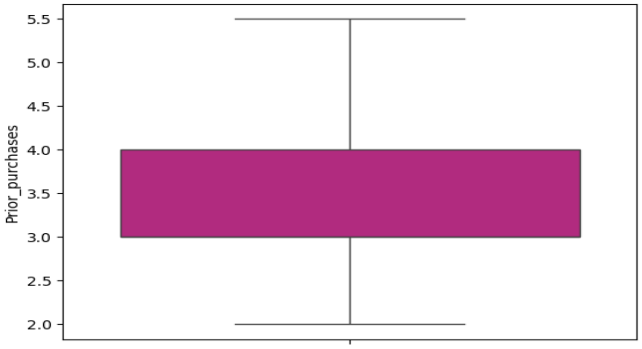


Figure 4: Color Distribution of Microplastics in Four Major Rivers

On the other hand, the Padma River had a larger number of dark blue and red microplastics, which shows that the distribution pattern was distinct from the other rivers. For the majority of parts, lighter colors like light blue, yellow, white, transparent, and orange were less prevalent across all rivers. Other colors, including green, grey, purple, and brown, were more abundant.

Microplastic Polymers

In this study, we identified and characterized a total of 6 types of polymers from 48 microplastic particles using ATR FT-IR spectrophotometry, selecting 12 from each river. These are namely polyethylene (PE), polypropylene (PP), polystyrene (PS), polycarbonate (PC), polyethylene terephthalate (PET), and cellulose acetate (CA). PE, PP, and PS were commonly found in all the rivers in varied percentages; particularly PET (2.1%) was found in the Jamuna River, PC (2.1%) was found in the Padma and Old Brahmaputra rivers, and CA (2.1%) was found in the Meghna. Overall, the most prevalent polymer was 48.5% PP, with PE (31.3%) and PS (14.6%) following in that order for the combined rivers. PE, followed by PP, PET, and PS, respectively, were previously found to be the predominant types of plastic polymers found in the sediment of the Ganga River Basin [10]. The polymers like PET, PP, and PS were also identified in the lower Brahmaputra River [11].

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IV. CONCLUSION

The results of this study indicated considerable occurrence of microplastics (MPs) at every station along all rivers, with an average concentration of 84, predominantly in fiber shape, blue in color, and mostly composed of polypropylene. It also gives a strong indication of an increased potential application in consumer products, plastic packaging, containers, textiles, ropes, bottle caps, food containers, and the straight-up disposal of plastic waste in waterways [12]. Moreover, the consistently highest levels of contamination in downstream accumulation zones reveal the interconnectedness of riverine systems, local human activities, and environmental factors such as rainfall, water discharge, velocity, and depth. The majority of the MPs that have been identified are colored, which is a concern due to their resemblance to marine organisms' prey, which highlights that they have a land-based origin [13]. Despite the ban on single-use plastics in Bangladesh, the significant level of microplastics in the rivers suggests noncompliance and a lack of effort to manage plastic waste, which violates existing policies and regulations. The present data will support the authorities in Bangladesh in taking action against plastic and microplastic pollution by implementing laws and regulations while also enabling research into the effects on aquatic life and habitats, ultimately impacting human health and improving approaches to address the problem.

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The Concrete Trap: Green Space Deficiency and Its Impact on Urban Health in Dhaka

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Abstract: **The research in this study is based on survey evidence from 27 respondents and supplemented with international literature and looks at the effect of green space deficiency on the mental and physical health of Bangladesh residents of Dhaka. The research concludes that even if residents stay a walking distance from parks, they shun them due to neglect, insecurity, and unavailability of facilities. Instead, recreation has the tendency to be pushed to commercial spaces or indoors, with resulting lower physical activity, stress, and worse well-being. Findings indicate that public demand for accessible, safe, and well-maintained green infrastructure is high. The paper concludes by proposing policy suggestions for integrating greenery into the planning of Dhaka city in order to improve health outcomes and livability.**

I.INTRODUCTION

The capital of Bangladesh, Dhaka, has emerged as one of the fastest-growing megacities in the world. There is an unprecedented spurt in concrete buildings as urbanization progresses. The growth comes at a fantastic price in terms of natural greenery, and it poses very serious questions about the health and happiness of the people. Scholars argue that access to urban greens greatly helps to alleviate stress, improve the quality of air, and encourage social interaction [5,7]. The absence of it creates space for what can be called a 'concrete trap', where the people are trapped within a increasingly artificial, health-depleting environment. The study examines the multi-dimensional impact of green space insufficiency on urban health in Dhaka. It seeks to acknowledge the effect of limited access to parks, quality parkland, open space, and indigenous vegetation on physical and mental health, especially among children, the elderly, and low-income individuals. Earlier research in urban areas has depicted that children who have wider exposure to green play spaces exhibit improved physical growth and mental ability [5], whereas older people especially gain benefits from strolling and meeting people outdoors [11]. In Dhaka, nevertheless, if someone wishes to enjoy natural scenery, he/she has to go to the outskirts of the city. For low- and middle-income families, renting a vehicle and booking a full-day outing just for the thrill of basking in vegetation is not practical and costly.

Restaurant settings then become the fallback entertainment option, where families spend substantial amounts on food, even when their main agenda is merely to spend quality time outside. Kids barely have safe opportunities for playing sports, crucial for their development, and the majority end up playing on roadsides, risking injury from accident and inconveniencing commuters. In the same way, elderly people are deprived of spaces to walk, exercise, and socialize — activities found through research to be determinants of active and healthy aging among developed world societies [4]. Overall, the lack of good quality green spaces, paired with rising pollution, heat, and traffic, will likely worsen mental health problems such as anxiety, depression, and stress, and erode city living standards overall in Dhaka. As cities all over the world turn to green infrastructure to mitigate urban health emergencies and enhance resilience [3], this research puts Dhaka into that global context, laying out the opportunities and challenges of more green in the city's grey.

II.METHODOLOGY

This study employed a mixed-method approach to examine how the lack of green parks in Dhaka affects both physical and psychological well-being. The study utilized quantitative data based on structured questions as well as qualitative responses from open-ended questions to achieve breadth and depth of understanding.

Survey design: Two sections were a part of a structured survey. The first section consisted of close-ended questions to obtain quantitative information on visit frequency to the park, journey time, most favored outdoor recreational activities, and self-assessed health condition. The second section comprised open-ended questions where respondents

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gave their personal experience and problems on outdoor recreation and access to green spaces.

Sampling and participants: A total of 27 respondents participated, recruited through convenience sampling from the researcher's personal and professional networks. While not representative of the entire Dhaka population, the sample captured a diverse mix of ages (young adults to elderly), occupations (students, service holders, homemakers), and household income groups (low to middle), allowing for varied perspectives.

Data collection: Both online and offline feedback were collected within a two-week window in July 2025 to ensure inclusivity.

Data analysis: Quantitative information were organized in a tabular form with descriptive statistics (percentages and frequencies). Qualitative responses were analyzed thematically, recording recurrent concerns such as safety, climate discomfort, and maintenance shortage. Triangulating both enhanced validity and provided a more balanced understanding of Dhaka's green space problems.

III. RESULTS AND DISCUSSION

Access but Underuse

Although 70% of respondents live within 30 minutes of a park, 100% reported not visiting regularly, instead opting for indoor or commercial alternatives (81% eating out, 67% staying home, 33% visiting friends).

High Latent Demand

A substantial 70.4% of respondents stated they would definitely visit parks if they were accessible and well-maintained, signaling considerable untapped demand for functional green spaces.

Poor Quality and Safety Concerns

- 63% described present park quality as "very poor," and 22% as "poor."
- 59% reported harassment or safety issues—most notably, women; 52% complained about lack of lighting or security.
- Environmental discouragements were heat (48%), air pollution (44%), and noise/crowding (33%).

Health Impact

- 74% characterized low physical activity, and 63% attributed this to repeated illness such as fatigue and frequent colds.
- 59% endured stress, anxiety, or boredom due to limited recreational spaces.
- Young children and adolescents are the most impacted, having too much television at home dominating their leisure time.

Community Support for Green Interventions

A staggering 89% also indicated that they would endorse initiatives like developing community parks, green rooftops and walls, child- and elderly-friendly playgrounds, wetlands and riverside conservation, and boosting overall security, cleanliness, and maintenance.

Oxfam Insights

An interview with Oxfam in Bangladesh's Head of Climate Justice & Natural Resource Rights, Dr. Mohammad Emran Hasan, cited the need for urban green infrastructure in building community resilience. Oxfam is increasingly focusing on urban resilience mechanisms, including green infrastructure to enhance community health and mitigate environmental pressures. Although Oxfam programs generally tackle broader climate threats, Dr. Hasan noted that having open, secure, and well-maintained green space within densely populated cities such as Dhaka can have substantial effects on physical and mental well-being, most importantly for disadvantaged populations.

Global Context & Inequalities in Green Space Cooling

Global research shows that cities in the Global South—such as Dhaka—receive far less cooling benefit from green spaces compared to cities in the Global North (around 1.9 °C versus 3.6 °C cooling effect). This shows a common disparity and highlights the need for superior urban greenery to address the challenge of heat stress in densely populated urban environments such as Dhaka.

Collectively, these findings—survey, thematic analysis, Oxfam expert input, and global evidence—depict a uniform picture: nearness is not in itself enough to ensure uptake; safety, beauty, and perceived benefit are the deciding factors. Additionally, the urban green infrastructure's climate mitigation capacity remains hugely under-realized in Dhaka.

IV.POLICY RECOMMENDATIONS

To turn around the acute shortage and underutilization of green space in Dhaka, city planners, private sectors, and civil society organizations need to adopt a multi-level approach founded on equity, safety, and sustainability. Informed by survey results, Oxfam observations, and global best practices in urban resilience, the following policy measures are recommended:

Green Infrastructure in Urban Planning

- Require all new residential and commercial construction to include accessible, child- and elderly-friendly parks within walking distance.
- Include zoning codes that maintain existing green spaces and enhance their utilization as public parks, particularly in impoverished communities.

Foster Vertical and Roof Top Greening

- Adopt policies mandating green roofs and vertical garden spaces for new buildings, both to optimize vegetation cover and alleviate heat stress.

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Provide tax incentives and subsidies for residents and builders for such green architecture.

Community-Based Parks and Recreation Centers

- Develop parks with accessible facilities (playgrounds, shaded picnic spots, walking paths, exercise stations) for all age groups.
- Make citizen participation in park planning to ensure the needs of the community, especially women, children, and the elderly.

Safety, Maintenance, and Governance

Establish public-private partnerships (PPPs) for park maintenance, with NGOs, local companies, and citizens' associations collectively maintaining the parks.

Improve safety with improved lighting, security patrols, and CCTV to address harassment concerns and encourage greater use by women and families.

Climate Resilience and Environmental Integration

[1] Set aside and renew wetlands, riverbanks, and abandoned areas as green corridors, improving biodiversity and open space for recreation.

[2] Make green space programs part of climate adaptation plans, recognizing the city greenery's role in reducing city heat and pollution.

Awareness, Engagement, and Equity

Organize city-wide public campaigns regarding the physical and mental well-being benefits of parks through community centers, schools, and media.

Promote community activities and green festivals in parks so that their utilization becomes a normality as secure, social spaces.

Ensure equal provision so that low- and middle-income households—who are hardest hit by the lack of green spaces—are provided with affordable recreation spaces.

By incorporating these recommendations into the urban development master plan of Dhaka, policymakers can proceed together to develop public health, social justice, and climate resilience. With current high public desire, an opportunity exists to rethink Dhaka not just as a megacity of concrete but as a city of balanced, sustainable green infrastructure.

V. Conclusion

This study establishes a striking correlation between Dhaka's lack of green spaces and residents' deteriorating physical and mental health. People live apparently next to parks but are dissuaded from utilizing them due to their poor condition, insecurity, and lack of amenities—using them instead to go to their indoor or commercial alternatives, which also encourages sedentary lifestyle, stress, and morbidity.

Still, Oxfam's strategic emphasis on urban resilience points the way to an under-studied path: green space that is accessible, safe, and well-maintained can be focal infrastructure for climate adaptation as well as for public health in rapidly urbanizing settings. The strong popular demand evidenced green interventions augmented by technical assistance—makes the case compelling. Above all, global evidence proves that expanding vegetation cover in Global South megacities like Dhaka can offer considerable temperature decrease benefits and health benefits—but as long as it is equitably and efficiently achieved. The fact that residents are willing to get involved, if areas were improved, gives a democratic mandate for instant urban greenings. In general, expanding access to secure and accessible green infrastructure is less a beautification process; one must work toward creating healthier, stronger, and more equitable future urbanisms for Dhaka and other megacities of the world.

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Integrating Sustainability and Digital Abilities in Education: A Framework for Developing Green Entrepreneurial Mindsets in Southeast Asia

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Abstract - **In the context of Industry 4.0 and pressing climate challenges, education must transform to foster both academic proficiency and a consciousness of sustainability and entrepreneurial mindset in young individuals. This article examines a conceptual and practice-oriented framework for integrating sustainability-oriented digital and entrepreneurial competencies into educational curriculum in Southeast Asia, specifically emphasizing Thailand and adjacent developing nations. This study outlines the intersection of digital learning technologies, entrepreneurship education, and Education for Sustainable Development (ESD) using data from recent doctoral research and relevant case studies. It examines how project-based and blended learning models strategically integrate sustainability themes—like the circular economy, climate resilience, and green innovation—to improve students' capacity for developing sustainable businesses. The report evaluates curriculum adaptability, instructional challenges, and institutional readiness for implementing this strategy. It proposes a scalable paradigm predicated on collaborations among educational institutions, technology providers, and the commercial sector to cultivate a new generation of socially responsible, technologically adept entrepreneurs. The results are anticipated to enhance policy dialogues and pragmatic approaches for harmonizing education with sustainability-oriented industry trends. By exploring how education may act as a transformative catalyst for sustainable business and technological innovation in the Global South, this paper aligns with the conference's main theme.**

Keywords - **Education for Sustainable Development (ESD), Green Entrepreneurship, Digital Learning, Sustainability, Curriculum Innovation, Southeast Asia, Technology in Education**

1. INTRODUCTION

Background and Rationale

The educational environment of the 21st century is being radically transformed by two global megatrends: the pressing need for sustainable development due to climate change and the rapid incorporation of digital technology associated with Industry 4.0. The traditional academic norms of educational systems in Southeast Asia must not be retained if the region is to cope with its twin problems of environmental fragility and economic development. They need to learn academic literacy and the entrepreneurial mindset, while ensuring that sustainability and particularly sustainability influenced by creativity and fluency in digital technology need to be developed.

Countries in Southeast Asia, including the Philippines, Vietnam, Indonesia, and Thailand, are undergoing rapid technological and economic transformation. Unfortunately, the amalgamation of technical expertise, entrepreneurial zeal and environmental commitment is not well-represented in educational policy or curricular. In such a scenario, there is a growing need for efforts to scale-up education for green entrepreneurship that focuses on enhancing education that stimulates green entrepreneurship as a conduit for the students to invent sustainable solutions for real-life challenges.

Problem Statement

Education for Sustainable Development to digitalization While Education for Sustainable Development (ESD) has increasingly been established in society in attempts to keep educating coming generations in a sustainable way, ESD is still fragmented regarding to connections with digitalization and education for entrepreneurship in Southeast Asia. Most syllabi are working on this in a stand-alone manner without the possibility of being either interdisciplinary or with an experiential dimension enabling them to be active, in terms of sustainability, as students. Furthermore, institutional inflexibility, absence of intersectoral coordination, and inadequate teacher readiness impede the implementation of these integrative frameworks.

Research Objectives

The paper aims to provide a theoretical framework and practical pedagogical model to embed sustainability, digital competencies and entrepreneurial education into the formalized educational education in Southeast Asia.

The specific objectives are:

To investigate the relationship between eLearning, entrepreneurship education and Education for Sustainable Development (ESD).

To examine best practices and explore examples of how sustainable themes can be infused in project-based and blended learning formats.

To assess the teaching challenges, curriculum adaptability, and institutional readiness for green entrepreneur education adoption.

To provide a scalable framework for helping students cultivate entrepreneurial mindsets that are motivated by sustainability and empowered by technology.

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Research Questions

- How can entrepreneurship education, digital skills, and ESD be successfully incorporated into Southeast Asian school curricula?
- What are the main factors that support and hinder the adoption of green entrepreneurship education?
- What pedagogical and institutional changes are necessary to underpin this holistic model of education?
- How can education in the Global South serve as a catalyst for the growth of entrepreneurial skills focused on sustainability?

Significance of the Stud*y*

This research contributes to theoretical discussions and has real world policy and practitioner implications for those interested in innovation, sustainability, and education. By providing a common reference, it provides education stakeholders, among them ministries, curriculum developers, teachers and the private sector involved in entrepreneurship, a tool for developing the green, digitally competent entrepreneur skills of students. The lessons have special value for emerging economies seeking to align human capital development with sustainability and digital transformation.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Education for Sustainable Development (ESD): A Global and Regional Perspective

Education for Sustainable Development (ESD) has become a pivotal strategy for realizing the United Nations Sustainable Development Goals (SDGs), especially Goal 4.7, which advocates for the attainment of knowledge and skills essential for sustainable living, human rights, and global citizenship. UNESCO characterizes ESD as a transformative educational process that enables individuals to make informed choices and engage in responsible actions for environmental sustainability, economic viability, and social justice.

A number of other models and methodologies, among them problem-based learning, experiential education, and systems thinking, represent sources being applied in different countries to integrate ESD into national curricula on a global level. However, uptake in Southeast Asia has been patchy. In Thailand, Education for Sustainable Development (ESD) is incorporated into the Basic Education Core Curriculum within the themes of civic and environmental education; nevertheless, its implementation is somewhat superficial and predominantly theoretical. Research has highlighted the lack of quantifiable competencies and insufficient integration with entrepreneurial or technical aspects.

Although ESD has be-come integrated with mainstream in Bangladesh in the form of national programmes on climate education (government of Bangladesh, 2010) and community awareness programmes, it is mostly delivered in the form of stand-alone modules. Two central problems: curriculum flexibility, teacher readiness. [5] have identified curriculum flexibility and teacher readiness as two of the crucial issues. Bangladesh and Thailand also encounter difficulties in integrating ESD within fast moving industrial and digital developments.

Digital Competencies in Education

Industry 4.0 has made it imperative for digital competencies for (a) continuous learning, and (b) optimizing economic competitiveness. Digital skills are not just technical abilities but they are also the capability to critically assess, to produce, and to innovate by means of digital media and collaboration. This encompasses everything from standardized LMS/ learning environments that integrate playful or simulated environments but also specialized programming, AI tutoring/ assessment tools, or blended learning.

Thailand In the framework of "Digital Thailand" policy in Thailand, the Thai Ministry of Education has implemented several ICT-in-Education projects, but is facing inadequate ICT infrastructure, digital pedagogy and accessibility in remote areas. Similarly, Digital Bangladesh of Bangladesh has introduced multimedia classrooms and teachers' training programmes; however, rural-urban divides and lack of investment in educational technology struggle to follow through in systemic incorporation.

Researchers [2] emphasize that digital preparedness in education necessitates more than mere access to devices; it demands institutional policies, teacher confidence, and student engagement frameworks adapted to specific local settings. There is less evidence of digital tools being utilized to promote sustainability or entrepreneurship education, indicating a necessity for integrative frameworks.

Entrepreneurship Education in Southeast Asia

Entrepreneurship education is widely regarded as a catalyst for job creation, innovation, and economic resilience, especially in post-pandemic recovery contexts. The ASEAN Secretariat has highlighted the importance of entrepreneurial skill development in its Education Work Plan (2021–2025), acknowledging its significance in safeguarding young from structural unemployment.

Although government programs like Thailand's OTOP (One Tambon One Product) program and start-up incubators aim to promote entrepreneurship at the grassroots level, their integration into regular education is still limited. On the other hand, Bangladesh has introduced entrepreneurial education at the university level, particularly in business schools; however, this is rarely incorporated into curricula at the school level or in line with sustainability goals.

Research from both countries points to a common shortcoming: project-based learning methods, contextual relevance, and interdisciplinary links with digital or environmental education are often absent from entrepreneurship education [4]. This emphasizes how entrepreneurial education needs to be rethought in a holistic way that aligns with technological advancements and global sustainability.

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Toward Integrated Frameworks: The Missing Link

According to recent interdisciplinary studies [36], entrepreneurship, digital literacy, and sustainability should not be viewed as distinct fields but rather as interconnected components of a future-ready educational system. An integrated framework in entrepreneurship education will enable students to identify problems (from ESD), develop solutions (ICT) and scale out through business model which is sustainable. However, contextually applicable models which implement this integration in countries such as Bangladesh, Thailand, and other similar Global South countries are missing from the literature. There are many studies on pilot projects or policy intentions, but they don't provide scalable, practice-oriented frameworks suitable to integrate into regular curricula.

Theoretical Framework

Two pertinent theoretical perspectives provide the theoretical foundation for this study:

Transformative Learning Theory (Mezirow, 1997) — Unsurprisingly, critical reflection and a change in perspective, central elements of a developmental mindset for sustainability, are core tenets of Transformative Learning Theory [12]. ESD promotes deep learning and responsible behaviour by having students be involved in projects they care about, of direct relevance to them and which challenge them to think.

Constructivist (Vygotsky, 1978): The socio-constructivist theory foregrounds the role of context, collaboration and authentic activity. It is focused on project-based blended learning that allows students to collaborate to construct understanding, especially around the use of digital tools and entrepreneurial problem solving.

When taken as a whole, these frameworks support the rationale for creating learner-centered, contextual, and sustainable innovation-focused educational interventions. Additionally, they contribute to the integrated model's instructional framework presented in this study.

3. METHODOLOGY

Research Design

In this study, a mixed-methods research design was employed [13] by employing qualitative and quantitative research methodologies to develop and to empirically test a conceptual framework which concerned in sustainability, digital competencies, and entrepreneurial education in Southeast Asia, particularly in Thailand and Bangladesh. The mixed-method design facilitates extensive analysis, by amalgamating data derived from doctoral research with the results of pertinent case studies and interviews with stakeholders.

3.2 Population and Sampling

The study population consisted of:

Primary, secondary and post-secondary education providers in Thailand and Bangladesh implementing initiatives on sustainability, digital learning, or entrepreneurship.

Education policymakers and curriculum developers engaged in the integration of various fields.

Teachers and students took part in related activities.

Sampling methods: Purposive sampling is also used to select 8–10 institutions that will represent a range of urban, and rural areas in both nations.

Snowball sampling aids in identifying the key policymakers and education experts, in. interview in depth.

Approximately 300 students (150 from each country) who participated in the pilot programs or the related courses, were selected to the quantitative phase in order to examine what and how well they learned and what they thought about.

Assembles Instruments and Procedures for Data Collection

Document review: National curricula, policies and program guidelines were reviewed to assess institutional readiness and integration of the curriculum.

Surveys: Students completed questionnaires to assess their ICT competences, their knowledge about sustainable issues of the ICT, and their entrepreneurial mindset using previously validated instruments in the literature.

Semi-structured interviews: Administered to teachers, curriculum developers, and policy makers to examine the issues and solutions and perspectives on integrated Instructional methods.

Case study: The pilot initiatives in Thailand and Bangladesh were compared as cases to provide contextual insights about best practices and challenges.

Validity and Reliability

The survey questionnaire was subjected to content validation by three educational specialists in sustainability and digital pedagogy.

A pilot test involving 30 students was performed to assess clarity and internal consistency; the resulting Cronbach's alpha for essential measures surpassed 0.80, signifying strong reliability.

Academic supervisors reviewed interview protocols to ensure alignment with study objectives.

Data Analysis

We analyzed the quantitative data obtained from the student questionnaires using SPSS (version 26). Descriptive statistics, such as means and standard deviations, described the sample, while inferential statistics, such as t-tests, ANOVA, and correlation analysis, looked at the relationships between variables, such as digital skills and an entrepreneurial mindset.

Qualitative data obtained from interviews and case studies were transcribed verbatim and analyzed thematically using NVivo software. Coding was performed iteratively to identify

themes related to institutional readiness, pedagogical approach, and implementation barriers.

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Data source triangulation was utilized to augment the credibility and depth of the findings.

3.6 Ethical Considerations

The Institutional Review Board (IRB) of Shinawatra University and the relevant authorities in related institutions gave their ethical approval.

All participants gave their informed consent, which protected their privacy and anonymity.

The data were kept safe and only authorized researchers could access them.

This methodology section lays out a clear and organized way to build your framework, based on both scientific evidence and qualitative insights.

SAMPLE SURVEY INSTRUMENT: MEASURING SUSTAINABILITY, DIGITAL COMPETENCY & ENTREPRENEURIAL MINDSET

Instructions: Please respond to the following statements based on your experience. Use a 5-point Likert scale:

1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree

Section A: Sustainability Awareness

- I understand the basic ideas behind environmental protection and sustainability.
- I know that what people do affects climate change.
- My education has taught me how to solve real-world problems in a way that sticks.
- I do projects that help the environment be healthy.

Section B: Digital Competency

I can definitely learn to use digital tools and technologies for school work.

I can use the web as a way to collaborate on group projects that is productive.

I can judge how reliable digital information sources are.

I can create digital content, such as presentations, movies, blogs.

Section C: Entrepreneurial Mindset

I have the ability to create and manage projects from the concept to the final result.

I'll take risks to learn new things.

I say that starting a business can be a path to long-term growth.

I say that starting a business can help with long-term growth.

Demographic Information (not required)

Age:

Gender:

Level of education:

School name (optional):

SAMPLE SEMI-STRUCTURED INTERVIEW GUIDE

Purpose: To investigate how different dimensions of the addition of sustainability, digital skills and business education to the curriculum are perceived through the lenses of institutions, teachers and policy.

Opening Questions

- Can you lay out where you stand on and what you've done with educational programs around sustainability, digital learning or entrepreneurship?
- How well prepared is your school to deliver a curriculum that emphasizes sustainability, digital and business skills?
- What is the existing state and state of practice to support this integration?

Curriculum and Pedagogy

How are concepts of sustainability and entrepreneurship integrated in teaching?

Do people make good use of digital tools?

How well does the curriculum support learning that crosses disciplines or is based on projects?

Challenges and Barriers

What are the main challenges faced by teachers and administrators when they try to use this integrative framework?

What do students think of programs like these?

Are there cultural or contextual factors relevant to the engagement?

Collaboration and Support

What kinds of partnerships (with businesses, NGOs, and tech companies) are needed or already exist to improve education for green entrepreneurs?

How do the rules and money from the government affect how well you can come up with new ideas for your curriculum?

Future Outlook

What changes or help will best help your school move forward in teaching digital and entrepreneurial skills along with education for sustainable development?

What do you think about how important education is for encouraging long-term business innovation in the area?

4. RESULTS

Table I: Analyzing Quantitative Data

Variable	N	Mean	Std. Deviation	Minimum	Maximum
Sustainability Awareness	300	4.12	0.58	2.5	5
Digital Competency	300	3.87	0.65	2	5
Entrepreneurial Mindset	300	3.95	0.62	2	5

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4. Results and Proposed Framework

Quantitative Results

We did a quantitative analysis of survey data from 300 students in Thailand and Bangladesh who took part in programs for sustainability, digital learning, and entrepreneurship education.

Statistics that describe Table 1 shows that the students were somewhat aware of sustainability (M = 4.12, SD = 0.58), good with technology (M = 3.87, SD = 0.65), and had an entrepreneurial attitude (M = 3.95, SD = 0.62). The correlation analysis (Table 2) showed that all of the variables were strongly related to each other in a positive way.

Long-lasting Awareness demonstrated a significant correlation with Entrepreneurial Mindset ($r = .62$, $p < .01$) and Digital Competency ($r = .56$, $p < .01$). Digital Competency showed a positive relationship with Entrepreneurial Mindset ($r = .48$, $p < .01$).

This indicates that enhanced digital competencies and awareness of sustainability correlate with more robust entrepreneurial attitudes among students.

A t-test comparing nations revealed that Thai students outperformed Bangladeshi students in Entrepreneurial Mindset ($t(298) = 2.89$, $p = .004$), potentially indicating disparities in curricular exposure and institutional support.

Qualitative Findings

Interviews with educators, policy-makers and curriculum developers were thematically analysed and three fundamental themes emerged.

Institutional Preparedness and Challenges

Both countries are committed to expanding green and digital education but the challenges include lack of teacher preparedness, lack of resources and infra structural issues, particularly in the rural areas.

"We have digital tools, but the hard part is getting teachers to use them well for projects that will last." (Interviewee 5, Thailand)

Curriculum Flexibility and Pedagogical Innovation

Project-based and mixed learning methodologies were valued but limited by rigid curriculum frameworks and examination requirements.

"Flexibility is key to integrating themes from different fields, but traditional syllabi make it hard." (Interviewee 8, Bangladesh)

Collaboration and Multi-Stakeholder Engagement

Working with NGOs, tech companies, and local businesses has become a way to make practical entrepreneurial education possible while also meeting sustainability goals.

"Collaborations make students' projects more real by connecting what they learn in class to what happens in the real world." (Interviewee 3, Thailand)

4.3 Proposed Framework: Integrating Sustainability, Digital Abilities, and Entrepreneurial Mindsets

Based on these results, a scalable and practice-oriented framework is suggested (see Figure 1).

Key Components:

1. Curriculum Integration Layer:

The three-layer integration of digital literacy, entrepreneurial skills and Education for Sustainable Development (ESD).

Utilizes project-based learning or PBL, blended learning, and addressing real-world challenges, which relates to sustainability.

Institutional Support Layer:

This features training workshops for teachers working around e-pedagogy and eco-edu aqua culture.

Ensures that infrastructure is in place, such as adequate technology, digital platforms, and flex scheduling.

Collaborative Ecosystem Layer:

This level of autonomy allows schools, companies, NGOs or government bodies to collaborate with one another more easily.

Assists in securing internships, mentorship, and access to networks of green innovation.

Student Empowerment Layer o Promotes entrepreneurial mindset such as innovative or risk-taker or socially responsible.

Promotes digital innovation to support businesses going green.

Framework Application and Benefits

This approach enables schools in Thailand, Bangladesh, and similar countries to:

Make it easier for students to work on climate, sustainability and other issues by bringing back entrepreneurial journeys.

Level up your digital skills to help you arrive at innovative, long-lasting solutions.

Supporting systemic change by integrating curriculum, teaching practice, institutional preparedness and partnerships with outside organizations.

Ensure that education objectives are consistent with local economic and environmental imperatives in the area and produce a new generation of green entrepreneurs.

Table II: Integrating Sustainability, Digital Skills, and Entrepreneurial Education

Layer	Focus Areas	Expected Results
1.Student Empowerment	Novelty and creativity - Risk-taking and proactiveness - The environment and society.	A business case for going green - student driven initiatives for sustainability

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2. Curriculum Integration	Digital literacy and entrepreneurialism - Project-Based and Blended Learning - Real-worldproblems - Education for Sustainable Development (ESD)	Interdisciplinary skills - hands-on-learning, sustainability focus
3. Institutional Support	Training of teachers in ESD and digital teaching - Learning platforms and infrastructure - Flexible curriculum representation	Creating learning spaces – teachers empowered and schools prepared for technology
4. Collaborative Ecosystem	Corporate partners, tech companies and NGOs - Mentoring, internships and centers for new ideas - Government help and policy	— Exposure to the world beyond school, adaptable pathways from school to work

5. DISCUSSION

Fusing digital skills, sustainability and entrepreneurialism

This study supports the general linkage between awareness of environment, digital literacy and the development of entrepreneurial mind-set in the students of Southeast Asia. The strong positive associations revealed in the quantitative analysis lend support to the theoretical assertion that these dimensions are mutually reinforcing foundations of future-ready schooling. This finding supports the findings of [22.12] promoting comprehensive learning promotion and transversality in ESD.

Challenges in Institutions and Teaching

The qualitative results emphasized long-standing constraints in institutional readiness, particularly with respect to training of teachers and infrastructure—problems that previous research in Thailand [29] and Bangladesh [26] have also found. These results call for substantial teacher training and flexible curriculum models to facilitate the effective integration of green entrepreneurial education. The tension between a highly prescriptive curriculum and innovative educational methods like project-based learning is a few of the complex issues that emerge in education reform in emerging democracies.

5.3 What Collaborative Ecosystems Do

The emerging problem of multi-stakeholder collaboration illustrates how connections between schools, business and civil society can make a difference. Such networks comprised reality based learning environments and resources which facilitate students F entrepreneurial experiences, corroborating the literature on EECs [12]. If anything, laws should facilitate and promote the growth of green entrepreneurships education.

Implications for policy and practice

Our proposed integrated approach provides a scalable approach for education systems in Thailand, Bangladesh, and over other (6) South-Asian countries to address the current inequality. Sustainability and digital literacy need to be baked into programs that train people to start their own businesses. That way the lessons would be current with the latest technology and environmental and technology issues.

And investing in developing teachers' skills and digital infrastructure is just as critical to getting this policy to work on the ground. By connecting learning objectives with local efforts at sustainability, we can more effectively educate students who are prepared to lead innovation toward a green economy.

Constraints and Prospective Investigations

This research presents broad conceptual and empirical groundwork, but is limited in its focus to select institutions in Thailand and Bangladesh. It requires verification in other contexts in Southeast Asia and for different levels of schooling. Longitudinal studies focusing on the effects of continued integrated sustainability and business education in student outcomes and the local economy would be useful. Moreover, there could be some empirical studies on focused instructional interventions in this framework to enhance best practices.

6. CONCLUSION AND RECOMMENDATIONS

Conclusion

The paper provides a full framework to implement Sustainability - Digital Skills - Entrepreneurial mindset system integration into educational systems in Southeast Asia (with focus on Thailand and Bangladesh). Quantitative and qualitative findings echo a pervasive interdisciplinarity among a wide array of fields, and illuminate opportunities and challenges that accompany efforts to enact integrated education. The proposed framework articulates curriculum innovation, institutional preparedness, multi-stakeholder participation, and enhanced student participation as key components for nurturing environmentally friendly entrepreneurial mindsets to address urgent environmental and socio-economic challenges. Education can be a major force in sustainable development and economic recovery in the Global South by preparing a generation of technologically savvy and community-responsible entrepreneurs.

Suggestions

The findings led to the following recommendations:

1. Policy Change: The education ministries need to legislate policies: where ESD, digital literacy, entrepreneurship education are explicitly included in the national curriculum.

2. Teacher Professional Development: Help teachers gain more expertise in digital pedagogy and sustainability-focused entrepreneurship, so they feel more prepared to be successful.

3. Curriculum flexibility: Promote the use of blended learning and project-based learning that allow cross-disciplinary methods to be effectively used and real-world problems to be solved more easily.

4. Infrastructure and Resources: Ensure it's easier for green innovation to access digital tools, platforms and networks — particularly in rural schools and undersourced communities.

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5. Collaborative Partnerships: Join forces with schools, businesses, government and community groups to make it more cost-effective for people to learn from one another, find mentors and secure funding.

6. More Research: Do a better job of allowing long-term and experimental studies to determine how well integrative educational frameworks work and how best to implement them.

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Media Representation of Entrepreneurs in Bangladesh's Business Landscape: A Gender-Based Analysis

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Abstract: **This study examined how entrepreneurs were represented in Bangladeshi media with particular attention to gender differences. Using a qualitative design, a purposive sample of 60 articles was coded for tone, narrative frames, visuals, and gendered language. In addition, a focus group discussion (FGD) was conducted with five entrepreneurs representing diverse sectors. Results showed that while all media coverage was positive in tone, approximately 18% of articles contained explicit gendered framings, most often applied to women through family or emotional narratives. Visuals largely depicted entrepreneurs in solo or workplace contexts, but family images appeared mainly in women's stories. FGD participants confirmed unequal access to coverage, biased questioning, and the risk of misrepresentation, though they also stressed the credibility benefits of positive media visibility. The findings underscore how media both uplifts and stereotypes entrepreneurs, and they highlight the need for gender-sensitive reporting, journalist training, and systematic coverage of entrepreneurship in Bangladesh.**

Keywords**: media representation, gender, entrepreneurship, Bangladesh, content analysis, focus group.**

I. INTRODUCTION

Entrepreneurship has become an increasingly important driver of Bangladesh's economic and social development, spanning startups, small businesses, and emerging digital enterprises. The media plays a pivotal role in shaping the public imagination of entrepreneurship by selecting whose stories are told, highlighting specific entrepreneurial qualities, and framing narratives that influence perceptions of legitimacy and success. In contexts like Bangladesh, where cultural norms and gender roles are deeply embedded in public life, media representation becomes more than a reflection of reality. It actively shapes the boundaries of opportunity. So, the study asked: (1) What dominant frames are used to portray. entrepreneurs? and (2) Do representations differ by gender?

Existing literature has demonstrated that gender bias in media representation remains a persistent global phenomenon. For example, Wang [1] found that over 65 percent of surveyed female entrepreneurs reported experiencing negative effects of biased reporting on their entrepreneurial spirit, while about 70 percent believed the media did not fairly represent their businesses. Such findings highlight how media narratives can reinforce inequality by dampening women's confidence and limiting their access to recognition. Other studies suggest that media depictions often confine female entrepreneurs to stereotypical frames. [2] analyzed portrayals of women in a lifestyle magazine and found that entrepreneurship was presented as domestically centered and tied to traditionally female activities. This framing not only narrowed the perceived scope of women's entrepreneurial activities but also influenced how stakeholders such as clients and financiers interacted with them. At the same time, comparative studies reveal that media play a role in strengthening entrepreneurial ecosystems by transmitting shared cultural narratives. [3], in their comparative analysis of local newspapers, showed that media representations often foreground ambition, success, and innovation, which can inspire collective entrepreneurial identity. However, they also found gaps: risk-taking and failure were less visible, and representations varied across regions, reflecting differences in ecosystem maturity. Taken together, these studies show that the media does not merely mirror entrepreneurship; it constructs its meaning and legitimacy in gendered and context-dependent ways. Yet, in Bangladesh, systematic research on how entrepreneurs, especially women, are represented in the media remains limited. This paper addresses this gap through a gender-based analysis of media coverage of entrepreneurs, combining content analysis of 60 articles with focus group insights from practicing entrepreneurs.

II. METHODOLOGY

A. Content Analysis

A purposive sample of 60 media articles was collected online from three leading outlets in Bangladesh: *The Daily Star* (20 articles), *Prothom Alo* (20 articles), and *The Future Startups* (20 articles). Articles were selected to capture feature-style coverage of entrepreneurs between 2020 and 2024. Each article was coded using a structured matrix covering:

Gender of entrepreneur(s) (male, female, mixed, unclear)
Business sector (e.g., tech, retail, creative industries)

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Tone (positive, neutral, negative, or mixed)
Narrative frames (e.g., innovation, success, resilience, family, policy)
Visual representation (portraits, family, workplace, product, event)
Gendered language or stereotypes (family/household emphasis, emotional framing, appearance-based descriptions, "despite being a woman," etc.)

The coding scheme was adapted from existing media studies frameworks and is provided in Appendix A.

B. Focus Group Discussion

An FGD was conducted with five entrepreneurs (two women, three men), representing diverse ages (below 18 to above 35) and sectors (clothing, crafts, edtech, marketing & advertising, and social enterprises supporting disabled people). Four of the five participants had prior media exposure through television, newspaper, or online media.

The FGD explored entrepreneurs' perceptions and experiences of media representation, focusing on themes of accessibility, fairness, gender differences, and impacts on credibility (Appendix B). The session was recorded in detailed meeting minutes and thematically analyzed.

III. RESULTS

A. Content Analysis

Table 1. Gender of Featured Entrepreneurs

Gender of Entrepreneur	Frequency	Percentage
Male	24	40.0%
Female	23	38.3%
Mixed/Multiple	11	18.3%
Not specified/unclear	2	3.3%
Total	60	100%

All articles were coded as having a positive tone.

Table 2. Narrative Frames in Articles

Narrative Frame	Prevalence	Notes
Success/Achievement	High	Awards, recognition, growth
Innovation/Leadership	High	Vision, creativity, risk-taking
Resilience/Struggle	Moderate	Overcoming barriers
Social Contribution	Moderate	Community /social impact
Technical/Business Detail	Moderate	Market, finance, product detail
Family/Human-interest	Low	Emphasized mainly for women
Policy/Institutional	Rare	Government, ecosystem focus
Controversy/Critique	Very low	Not observed in this sample

Visuals reinforced these patterns: solo portraits and workplace/team photos dominated, while family images were rare but appeared mainly in women's profiles.

About 18 percent of articles included gendered language or stereotyping. The most frequent were family/household emphasis and emotional/maternal framing. B. Focus Group Discussion

Table 3. Participant Demographics

Participant	Gender	Age Group	Sector	Media Exposure
P1	Male	<18	Edtech	Yes
P2	Male	26-35	Marketing & Advertising	Yes
P3	Male	26-35	Crafts	Yes
P4	Female	18-25	Clothing	Yes
P5	Female	>35	Home decor	No

Themes and Illustrative Quotes

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Access to Coverage: Media attention often required references or hype. Early ventures struggled. *"Initially, the media don't give attention; once there's hype, then they get attention".*

Selective and Biased Framing: Women-led ventures were often highlighted for novelty rather than substance.
"You all got featured because you all were girls".

Gendered Questioning: Women were asked personal or family questions, while men faced business queries.
"For men, they only ask about the business, but for women, they ask if the husband or in-laws allowed her".

Impact of Coverage: Coverage enhanced credibility but risked harm when misrepresented. *"When donors do background research, positive news is a good sign".*

Recommendations: Participants urged media reform and training. *"Media should focus on the entrepreneur's work, not gender".*

IV. DISCUSSION

The triangulation of content analysis and FGD findings paints a nuanced picture of media representation of entrepreneurs in Bangladesh. On the surface, coverage was overwhelmingly positive, yet deeper analysis reveals unequal access and gendered portrayals.

First, visibility itself is uneven. Entrepreneurs with PR support, references, or competition success were more likely to attract coverage, while early-stage founders struggled. Positive tone, therefore, conceals structural inequalities in access.

Second, gendered patterns persist. About one in five articles included stereotypes, emphasizing family roles or emotional qualities. FGD participants confirmed that women faced more personal and intrusive questioning, while men were asked strictly business-oriented questions. These framings reinforce traditional gender roles and risk undermining women's credibility.

Third, coverage functions as credibility capital. Media visibility influences donor and investor confidence, directly affecting entrepreneurial opportunities. However, sensational or tokenistic portrayals, as described in the FGD, may backfire and damage reputations.

Finally, outlet differences reflect broader editorial incentives. Mainstream dailies leaned toward human-interest and novelty, while *The Future Startups* highlighted technical and leadership narratives. This points to a tension between audience-driven virality and substantive representation.

Taken together, the findings suggest that Bangladeshi media both amplify and constrain entrepreneurship. The challenge lies not in tone but in access and framing, issues that call for more systematic and gender-sensitive media practices.

V. CONCLUSION

This study makes three contributions. First, it documents that Bangladeshi media portray entrepreneurs positively but unevenly, with access depending on PR, networks, or visibility events. Second, it highlights how gendered framings persist in nearly one-fifth of coverage, disproportionately affecting women. Third, it shows that media visibility directly influences entrepreneurial credibility, yet misrepresentation can cause reputational harm.

Limitations include the small FGD sample of five entrepreneurs and reliance on a purposive dataset of 60 articles. Broader surveys and cross-regional comparisons could enrich future work.

Practical recommendations include training journalists in gender-sensitive reporting, dedicating media segments to entrepreneurship, and supporting underrepresented entrepreneurs with communications resources. Policymakers and ecosystem actors should recognize that media narratives are not neutral but help construct entrepreneurial opportunities.

Future research should examine how new media platforms, such as YouTube and social media influencers, are shaping entrepreneurial representation in Bangladesh.

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Appendices

Appendix A. Content Analysis Coding Scheme

Variable: Gender of Entrepreneur

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- 1 = Male
- 2 = Female
- 3 = Mixed/Multiple
- 4 = Not specified/unclear

Variable: Sector

- 1 = Tech
- 2 = Retail/Trade
- 3 = Real Estate
- 4 = Finance/Banking
- 5 = Education
- 6 = Health/Pharma
- 7 = Food & Beverage
- 8 = Creative/Media
- 9 = Manufacturing
- 10 = Services (youth development, training, consulting, travel & logistics, etc.)
- 11 = Agriculture/Agri-business
- 12 = Mixed
- 13 = Other/Not specified

Variable: Tone

1 = Positive
2 = Neutral
3 = Negative
4 = Mixed (praise and critique)

Variable: Narrative Frame

- 1 = Success story (achievement, growth, recognition)
- 2 = Resilience/Struggle (overcoming barriers)
- 3 = Innovation/Leadership (visionary, risk-taking)
- 4 = Family/Human-interest (personal life, family role)
- 5 = Social contribution (impact on community/society)
- 6 = Technical/Business (strategy, finance, market detail)
- 7 = Controversy/Critique (failure, scandal)
- 8 = Policy/Institutional (government, regulation, ecosystem)

Variable: Visuals

0 = No image
1 = Solo portrait
2 = With family
3 = Team/Workplace context
4 = Product/Building focus
5 = Group photo (event/conference)

Variable: Gendered Language/Framing

- 0 = No gendered language
- 1 = Family/household emphasis
- 2 = Emotional/maternal framing
- 3 = Appearance-focused
- 4 = “Despite being a woman” framing
- 5 = Masculinity/leader trait emphasis
- 6 = Other stereotypical framing

Appendix B. Focus Group Discussion (FGD) Questions

[1] Could you briefly introduce yourself, your business, and have you or your business ever been featured in the media?
[2] How do you feel entrepreneurs in Bangladesh are generally represented in the media?
[3] Have you personally had any positive or negative experiences with media coverage?
[4] Do you feel that media coverage helps or hinders your business's credibility?
[5] From your perspective, do male and female entrepreneurs receive different kinds of coverage? In what ways?
[6] (To women) Do you feel your stories are framed differently compared to men?
[7] (To men) How do you perceive media coverage of women entrepreneurs compared to men?
[8] What role do you think the media should play in promoting entrepreneurship fairly across genders?
[9] What changes would you like to see in how Bangladeshi media covers entrepreneurs?

Appendix C. Media Article Sample

https://www.thedailystar.net/life-living/news/tanvir-shahriar-inspiration-young-entrepreneurs-bangladesh-3141896
https://www.thedailystar.net/business/news/mentor-women-entrepreneurs-business-leaders-3289561
https://www.thedailystar.net/tech-startup/news/meet-rousseau-kazi-the-bangladeshi-born-ceo-and-co-founder-the-other-threads-3364831
https://www.thedailystar.net/campus/campus/news/bangladesh-silicon-valley-the-draper-university-experience-3701201
https://www.thedailystar.net/tech-startup/news/bangladeshi-born-australian-named-business-person-the-year-australian-financial-review-3773711
https://www.thedailystar.net/youth/young-icons/news/introducing-winners-joy-bangla-youth-award-2021-2933696
https://www.thedailystar.net/youth/young-icons/initiative/news/dydf-strives-more-inclusive-world-2957021
https://www.thedailystar.net/news/bangladesh/news/moner-school-gets-global-recognition-2181156
https://www.thedailystar.net/lifestyle/interview/news/aspirations-and-towering-responsibilities-1894732
https://www.thedailystar.net/star-youth/news/guiding-light-the-visually-impaired-2967716
https://www.thedailystar.net/star-youth/news/lighting-lives-through-eco-friendly-practices-2198856
https://www.thedailystar.net/star-youth/news/working-towards-inclusive-society-1903453
https://www.thedailystar.net/star-youth/news/looking-back-reflective-teens-eventful-decade-3644886
https://www.thedailystar.net/daily-star-books/news/sister-library-discusses-book-travelling-woman-3252976

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https://www.thedailystar.net/business/economy/news/women-entrepreneurs-pushing-forward-economic-growth-pabna-3237761
https://www.thedailystar.net/supplements/22nd-bangladesh-business-awards/news/trailblazer-women-business-3737396
https://www.thedailystar.net/lifestyle/news/empowering-women-entrepreneurs-bangladesh-the-role-smes-and-ebl-women-banking-3765781
https://www.thedailystar.net/supplements/32nd-anniversary/the-changing-middle-class-story/news/women-the-move-making-travelling-easier-3246061
https://futurestartup.com/2025/07/16/building-krenovator-an-interview-mahadhir-yunus-founder-and-ceo-krenovator-technology/
https://futurestartup.com/2025/03/24/an-interview-with-ratul-rahman-hubxpert-p2/
https://futurestartup.com/2024/11/17/the-art-of-building-the-future-06-fascinating-founder-interviews-on-entrepreneurship-and-life/
https://futurestartup.com/2024/10/24/conversation-with-alvi-sakib-and-ayaz-hossain-jomee-jomaa/
https://futurestartup.com/2024/10/15/taabu-ekduaria-and-creating-a-sustainable-village-tourism-model-in-bangladesh-with-jafar-tuhin-founder-taabu-ekduaria-village-homestay/
https://futurestartup.com/2024/10/09/how-to-build-the-future-4-must-read-founder-interviews/
https://futurestartup.com/2024/09/19/wasiul-haque-bhuiyan-ohmtech-electronics/
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https://futurestartup.com/2024/06/16/08-inspiring-founder-interviews/
https://futurestartup.com/2024/05/01/irfan-rafique-founder-supplyline/
https://futurestartup.com/2024/02/19/aminul-islam-ayykori-digital-ltd/
https://futurestartup.com/2023/09/27/ayman-sadiq-10-minute-school-the-future-of-edtech-navigating-fame-and-building-an-organization-part-ii/
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https://futurestartup.com/2023/09/05/rayana-hossain-on-growing-isho-furniture-business-designing-organizational-dynamism-and-upsides-of-being-yourself/
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https://futurestartup.com/2023/07/23/founder-at-work-abdul-gaffar-sadi-co-founder-and-ceo-drutoloan/
https://futurestartup.com/2023/05/26/rare-al-samir-interactive-cares-edtech/
https://futurestartup.com/2023/01/09/azra-salim-shombhob-health/
https://futurestartup.com/2022/09/07/sadia-haque-on-the-evolution-and-ambition-of-sharetrip-emerging-travel-trends-and-the-future-of-travel-in-bangladesh/
https://tinyurl.com/4sbf2fvn
https://tinyurl.com/muddfhj7
https://tinyurl.com/pafdjyjv
https://tinyurl.com/mtf7v2kz
https://tinyurl.com/mrxp5mxf
https://tinyurl.com/3s5bhkpz
https://tinyurl.com/2x3c7jyu
https://tinyurl.com/5bmpw3xy
https://tinyurl.com/49jwr54v
https://tinyurl.com/4bf38bvv
https://tinyurl.com/ye5na56y
https://www.prothomalo.com/business/corporate/gnltlzvoq2
https://www.prothomalo.com/business/%E0%A6%89%E0%A6%A6%E0%A7%8D%E0%A6%AF%E0%A6%95%E0%A7%8D%E0%A6%A4%E0%A6%BE/5xvvrur9bx
https://www.prothomalo.com/business/%E0%A6%89%E0%A6%A6%E0%A7%8D%E0%A6%AF%E0%A7%8B%E0%A6%95%E0%A7%8D%E0%A6%A4%E0%A6%BE

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Empowering First-Time Entrepreneurs with Uddokta AI: A Rule-Based and AI-Enhanced Business Advisory System

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***Abstract*—UddoktaAI is a AI-driven platform that can assist First time entrepreneurs in Bangladesh in the absence of formal business training or expert mentorship. The platform solves common and key issues that new entrepreneurs have conventionally faced, such as difficulty in determining competitive product prices, planning business expenditure, stocking effectively, and organizing sufficient marketing strategies. UddoktaAI steps in at such points with Bengali step-by-step instructions, simplifying difficult business ideas and making the users equipped with functional tools granting them confidence in making decisions. Its main features are smart price calculators, template business checklists, carefully curated sourcing tips, and an AI module for creating marketing concepts, all tailored to the specific socio-economic environment of Bangladesh.With the inclusion of rule-based reasoning and weak artificial intelligence, UddoktaAI provides personalized advice, which takes into consideration the unique requirements, businesses, and financial means of users. The portal is open to all and is aimed at students, homemakers, and small-town entrepreneurs with minimal digital or financial awareness. Contrary to universal global tools, UddoktaAI incorporates localized information and vernacular help, enabling users to better manage entrepreneurial challenges.**

A virtual mentor and not just a digital platform, UddoktaAI enables users to conceptualize, launch, and develop their businesses in a sustainable manner. It makes it easier for promotion of financial independence and greater access to eco systemic opportunities through the bridging of the knowledge divide between urban startup culture and semi-urban or rural enterprise development. With this initiative, UddoktaAI aims to democratize entrepreneurial access and pursue inclusive economic progress for Bangladesh's budding business ecosystem.

***Index Terms*—UddoktaAI, entrepreneurship, AI platform, Bengali language support, startup guidance, business tools, marketing strategies, pricing calculators, sourcing suggestions, first-time entrepreneurs, Business Assistant.**

I. Introduction

There has been an amazing increase in entrepreneurial businesses in Bangladesh in recent years, primarily due to the abundance of motivated young women and men engaging in entrepreneurial activity to capitalize on the potential investment opportunities. Many budding entrepreneurs face considerable challenges, especially since most do not have formalbusiness education and have to rely on their limited means of resources for support. Opportunities for entrepreneurs exist in Bangladesh on venues such as Facebook Marketplace, or websites to allow businesses to showcase themselves, however, the process of running a business is complicated enough as it is, and navigating those processes is problematic without proper guidance. Now, the challenges include figuring out the best pricing strategy, controlling expenses, where to source product or supplies from, and marketing and promoting their businesses; especially being the fact that most of them do not have the specialized training. In many cases, due to the high costs of consulting services, and the inherent lack of resources that is in their native language, this has created a considerable chasm in support for well-meaning, committed entrepreneurs that have a considerable amount of cognitive or educational support needed. To that end, UddoktaAI has been developed, an AI-powered business advising platform, tools, and resources that are all contextually relevant to Bangladesh. UddoktaAI has been developed to be user-friendly and Bengali-centered, to give business owners the ability to start, run, and grow their businesses successfully. UddoktaAI will be home base for all of Bangladesh in the future, where business knowledge is available to everyone and entrepreneurs can go after their business intended goals without hesitation. UddoktaAI will continue to improve, based on user feedback, adopted by the platform to make it better and stronger assist , to build a community that supports small businesses and create a next generation of entrepreneur that is independent.

II. Literature Review

Artificial Intelligence (AI) is beginning to change the speed of decision-making in business and will do so in scenarios of time frames of use, easily less than one hour. More importantly, I believe AI will definitively improve the decision-making processes of many users in environments where business education and consultancy are neither widely available nor commonly used. For example, AI-enabled decision support systems have been demonstrably effective for individuals lacking business expertise or business fundamentals to be able to complete complex business processes - especially in developing countries like Bangladesh.Rather, they inves- tigate the potential of digital entrepreneurship platforms in emerging economies. Findings, highlighted local language support, contextualization, and design for a low digital literacy audience. UddoktaAI incorporates all three types while using a 100% Bengali-language interface, provides localized startup

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checklists, and tools of interest for the Bangladeshi market [1].The report by McKinsey details what AI is strong at and less strong at (classification; optimization; prediction) and areas where it still struggles (abstract reasoning; moral reasoning). UddoktaAI addresses those issues by providing rule based logic in combination with lightweight AI modules for decision recommendations and context and practical action [2].Farayola et al [3]demonstrate how AI can change the way businesses made strategic decisions by allowing for more agile, datadriven decision-making, and similarly, Jo¨hnk et al. show how AI transformation is actioned in enterprise systems. UddoktaAI offers a multi-functional experience for pricing, sourcing, and marketing within one system [4]. The MDPI paper articulates a similar message about responsible AI development including key elements of inclusion, trans- parency, and accessibility [5]. UddoktaAI embodies those principles, as we have purposefully designed UddoktaAI to be user-friendly, low-threshold, and free for marginalized, under- represented, and under-resourced segments of business owners[6] . The Rise of AI in Business report is also valuable in assessing how AI can be influential in reducing inequity via democratization of decision support, and automation.This IBM case study on AI in HR illustrated how AI could offer accelerated, [7]repeatable workflows and personalized support by intelligent recommendations. UddoktaAI has a parallel design for business onboarding that enables agents or users to see recommended options based on the category of business and financial inputs. Additionally, in a study from the IEEE that compares AI chatbots [8] demonstrated how well chatbots could work when aligned to the intent of the user, which is the design we have considered for UddoktaAI's Bengali module chatbot.The literature review highlighted that AI-based platforms will be able to best succeed when... They are designed with a local language/cultural context. AI systems will most likely only be successful when... they combine rule-based logic with AI-based intelligence. AI platforms should presumably provide a complete, end-to-end infrastructure for businesses. AI platforms must ensure their online systems are inclusive, free from barriers and useable for users who vary in levels of systems knowledge and expertise. UddoktaAI represents a blending of these principles by offering a hybrid, user-centric platform that provides first-time entrepreneurs in Bangladesh with accessible, intelligent, localised business support.

III.METHODOLOGY

The UddoktaAI methodology came out of an iterative process of secondary research, system design, and prototyping in stages to address the needs of Bangladeshi business owners. The research component drove evidence through thematic analysis of literature from existing literature such as academic journals and industry reports of competitors like McKinsey and IEEE that established a shared need to support local languages, localize, and produce for low digital literacy. This literature guided the system's architecture, architected as a hybrid that utilized a client-side interface with HTML, JavaScript, and Vanilla CSS for current functionality with a suggested, extensible backend on Node.js and Firebase services (Firestore for data storage and Authentication for user management) to facilitate future growth and low-latency function. As the process went on, a modular methodology seemed to be at the forefront of creating such things as an intelligent price calculator, business-checklist-structured checklists, and a marketing-idea-generating AI tool; all specifically designed to actually build into the local socio-economic environment from ground-up, and facilitated with a 100%, Bengali Language interface.A key part of the approach was the construction of a "Rich Picture" in order to visually bring together the end- to-end socio-technical system, in which stakeholders, external systems like the OpenAI API, and context issues like language constraints were stack mapped to ensure that the platform was designed from a systems approach, not a digital product mindset. While the prototype itself was being used as the main test artifact, internal testing by the development team both validated that it worked as expected and served as a benchmark for performance and navigating improving visuals and flow. This. This methodology, providing rule-based reasoning with light artificial intelligence, guarantees that the site not only will be rooted in tested research, but will be constructed for future development such as customized real-time recommendations and enabled access, as important as it needs to be an inclusive economic growth virtual mentor.

IV.SYSTEM ARCHITECTURE

UddoktaAI system architecture is a modular system de- signed to the first-time entrepreneurs of Bangladesh, with the frontend prototype augmented by scheduled backend ad- ditions. Its core is an HTML, JavaScript, and Vanilla CSS client-side interface providing an interactive mockup of core features like the Dashboard, Pricing Calculator, and Marketing Idea Generator. The frontend provides user interaction in the form of a responsive layout accommodating low-digital- literacy users across different devices.Underneath this level, a Node.js backend is envisioned to perform business logic, rule processing, and API integration, all in scalability and low-latency. Firebase services are central to the architecture, with Firestore serving a secure database for user profiles, business plans, and activity logs and Authentica- tion and Hosting controlling user access and deployment. Light AI components, expected through OpenAI API integration, provide personalized recommendations and Bengali-language support, dynamics sensitive to individual user profiles and local market dynamics.Data flows go both ways across the structure since user inputs on the frontend initiate backend computation, which invokes the database or external APIs and gets back tailored outputs. The structure of modularity offers easy updatability and multilinguality since it sets the system for decentralized deployment in rural and semi-urban areas. With the use of rule-based engines and AI functionalities, the structure adapts to entrepreneurial issues adequately, making UddoktaAI an efficient scalable solution for economic growth under an inclusive economy.

Rich Picture

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The rich picture of UddoktaAI summarizes the complex ecosystem facilitating first-time entrepreneurs in Bangladesh in a visual description of stakeholders, processes, and dynamics of context. It is based on the UddoktaAI platform, represented by a hub that includes a prototype developed with HTML, JavaScript, and Vanilla CSS, with arrows pointing towards fu- ture development using Node.js and OpenAI API integration. Around this hub are the core users-potential entrepreneurs, such as students, homemakers, and vendors—represented by considerate bubbles of thought embodying their issues, from price issues and sourcing challenges. These buyers are in- volved in a two-way communication with the platform, submit- ting business information in exchange for personalized advice in Bengali, a value highlighted by a script localized symbol. Peripheral placement is allocated to external systems, such as Firebase for data and authentication storage and OpenAI for AI functionality, with arrows representing API calls and data transfer adding the functionality. The market and economy of Bangladesh is a background environment influencing tool customization by local fashion with the economic benefit of the platform, represented by dashed arrows. Problems of busi-

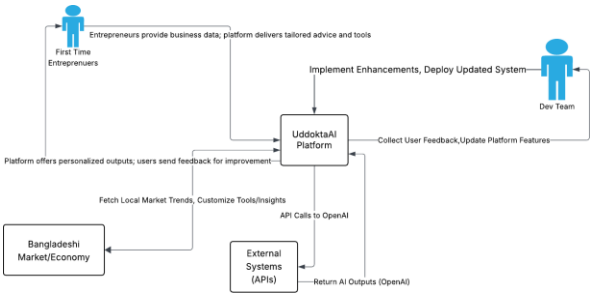
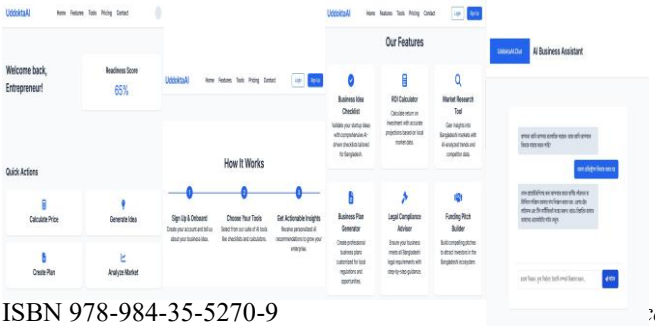


Fig. 1: Rich Picture of the UddoktaAI

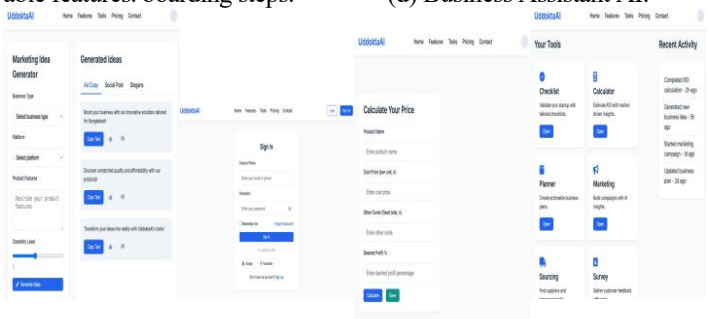
ness inexperience and language limitations become ominous red clouds on the horizon that challenge entrepreneurs, while the system is a counterbalance. Green stars embody dreams of economic self-sufficiency and mutual progress, emanating from the system to indicate its utopian results. A handshake symbol between the system and users emphasizes community empowerment, anchors the diagram to the existing level of development. With a legend that explains symbols, this packed picture is an strict visual tool, complementing the written description of architecture and shedding light on the socio- technical interaction in UddoktaAI design.

B. Proposed System

Fig. 2: Screenshots of different sections of the UddoktaAI application.



(a) Dashboard with Readiness-able features. (b) Your Tools section with avail-boarding steps. (c) How It Works section with on-Score and Quick Actions.



(d) Business Assistant AI. (e) Marketing Idea Generator inter face. (f) Sign In pop-up with email and password fields (g) Pricing Calculator interface (h) Your Tools section with feature options.

UddoktaAI development was based on a user-centered de- sign methodology built upon a modified waterfall software development model to support orderly deployment and iterated testing. It commenced with an PRISMA-catalogued review of the literature to investigate first-time entrepreneurs' needs in Bangladesh. Secondary research provided insights based on knowledge of typical problems that entrepreneurs who have received no business education or resources are likely to experience. Particular pain areas that were identified were difficulties in setting competitive prices, managing cost, ob- taining inventory, and creating marketing initiatives.

Based on these findings, the key system components were identified, such as a Bengali chatbot, startup checklists, a price and sourcing calculator, and rudimentary learning modules on marketing and finance literacy. The user flow and system architecture were demonstrated through rich pictures, sequence diagrams, and subsystem models, with modularity, accessi- bility, and usability in mind. The prototype was constructed using Vanilla CSS, JavaScript, and HTML on the client- side to offer a working mockup to showcase the features planned. The backend infrastructure is to be built with Node.js, with Firebase Firestore as the main database and Firebase Authentication and Hosting for user management and hosting. Light-weight AI functionality, e.g., GPT-boosted responses and rule-based inference, is to be incorporated to offer context-sensitive and personalized suggestions. UddoktaAI employs a modular architecture consisting of an HTML/CSS/JS frontend prototype, with a planned Node.js backend, and Firebase services for authentication, hosting, and Firestore database storage. This ensures scalability and low-latency access across devices. AI features are planned to be embedded through lightweight rule-based engines and prompt-based interactions integrated with OpenAI's API, offering personalized assistance tailored to user profile data. It supports seamless upgrades, multi-language support, and low server overhead and hence should be deployed in a decentralized fashion.

III. Results

Internal testing within the development team was performed for functional and user interface assessment of the UddoktaAI

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prototype. The testing confirmed that fundamental functions such as the Dashboard and Pricing Calculator were functional as intended within the HTML, JavaScript, and Vanilla CSS environment. The performance scores obtained via the Google Lighthouse tests averaged 87 out of 100, indicating an acceptable load and response times with potential for advancement. Team observations confirmed strengths of feature accessibility and set out guidelines for more effective navigation flow and visual consistency. Prototype confirmed the viability of the system proposed and acted as a basis for future enhancement. User feedback will be integrated into future iterations to further enhance design aspects and add functionality, especially with future backend and AI integrations.

A. LIMITATIONS

The concept proof of UddoktaAI is dependent only on frontend tools like HTML, JavaScript, and Vanilla CSS, which stands the test of adding backend features and AI-powered features that are required for complete functionality. Internal user testing within the development community provides initial usability feedback but does not incorporate multi-dimensioned user insights and can neglect intuitive problems experienced by target markets such as housewives or rural business owners. Even though the platform is focused on support for the Bengali language, the existing architecture fails to incorporate voice interaction, hence limiting the access of low-literacy groups or those with low exposure to technology. Research methodology borrows from secondary sources through PRISMA-guided literature review but can be lacking in context-specifically generated insights within the entrepreneurial ecosystem of Bangladesh as could be presented by primary collection of data. Google Lighthouse performance metrics dictate adequate responsiveness but exclude test cases to reflect high traffic or mixed-device scenarios that would reveal scalability issues. Live economic data integrations are excluded from this release, so pricing calculators and marketing recommendations rely on static rule-based logic instead of dynamic response to economic changes. In addition to that, non-cooperation with financial agencies or government institutions does not provide direct funding channels or compliance support for the users, lessening the functionality of the platform as a one-stop entrepreneurial ecosystem.

CONCLUSION & FUTURE WORK

UddoktaAI presents a new innovative solution to the challenges of the Bangladesh new entrepreneurs through the offer- ing of an end-to-end user interface that makes venture creation and management easier. It offers potential entrepreneurs step- by-step Bengali guidance so that they can prepare to make informed decisions even without any formal business profes- sional training. UddoktaAI's tools powered by AI, ranging from business checklists and business calculators to pro- curement suggestions, provide end-to-end visibility, which achieves the inclusivity in a non-English language so that accessibility as well as manageability are better facilitated in a very diverse set of end-users, becoming increasingly confident and overcoming uncertainty which would normally be applicable to startups for new businesses.

UddoktaAI is not only a business planning tool but also an entire support mechanism for aspiring entrepreneurs who would be interested in turning their thoughts into thriving businesses. By making knowledge and resources accessible in business, UddoktaAI is eagerly anticipating business to become inclusive where it can thrive and help drive economic growth as well as innovation in the worldwide business community of Bangladesh.

Future development to UddoktaAI will also include sophisticated AI features for customized business advice, based on real-time market information and personalized user pat- ter behavior. Developers intend to build a separate mobile app for increasing the reach of the platform to low-density and rural areas, further broadening inclusivity across many socioeconomic classes. More templates for adaptable busi- ness types will be offered with user analytics dashboards, providing detailed reports on performance metrics for users and businesses. Collaborations with government and finan- cial institutions under consideration would offer access to resources for financing options, legal registration procedures, and regulation. Bengali voice interaction is a major addition with the goal of offering support for users who have basic literacy or technology exposure. Large-scale user testing will measure the effectiveness of these features in real life, guiding successive refinements based on empirical input. Integration with machine learning systems can enhance pricing algorithms and marketing recommendations as well, adapting dynamically to changing economic conditions in Bangladesh.

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The Impact of Consumer Confusion on the Service Recovery Effectiveness in "App-Based" Food Delivery Services

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Abstract: **The food-delivery service sector has been experiencing a sharp growth in Bangladesh due to the changing social and technological landscape. The fast-paced lifestyle and widespread access to internet have created a substantial market for such daily convenience services. Given that services are variable in nature, they are prone to service failures in order fulfillment due to probable delayed or wrong delivery, payment issues, technical glitch, and other actions that fall below customer expectations. When service failures occur, customers often experience confusion, especially in understanding company policies, resolutions, and communication, leading towards customers' negative emotional response. This study investigates the impact of "customer confusion" due to the inevitable uncertainty in realizing every order and its corresponding service recovery facilitation by the food-delivery entity. Drawing insights from service recovery models and consumer behavior theories, the research focuses on the occurrence of "Negative Emotional Response", and "Consumer Confusion", and/or the lack of "Customer Satisfaction", and "Perceived Justice" instigating "Negative Word of Mouth (NWoM)", eventually affecting customers' "Repurchase Intention".A quantitative approach has been devised through a structured questionnaire to evaluate customer perceptions regarding food delivery service recovery in Bangladesh. The survey respondents are active users of food delivery apps in Bangladesh irrespective of demographic variables like age, gender, income group, etc. The survey instrument (structured questionnaire) encompasses constructs that measure consumer confusion, negative emotions, perceived justice, customer satisfaction, negative word-of-mouth, and repurchase intention, drawing on validated scales. A sample of 400 respondents have been surveyed using convenience sampling procedures. The data is analyzed through descriptive statistics, correlation analysis, and hypothesis testing via regression and ANOVA to explore the relationships between variables and validate the proposed conceptual model, test its reliability using Cronbach's alpha.**

The findings indicate that the higher the level of "Customer Confusion" and "Negative Response", the higher tendency of spreading "Negative Word of Mouth". On the contrary, the lower the level of "Customer Satisfaction", and "Perceived Service Justice", the higher the tendency of spreading "Negative Word of Mouth" of the customers. Consequently, increase in NWoM is inversely proportional to "Repurchase Intention".

Keywords: **Food-Delivery Services, Service Failure, Negative Emotional Response, Service Recovery, Negative WoM, Repurchase Intention**

I.INTRODUCTION

Statement of the Problem and Research Objectives

The app-based food delivery industry in Bangladesh has witnessed rapid growth, driven by urbanization, technological advancement, and the growing demand for convenience. However, the inherently variable nature of service delivery—manifested through delays, incorrect orders, payment issues, or app-related glitches—frequently results in service failures that compromise customer expectations.

These service failures not only frustrate customers [2], but often lead to **consumer confusion**, particularly regarding unclear policies, ineffective communication, and inconsistent recovery efforts [1]. This confusion can trigger negative emotional responses, undermining customer trust and satisfaction [2]. Furthermore, customers' perceptions of injustice and lack of satisfaction in service recovery are likely to fuel negative word-of-mouth (NWoM), which significantly damages brand reputation and deters future customer engagement [4].

Despite growing academic interest in service recovery strategies, there is a limited understanding of how **consumer confusion and emotional responses** influence post-failure customer behavior [4] —especially in the context of app-based services in emerging markets like Bangladesh. While previous studies have examined individual factors like **customer satisfaction** or **perceived justice [5]**, few have investigated how these variables jointly affect **repurchase intention**, especially through the mediating role of NWoM.

This research addresses this gap by examining the complex interplay among **negative emotional response, consumer confusion, perceived justice, and customer satisfaction** as predictors of **negative word-of-mouth**, and

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ultimately, **customer repurchase intention**. The findings reveal that heightened confusion and dissatisfaction significantly increase NWoM, which inversely affects consumers' likelihood to repurchase. These insights are critical for app-based service providers striving to design effective recovery strategies in a highly competitive and digitally driven marketplace.

Based on the above-mentioned research problem, the following research objectives have been formulated: To investigate the extent to which negative emotional response and consumer confusion towards service recovery experience are associated with negative word of mouth, and how these factors collectively impact repurchase intention within app-based food delivery services.

To investigate the relationship between customer satisfaction and perceived justice towards service recovery experience with negative word of mouth, and how this association influences repurchase intention in the context of app-based food delivery services."

The following hypotheses are derived from the above research model based on the review of literature.

H1: Consumer confusion tends to influence the intention to share negative word-of-mouth

H2: Negative emotional reactions contribute to the likelihood of engaging in negative word-of-mouth.

H3: Customer satisfaction reduces the tendency toward negative word-of-mouth behavior.

H4: Perceived justice is inversely related to the intention to engage in negative word-of-mouth.

H5: Negative word-of-mouth is negatively associated with repurchase intention.

II. METHODOLOGY

The Research Design – Methods and Procedures

This study employed a causal research design, specifically a correlational approach, in which six variables were assessed, and correlation data were utilized to examine causal relationships. It was a cross-sectional study, as data were collected from the sample at a single point in time.

Primary data were gathered through a survey targeting middle and upper-middle-class residents of Dhaka City, as this socioeconomic group typically has the financial means and tendency to engage in ordering online food. The survey focused on five specific areas—Banani, Dhanmondi, Gulshan, Uttara, and Mirpur—based on the assumption that residents in these neighborhoods are economically stable and has the ability to order food online. A sample of 400 individuals were approached using a structured questionnaire, resulting in 384 complete responses. A convenience sampling technique was employed, with 70 participants selected from each of the five areas based on the researcher's judgment and familiarity with the population.

A 5-point Likert scale was employed in the questionnaire to measure all variables. The survey included 21 items related to the study variables and 5 demographic questions (see Appendix). The dependent variable, **Customer Repurchase Intention**, was initially assessed using 4 items. The independent variables were measured as follows: **Negative Emotion** with 3 items, **Consumer Confusion** with 5 items, **Customer Satisfaction** with 3 items, and **Perceived Justice** with 3 items. The mediating variable, **Negative Word-of-Mouth**, was measured using 3 items.

III. RESULTS

The analysis was conducted using the Statistical Package for Social Sciences (SPSS v.23) and SmartPLS software. Descriptive statistics, including frequency distributions, were generated through SPSS to summarize the demographic characteristics of the respondents. Reliability analysis was carried out to assess the internal consistency of the scale items used in the questionnaire. Additionally, regression analysis was performed to determine the extent to which the independent variables explained the variance in the dependent variable. Hypothesis testing was conducted using a Pearson Correlation and Spearman's Rho test in SPSS V.25.

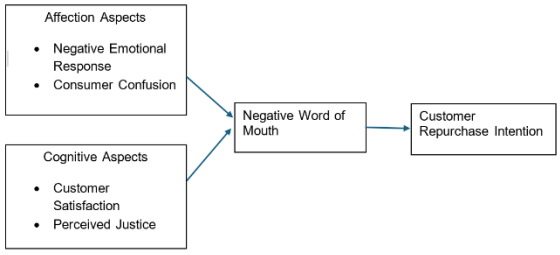


Figure 1: Research framework

Data Analysis

Statistical Package for Social Science (SPSS) software was adopted in this study for data analysis in three steps. In the first step, a descriptive analysis was done to describe the demographic characters of the respondents. Here, frequency distribution was used to analyze demographic data. In table 1, a summary of the descriptive analysis was presented.

Table 1: Frequency distribution of the sample's demographic variables

Variables	Categories	Number of Respondents	Percentage
Gender	Male	78	60.00
	Female	52	40.00
Age	18 to 24 years	101	77.7
	25 to 34 years	28	21.5
	35 to 44 years	1	0.8
Usage (Whether the respondents ever used the service)	Yes	123	94.6
	No	7	5.4
Frequency of use	Everyday	5	3.8
	Several days a week	25	19.2
	Once every week		
	A couple of times a month	15	11.5
	Once every month	28	21.5
	Once in few months or lesser	20	15.4
		37	28.5
Food delivery app that the respondents discontinued or skeptical about recovery practice	Foodpanda	102	78.5
	Pathao	12	9.2
	Foodi	9	6.9
	Munchies	1	0.8
	Others	6	4.6

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In the second step, reliability test of the scale (Likert) was performed. Here the value of Cronbach's alpha was computed to gauge the internal consistency of the items used in the questionnaire. According to the reliability cutoff values proposed by Yockey (2016), a value of 0.7 and above is acceptable, 0.8 or above is good and 0.6 or above is questionable and 0.5 or above is poor. A summary of the outcome of reliability test is presented in the following table 2.

Table 2: Reliability values of items used in variables

Variable	No. of Items	Chronbach's Alpha Value	Result
Customer Repurchase Intention	*4*	*0.834*	*Good*
Negative Emotional Response	*3*	*0.832*	*Good*
Customer Confusion	*5*	*0.802*	*Good*
Customer Satisfaction	*2*	*0.585*	*Poor*
Perceived Justice	*4*	*0.672*	*Questionable*
Negative Word of Mouth	*3*	*0.804*	*Good*

The following table displays the output of regression analysis. The R^2 value of 0.320 indicates that 32.0% variance in dependent variable (Customer repurchase intention) is explained by the independent variables.

IV.DISCUSSION

Interpretation of hypotheses

Table 4: Result of hypotheses testing

Hypothesis	Spearman Rho	Pearson r	Significance
H1	**0.427**	**0.443**	**0.000**
H2	**0.530**	**0.543**	**0.000**
H3	**0.353**	**0.375**	**0.000**
H4	**0.370**	**0.373**	**0.000**
H5	**0.423**	**0.418**	**0.000**

Table 3: Regression Analysis

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.565[a]	.320	.292	.81671

a. Predictors: (Constant), NEGATIVE WORD OF MOUTH, PERCEIVED JUSTICE, CONSUMER CONFUSION, CUSTOMER SATISFACTION, NEGATIVE RESPONSE

H1: Consumer confusion tends to influence the intention to share negative word-of-mouth

From table 2, Spearman Rho value of 0.427 which is not equal to 0, Pearson correlation coefficient (r) value of 0.443 and significance (α) value of 0.000 indicates that there exists a moderately positive relationship between consumer confusion and negative word of mouth.

H2: Negative emotional response contributes to the likelihood of engaging in negative word-of-mouth.

From table 2, Spearman Rho value of 0.530 which is not equal to 0, Pearson correlation coefficient (r) value of 0.543 and significance (α) value of 0.000 indicates that there exists a strong positive relationship between negative emotional response and negative word of mouth.

H3: Customer satisfaction reduces the tendency toward negative word-of-mouth behavior.

From table 2, Spearman Rho value of 0.353 which is not equal to 0, Pearson correlation coefficient (r) value of 0.375 and significance (α) value of 0.000 indicates that there exists a weak positive relationship between customer satisfaction and negative word of mouth.

H4: Perceived justice is inversely related to the intention to engage in negative word-of-mouth.

From table 2, Spearman Rho value of 0.370 which is not equal to 0, Pearson correlation coefficient (r) value of 0.373 and significance (α) value of 0.000 indicates that there exists a weak positive relationship between perceived justice and negative word of mouth.

H5: Negative word-of-mouth is negatively associated with repurchase intention.

From table 2, Spearman Rho value of 0.423 which is not equal to 0, Pearson correlation coefficient (r) value of 0.418 and significance (α) value of 0.000 indicates that there exists a moderate positive relationship between negative word of mouth and repurchase intention.

V. CONCLUSION

Table 3: Regression Analysis

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.565[a]	.320	.292	.81671

a. Predictors: (Constant), NEGATIVE WORD OF MOUTH, PERCEIVED JUSTICE, CONSUMER CONFUSION, CUSTOMER SATISFACTION, NEGATIVE RESPONSE

Understanding these dynamics is crucial for food delivery services seeking to improve recovery strategies and retain consumers in a competitive digital market. The understanding of the effect and significance of the dynamics studied have both theoretical and practical implications. The result identifies the major dimensions affecting customer experience so that consequent studies and corrective service decisions focus on effective measures of overcoming the shortcomings in ensuring satisfactory service recovery that would reduce negative repurchase intension of customers.

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APPENDIX

Questionnaire Scales
Demographic Questions
1. Gender
2. Age Group
3. Have you ever used "App-Based" Food Delivery Services for home delivery of food in Bangladesh?
4. How frequently do you order through the "App-Based" food-delivery services in Bangladesh?
5. Choose the Food-Delivery App you took the service from but discontinued later or still take services from but are skeptical about their service recovery practices in case of service failure.

Customer Repurchase Intention
1. The scales below measure customers' willingness to continue availing the food delivery service from the concerned food-delivery service provider.
2. I will continue to order food through home delivery services through this Food Delivery App
3. I will recommend this Food Delivery App to the people around me.
4. I would like to be a loyal customer to this Food Delivery service provider
5. I trust the Food Delivery App more than other food delivery service providers

Consumer Confusion
1. I experience confusion due to chances of "service failure" concerns about order being not delivered to the right address, wrong items being delivered, missing items in order delivery, or miscalculation and payment issues
2. In case there is any inconvenience or service failure, I am confused about the way of claiming service recovery. The service provider does not give clear instructions and contact details for resolving service failure issues.
3. I am confused or uncertain about what to expect in terms of the attitude of the service providing organization's representatives while contacting them for service recovery
4. I am confused about the effectiveness of service recovery offered after the service provider fails to provide the service.
5. I am confused about the environment of service recovery in terms of process and course of actions

Negative Emotional Responses
How likely are you to have felt the following emotions if the food delivery service failed?
1. Angry
2. Offended
3. Disappointed

Customer Satisfaction
1. This section explores the responses of customer satisfaction arising from delivery of successful services by the concerned food delivery service provider.
2. How well did this service experience meet your needs?
3. Overall, how satisfied or dissatisfied does this food delivery experience leave you feeling?

Perceived justice
1. The outcome I received from the food-delivery company was fair to compensate for the inconvenience caused by their service failure
2. The process of reporting service inconvenience and seeking help was complex to find and understand
3. The service providing company's employees handled the problem in a timely manner; they were prompt and responsive
4. The interaction of the service company employees was empathetic and cordial- they really seemed to care about the problem I encountered in the service

Negative WoM
1. I will inform my friends and/or family about my disappointing experience
2. I will warn my friends and/or family to ensure they do not have to go through the same experience
3. I will convince my friends and/or family not to avail this food-delivery service
4. I will share negative reviews and poor ratings on public platforms

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The AI-Powered Chatbots in Omnichannel Integration Services (OIS) Model: Enhancing Recovery Satisfaction and Sustainability

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Abstract: **Artificial Customer loyalty remains to be made or broken through the service recovery in the era of easy digital experiences. Although AI (Artificial Intelligence) chatbots provide speedy, available-24/7 services, little is known about their emotional performance in the case of service breakdown. This research expands the Omnichannel Integration Services (OIS) model and adds the dimension of chatbot communication style with trust. This study expands the Omnichannel Integration Services (OIS) concept by including AI-driven chatbots as service recovery tools to improve customer satisfaction experience. It has investigated the impact of chatbot communication patterns, utilizing cognition and affect-based trust as factors. The study evaluates the combined impact of online and offline experiences on recovery satisfaction and net benefits including perceived value and customer retention, providing a trust-oriented enhancement of the OIS model. A quantitative research methodology has been designed for this study, a sample size of 100 respondents from urban cities has been used, concentrating on the e-commerce industry. This study has collected primary data to measure customer recovery satisfaction by illustrating how smart design can transform service failure into a strategic source of satisfaction and long-term engagement as well as sustainability. The information has been collected via questionnaires, which have measured service recovery experiences, as well as chatbot efficiency. The paper has used Statistical programs like SPSS and MS Excel to analyse data, identify important variables among the satisfaction score and usage rate. In this paper, we have proposed a bridge the gap between OIS model and AI chatbot integration by leveraging real-time data processing and automation to increase customer recovery satisfaction.**

Keywords **- Artificial Intelligence (AI), Omnichannel Integration Services (OIS), Chatbot, Customer Service Recovery Satisfaction, Sustainability.**

I. INTRODUCTION

In today's highly digitalized economy, consumer expectations for seamless service are at an all-time high. Yet, the reality of service breakdowns such as late deliveries, refund delays, or inconsistent information across channels continues to challenge the stability of customer loyalty. For emerging markets like Bangladesh, where e-commerce adoption is rising rapidly, these challenges are magnified by infrastructural limitations and inconsistent service practices [10]. As competition intensifies and brand differentiation becomes increasingly difficult, effective service recovery has emerged as one of the decisive factors in retaining customers and sustaining loyalty across Omni channel systems.

The Omni channel Integration Services (OIS) model has been widely used to explain how online and offline experiences collectively shape customer satisfaction and loyalty. Online customer experience is determined by information quality, including accuracy, completeness, and timeliness, as well as system quality factors such as usability, reliability, and security [8], [15], [7]. Offline customer experience, by contrast, is grounded in service quality reliability, responsiveness, empathy, and tangibles where human interaction plays a decisive role in building trust and loyalty [13], [3]. Together, these experiences influence satisfaction, which serves as a bridge to perceived value and long-term consumer stickiness.

Service recovery adds another critical dimension to this process. Grounded in justice theory, recovery effectiveness is shaped by distributive, procedural, and interactional justice [2], [4], [6]. Key predictors include speed of response, fairness of outcomes, and empathetic communication. More recently, AI-powered chatbots have entered this domain as digital recovery agents. Their ability to provide immediate, personalized, and 24/7 responses positions them as efficient solutions for service failures [5]. Yet efficiency alone is insufficient. The communication style of chatbots whether transactional, empathetic, or hybrid determines their effectiveness in fostering cognitive and affect-based trust [1], [12].

Satisfaction then mediates the pathway to net benefits, particularly perceived value and stickiness. Perceived value reflects the balance between what customers give

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and what they receive, while stickiness describes behavioral persistence, expressed through repeat visits, continuous platform use, and long-term engagement [9], [14], [16]. These constructs are especially relevant in Omni channel contexts where switching costs are low and customer retention depends heavily on the quality of recovery experiences.

Nonetheless, important gaps remain in the literature. Existing studies often focus on the efficiency of chat bots while neglecting their emotional and relational role in service recovery. Trust, both cognitive and affect-based, has not been fully integrated into OIS frameworks, especially in the context of service breakdowns. Moreover, most existing research is concentrated in developed markets, leaving a lack of localized insights for emerging economies such as Bangladesh, where bilingual (Bangla-English) interaction is essential to customer engagement. Finally, little work has examined how chatbot-driven recovery translates into long-term benefits such as perceived value and stickiness.

Thus, this study makes an important contribution by extending the OIS framework to include chatbot-mediated service recovery. The objectives are four-fold:

To investigate how AI-powered chatbots influence service recovery outcomes within the OIS model.

To evaluate how chatbot communication styles foster cognitive and affect-based trust.

To assess the role of online and offline satisfaction as mediators between recovery and customer loyalty outcomes.

To analyze how chatbot-enabled recovery enhances net benefits, specifically perceived value and stickiness, in the Bangladeshi e-commerce sector.

II. METHODOLOGY

This research used a quantitative, cross-sectional design to empirically support the extended Omni channel Integration Services (OIS) framework, which incorporates AI-based chatbots in the service recovery process. The model measures the correlation between online/offline customer experience, service recovery, satisfaction, perceived value, and stickiness with the dimensions of chatbot communication styles and trust introduced.

Data Collection and sampling

It gathered the data of 100 Bangladeshi e-commerce customers who had previously received a service failure (e.g., untimely delivery, delayed refund, or incorrect product) but engaged with a chatbot to get it resolved. Stratified random sampling was used to recruit respondents who had a residence in four urban areas (Bashundhara, Mirpur, Middle Badda, and ECB Circle). We used both online and offline methods to administer questionnaires to cover.

Measures

Validated scales were modified to fit the research context and used to measure constructs:

Online Customer Experience: system quality, information quality.

Offline Customer Experience: perceived service rate

Service Recovery: distributive, procedural and interactional justice.

Satisfaction: online satisfaction and offline satisfaction

Net Benefits: perceived value and stickiness

AI-Powered Chatbots: style of communication (transactional vs. empathetic), trust (cognitive and affect-based).

Everything was measured on the scale of 7 points (1 = strongly disagree; 7 = strongly agree).

Data Analysis

IBM SPSS was used to analyze the data. To verify the reliability and validity, Cronbach alpha and item-total correlations were performed first. Subsequently, Pearson and Spearman correlation tests were performed to evaluate hypothesized (H1-H9) construct to construct relationships. It was analyzed whether chatbot-mediated recovery improves online and offline satisfaction, which in turn contributes to the improvement of perceived value and customer stickiness.

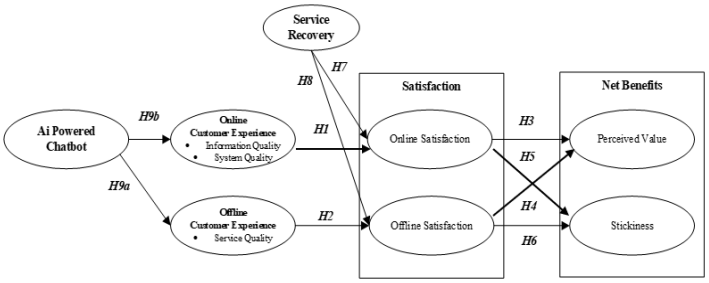


Fig.1. Conceptual Framework

The methodology guarantees the attendant rigorous testing of the proposed framework and embodies the lived experiences of e-commerce users within an emerging market setting.

III. RESULTS/FINDINGS

The proposed framework was tested on a sample of 100 valid responses analyzed with IBM SPSS, which corroborated the strength of the suggested framework. Simply put, SPSS is a software application that assists a

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researcher in determining whether his/her survey findings are consistent, reliable, and whether the associations among various variables are statistically significant.

- Reliability and Validity

All measures were statistically sound, with Cronbach alpha values of between 0.81 and 0.91, indicating that the questions themselves (used to measure each factor e.g. satisfaction, perceived value, stickiness) were consistent. The absence of any statistical errors like overlapping between unrelated variables supported the validity of the results.

- Internet, and Physical Experiences

Results indicate that those customers who said they had experienced a better online experience (such as correct product information and efficient site functionality) also said they had greater online satisfaction ($r = 0.64$, $p < 0.01$). Similarly, offline sensitivity, e.g., responsive staff and reliable service, created greater offline satisfaction among the individuals who positively experienced offline ($r = 0.59$, $p < 0.01$). This means that online and physical touch points are complementary and very efficient in their own domain.

Artificial Intelligence-powered Chatbots and Service Recovery. Service recovery activity was positively correlated with online ($r = 0.55$) and offline ($r = 0.52$) satisfaction. Chatbots played a particularly important role: they not only improved the pace of recovery and its availability, but also improved the quality of online experiences. Notably, chatbot communication which is empathetic (friendly, human-like responses) influenced more trust and satisfaction ($b = 0.41$, $p < 0.01$) than simply transactional communication (short and task-oriented replies; $b = 0.22$, $p = 0.05$).

- Net Benefits

Customer satisfaction was determined to mediate between the experiences and long-term outcomes of loyalty. The customers had higher perceived value ($r = 0.61$, $p < 0.01$) when they were satisfied; that is, they thought the service was worth their time and money. Perceived value, in turn, had a strong impact on stickiness ($r = 0.67$, $p < 0.01$), i.e., the readiness of customers to use the same e-commerce platform. The most related to stickiness and the importance of digital recovery experiences was online satisfaction.

- Overall Contribution

The results confirm that AI-based chatbots are not only capable of resolving problems more quickly, but also ensure that customers feel special, are trusted, and become loyal, in the long-term. The statistical evidence contained in the SPSS analysis and the practical interpretation of the results indicate that successful chatbot-based recovery can transform service failures into competitive advantages to build better customer relationships, particularly in the rapidly-developing Bangladeshi e-commerce sector.

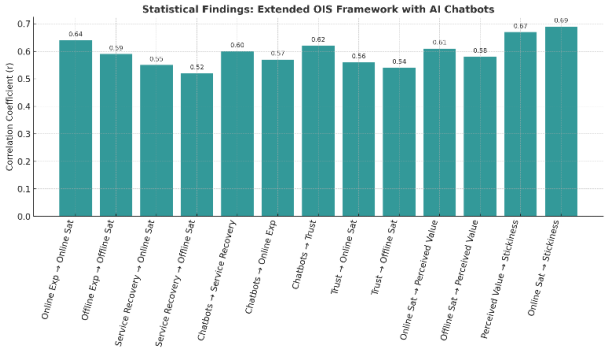


Fig-2: Statistical Finding Comparison

IV. DISCUSSIONS

This paper builds upon the Omni channel Integration Services (OIS) model by demonstrating how AI-based chatbots help to restore service, build trust, and customer loyalty in the long run. The results indicate that chatbots do not only solve problems fast, but they also have a significant relational role to play when they express themselves in a human and empathetic manner.

A. Practical Contributions

Regarding the e-commerce firms, the results show that the properly trained chatbots can turn service failure into the relationship-building opportunities. The ability of chatbots to be efficient and empathetic make customers feel important, leading to higher levels of trust, satisfaction, and loyalty. Businesses in Bangladesh and other markets can use these insights to improve service recovery, reduce customer loss and repeat purchases.

B. Theoretical Relevance

The research contributes to the literature since it incorporates chatbot trust and communication style as a part of the OIS framework. It demonstrates that customer satisfaction is an intervening variable between service recovery and long-term consequences such as perceived value and stickiness, which provides new insights into the role of digital recovery tools in influencing customer experience.

C. Future Research Scope

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This model can be applied to other industries, like fin-tech or healthcare, or in another country to compare cultural differences in chatbot trust in the future. Making larger samples and employing a sophisticated technique such as structural equation modeling may also be beneficial. Lastly, the topic of ethical concerns, including transparency and privacy with chatbots, is another direction that should be investigated in the future.

V. CONCLUSION

The proposed study elaborates the Omnichannel Integration Services (OIS) framework, adding the use of AI-enabled chatbots in the service recovery process. The results indicate that chatbots with humane communication and trust-building capabilities can contribute to customer satisfaction, perceived value, and loyalty in online shopping to a considerable degree. Online and offline experiences will continue to play a vital part, yet, chatbot-powered recovery will provide an additional layer of relational value that will help the firms transform service failure into a retention opportunity. Altogether, the analysis indicates that the idea of efficiency and empathy co-determined when developing a chatbot can help the company build trust among customers and maintain their interest over an extended period, which should be viewed as a theoretical and practical guide to companies in such an emerging economy as Bangladesh.

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BRI Experience of Bangladesh - Present Scenario and Future Aspects

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Abstract- **This paper examines the experience of Bangladesh under China's Belt and Road Initiative (BRI) by highlighting the current situation and future prospects. Over the past decade, various landmark projects like Padma Bridge Rail Link, Karnaphuli Tunnel, and Matarbari Deep Sea Port have strengthened the trade links, connectivity, and industrial growth. Bangladesh's GDP is expected to be increased by 2.1% because of BRI investments. It will create new jobs, along with technology transfer and manufacturing expansion. Though challenges like, rising external debt which is approximately about USD 4 billion to China, dependency of fossil-fuel projects, and the need to balance diplomatic ties with India and other global partners remain there. This study suggests that Bangladesh can benefit most from BRI by ensuring greater project transparency, shifting towards green and renewable energy investments, and carefully diversifying its foreign economic partnerships. Overall, BRI journey of Bangladesh has drawn a strong economic potential. But the long term success of this journey can be achieved by establishing sustainable policies and balanced foreign engagements.**
Keywords: **Belt and Road Initiative, Bangladesh, Infrastructure development, Debt sustainability, Green investment, Technology transfer, Geopolitics.**

I. INTRODUCTION

The Belt and Road Initiative (BRI), which was introduced by China in 2013, is one of the largest development and connectivity programs of the world. It connects Asia, Africa, and Europe through roads, railways, ports, and digital routes. The main target is to promote trade, investment, and cooperation among more than seventy countries [1, 2]. In South Asia, BRI has brought new opportunities for economic growth, especially in countries with limited infrastructure. Researches explain that regional trade and logistics can be improved by the help of the projects under the BRI and also these projects can draw the attention of new investment [3]; [4]. But, fragile project governance, low transparency, and the risk of debt burden for developing nations are the critical problems [5]; [6].

BRI has become a significant part for the national development strategy of Bangladesh. To develop the connectivity and regional trade, major projects such as Padma Bridge Rail Link, Karnaphuli Tunnel, and Matarbari Deep Sea Port are playing the vital role [7, 8], 2} percent GDP growth and new employment opportunities can be observed because of these projects [9].

But challenges are still there. To keep a balance between growth and sustainability has become a tough task because Bangladesh's external debt to China has increased. Also, issues about project transparency, environmental costs, and the importance of managing the relations with India are frequently discussed in recent studies [10, 11]. So, the BRI is both an opportunity and at the same time risk for Bangladesh. This initiative can improve trade and industry, but transparency, diversification, green investment, and effective governance are the significant factors on which the long-term success of BRI is dependent [3,[7].

II. LITERATURE REVIEW

Studies on BRI show that it is not only an infrastructure initiative but also a geopolitical strategy. [12,13] explain the program as China's attempt to reshape global trade networks. Researchers argue that BRI reduces transport costs, increases market incorporation, and also creates new energy corridors [6, 2]. Critical studies highlight the risks of overdependence on Chinese finance and possible "debt-trap diplomacy" [5,2,4]. Weak project governance and low transparency have often led to delays and cost overruns. Research also shows that environmental and social issues are frequently overlooked during the planning stage [11].

For Bangladesh, existing studies provide mixed outcomes. On the positive side, [3] argue that BRI projects help close major infrastructure gaps, particularly in energy and transport. [7] explain that technology transfer and new industrial opportunities can raise Bangladesh's global effectiveness. [8] explains that the deep-sea port project in Matarbari may turn Bangladesh into a regional trade hub.

There are some concerns too. [10] shows that Bangladesh's foreign policy is under pressure due to struggle between China and India. [9] argues that while GDP growth is likely to rise, social inequality could widen if benefits are not distributed fairly. [11] warn that the reliance on fossil-fuel projects may damage Bangladesh's climate assurances.

The literature suggests that BRI has strong potential to promote trade, industry, and technology in Bangladesh; however, challenges related to governance, debt, and geopolitics may hinder overall growth.

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III. METHODOLOGY

This study uses a qualitative approach. The goal is to analyze the opportunities, risks, and long-term consequences of BRI for Bangladesh. Data were collected from peer-reviewed articles, policy reports, and government documents published between 2013 and 2025.

The research follows a narrative synthesis approach. All sources were reviewed and classified into key themes such as infrastructure benefits, economic growth, debt sustainability, political influence, and environmental challenges.

The use of existing literature as the main methodology is justified because BRI-related data are already widely studied, and academic publications provide reliable insights. Secondary data analysis avoids the limitations of small-scale fieldwork and allows an all-inclusive review of Bangladesh's position within a global framework.

Limitations include the absence of primary interviews and the reliance on published material, which may not capture the most recent unpublished developments. Despite this, the chosen method is suitable for providing an academically rigorous and policy-relevant analysis.

IV. FINDINGS

A. Long-Term Benefits

BRI projects have the potential to boost Bangladesh's GDP by around 2 percent, primarily through infrastructure, industrialization, and logistics effectiveness (Yasmin, 2023) [9]. The Padma Bridge Rail Link and Karnaphuli Tunnel can improve national connectivity, while Matarbari Deep Sea Port can transform Bangladesh into a regional trade hub (Akter et al., 2023) [7]; (Ehsan, 2021) [8]. These developments create jobs and support industrial clusters.

B. Challenges and Risks

Bangladesh's external debt to China, currently about USD 4 billion, raises concerns about long-term sustainability (Rahman, 2025) [5]. Transparency problems and cost overruns during the time of project application are also reported (Sultana et al., 2024) [11]. Environmental risks, especially linked to fossil-fuel projects, conflict with Bangladesh's green development goals (Lu et al., 2018) [6].

C. Political Influence

Governance and political decisions strongly shape BRI outcomes. Uddin (2025) [10] notes that ruling-party strategies and regional diplomacy play significant roles in project approval and execution. India's resistance to BRI creates additional political challenges (Mallick, 2024) [4].

D. Economic and Social Impact

While economic indicators suggest improvements in trade and foreign investment, social concerns include unequal benefit distribution and dislocation of local communities (Sultana et al., 2024) [11]. Though technology transfer and industrial expansion, can provide long-term human capital benefits (Simonov, 2025) [1].

E. Regional Integration

The BRI strengthens Bangladesh's role in regional trade networks with the help of linking South Asia with China and Southeast Asia (Hosain et al., 2024) [3]. Improved connectivity may reduce logistics costs and strengthen Bangladesh's effectiveness in global supply chains.

V. RECOMMENDATIONS

- Transparency and Accountability: Establishing clear reporting systems, independent audits, and public disclosure of project details to reduce corruption and cost overruns.
- Debt Management Strategy: Focusing on concessional loans, strengthening debt sustainability frameworks, and diversifying financing sources to avoid overdependence on China.
- Green Development Transition: Prioritizing renewable energy projects within BRI assistance, and gradually phasing out fossil-fuel-based projects.
- Institutional Strengthening: Enhancing governance effectiveness, improving coordination among ministries, and ensuring better project assessment before approval.
- Community Engagement: Involve local stakeholders in decision-making, guarantee fair benefits, and minimize the dislocation of communities.
- Balanced Diplomacy: Maintain cooperation with China while strengthening relations with India, Japan, and the European Union.
- Capacity Building and Technology Transfer: Ensuring that Chinese investments are allied with local training, skill development, and technology advancement.
- Regional Cooperation: Using BRI platforms to increase South Asian connectivity, logistics, and trade partnerships to get the most out of this project.

VI. CONCLUSION

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In the field of infrastructure, trade, and industrialization, the BRI has created new opportunities for Bangladesh. Projects such as Padma Bridge Rail Link, Karnaphuli Tunnel, and Matarbari Deep Sea Port have expressed the economic benefits and potential of BRI initiative. But, debt risks, governance flaws, environmental issues, and geopolitical pressure are the critical issues which can hamper the initiative. The experience of Bangladesh explains that transparent governance, responsible financing, community inclusion, and balanced foreign policy can bring sustainable profits from the BRI initiative. By following these strategies, Bangladesh can ensure that BRI contributes not only to growth but also to long-term national development and regional solidity.

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Smart Ports and Digital Transformation: The Future of Port Operations in the UAE

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Abstract– **Port operations all over the world are being transformed by the fast growth of digital technologies, which include artificial intelligence (AI), the Internet of Things (IoT), blockchain, and digital twins. The United Arab Emirates (UAE) has made the development of smart ports a top priority in order to be in accordance with UAE Vision 2031 and Dubai's Smart City plan. This is because the UAE is a significant logistics and transshipment center. Nevertheless, there is a limited amount of empirical synthesis about the impact of digital transformation on the operational and strategic performance of ports in the United Arab Emirates. This conference paper on smart port development focuses on Khalifa Port and Jebel Ali Port, and the objective of the paper is to examine the digital transformation process validated through the Integrated Supply Chain Performance Measurement (ISCPM) model, which incorporates ten strategic performance attributes are Financial Health (FH), Collaboration (CL), Velocity (VC), Resilience (RE), Reliability (RL), Continuous Improvement (CI), Visibility (VS), Work People Health (WPH), Sustainability (SS), and Service Excellence (SE). This study applies a mixed-method approach; a systematic literature review was done from Web of Science and Scopus indexed publications from (2017-2025) along with a secondary quantitative benchmark of port performance indicators. The study unlocks that the ports of the United Arab Emirates have made significant progress in turnaround time for ships, operational dependability, documentation speed, sustainability, etc. with the adoption of automation, AI-driven scheduling, blockchain documentation, and digital twin systems. This conference paper offers theoretical insights and practical guidance for policymakers and port authorities seeking to enhance operational efficiency, resilience, and sustainability through digital transformation.**

Keywords: **Smart Ports, Digital Transformation, UAE Ports, Jebel Ali, Khalifa Port, ISCPM, AI, IoT, Blockchain, Maritime Logistics.**

I. INTRODUCTION

Modern digital technology is driving the global maritime sector's massive transformation. Ports are becoming data-centric, cyber-physical ecosystems from physical gates for freight. The Smart Port paradigm, which describes this industrial transformation, includes blockchain, IoT, AI, big data analytics, autonomous vehicles, and digital twins. These technologies enhance predictive planning, real-time decision-making, and operational insight. Smart ports have global benefits [4,5]. Studies in Shanghai, Singapore, and Rotterdam found that vessel turnaround time has lowered by 20–30%, sustainability KPIs have increased by 15%, and operational interruption resilience has improved [1,3, 4,9]. These discoveries have shifted the focus of port performance from cost efficiency and throughput to systemic competence, resilience, and sustainability.

As a global logistics and transshipment hub, the UAE is crucial. The government's economic diversification policy includes UAE Policy 2031 and the Dubai Smart City Strategy. The country's two largest seaports, Jebel Ali Port (DP World) and Khalifa Port (AD Ports Group), underpin both proposals. Jebel Ali Port and Khalifa Port handle most cargo traffic. Over the past decade, these ports have become some of the most advanced in the Middle East by implementing blockchain-based trade paperwork, autonomous container trucks, real-time IoT-enabled cargo tracking, and AI-powered berth scheduling systems. [9,23,31]

Despite rapid technological improvement, there is no empirical research on smart port transformation in the UAE. Mostly descriptive, this study is scattered. Most global studies focus on technical implementations, cost savings, or specific operational KPIs, but they do not integrate them within a corporate performance framework. There is little known about how digital transformation affects strategic and systemic performance goals at UAE ports [8,10]. These outcomes include stakeholder cooperation, workforce readiness, environmental sustainability, disruption resilience, and customer service excellence. Policymakers, port authorities, and industry leaders struggle to analyze return on investment, prioritize digital activities, and define evidence-based roadmaps for sustainable smart ports in the UAE without a comprehensive measuring framework. [3,13]

This study addresses this gap by proposing an integrated performance measurement approach for assessing smart port transformation in UAE ports [31]. The approach is grounded in the Integrated Supply Chain Performance

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Measurement (ISCPM) model developed and validated by [21,22]

The ISCPM framework fuses the logic of the Balanced Scorecard (BSC) and the Supply Chain Operations Reference (SCOR) model and incorporates ten interlinked performance attributes: Financial Health (FH): economic performance, cost, profit, and budget variance. Collaboration (CL): quality of internal/external stakeholder relationships Velocity (VC) encompasses factors such as responsiveness, cycle time, lead time, and time-to-market. Resilience (RE) is the ability to anticipate, absorb, and recover from disruptions. Reliability (RL) is accuracy, predictability, and consistency of operations. Continuous Improvement (CI) is a culture of Lean, Kaizen, TPM, and innovation. Visibility (VS), traceability, and transparency across the supply chain. Work People Health (WPH) workforce safety, skills, engagement, and governance. Sustainability (SS) is environmental and social responsibility performance. Service Excellence (SE) customer service quality, satisfaction, and innovation. 21,22]

These attributes are categorized across three supply chain domains Supplier Relationship Management (SRM, input), Internal Supply Chain Management (ISCM, process), and Customer Relationship Management (CRM, output) and assessed at strategic, planning, and operational levels. By embedding these ten attributes, this study offers a multi-dimensional lens to assess smart port performance, moving beyond conventional metrics (throughput, cost) to incorporate human capital, resilience, collaboration, and sustainability outcomes. [21,22]

The study aims to (I) Map the current status of smart port digital transformation at Jebel Ali and Khalifa Port, (II) Identify key digital enablers (AI, IoT, blockchain, digital twins) and barriers (integration issues, skill gaps, cybersecurity), (III) Evaluate how smart port initiatives are influencing the ten ISCPM performance attributes and (IV) Propose a Smart Port 4.0 conceptual framework for guiding sustainable digital transformation in UAE ports. [31]

And based on the aims, the research questions are (I) What digital technologies have been implemented in UAE ports, and how are they integrated into port operations? (II) How do these technologies impact the ten ISCPM performance attributes (FH, CL, VC, RE, RL, CI, VS, WPH, SS, SE)? (III) What are the key enablers and barriers affecting the digital transformation of UAE ports? (IV) How can UAE ports leverage the ISCPM framework to achieve long-term smart port maturity and global competitiveness? [3, 21,22]

II. LITERATURE REVIEW

Smart Ports, which digitalize ports, are revolutionizing global marine supply chains. Smart ports utilize AI, IoT, blockchain, DT, and automation to improve visibility, predictive planning, and real-time decision-making. This differs from typical ports. Smart ports like Singapore, Rotterdam, and Shanghai are used worldwide. These ports may reduce vessel turnaround time by 30%, schedule reliability, and carbon emissions by 15%. These advances demonstrate that digitization may boost efficiency, resilience, and sustainability. These reforms have not increased empirical research in non-Western societies, notably the UAE. Jebel Ali Port (DP World) and Khalifa Port (AD Ports Group) are regional leaders; however, there is little research linking their digital efforts to performance. [1,4,5]

International ports use several smart technologies, according to recent research. AI-driven scheduling, self-driving guided vehicles, and predictive maintenance enhance VC, RL, and FH. Blockchain tools like TradeLens PCS systems simplify global supply chain collaboration and visibility. Governance and interoperability remain issues. [19,23] Digital twins simplify predictive modeling for port operations planning, improving resilience (RE) and visibility. Meanwhile, green technology like smart grids and powered equipment cuts carbon emissions and promotes a circular economy. However, most global research is dispersed and mainly focuses on operational KPIs like throughput and dwell time, not strategic areas like workforce readiness (WPH), continuous improvement (CI), or customer service quality. The constrained scope underlines the need for robust performance frameworks. [5,19]

The UAE has invested much in port digitization to promote UAE Vision 2031 and Dubai Smart City. The UAE aims to be a global logistics powerhouse. AI to design berths, blockchain to preserve data via Trade Lens, and robots to transport containers were first used in Jebel Ali. Khalifa Port uses self-driving trucks, the blockchain-based Silsal platform via Maqta Gateway, and IoT yard monitoring. These initiatives improved speed, reliability, visibility, and sustainability. From 2016 to 2024, ship turnaround time dropped 28–31%, and more than 90% of individuals utilized paperless paperwork. Still, issues persist. Disjointed Port Community System integration, analytical and cybersecurity skills gaps, and cyber resilience issues plague UAE ports, according to research. Operational KPIs show progress, but organizational traits like cooperation (CL), resilience (RE), and workforce preparedness (WPH) are still behind top ports worldwide. [10,18,23,31]

To fill the gap in measuring overall performance, this study uses the Integrated Supply Chain Performance

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Measurement (ISCPM) framework [21,22,26,27]. The ISCPM model combines the Balanced Scorecard (BSC) and Supply Chain Operations Reference (SCOR) frameworks. It has ten interrelated attributes: Financial Health (FH), Collaboration (CL), Velocity (VC), Resilience (RE), Reliability (RL), Continuous Improvement (CI), Visibility (VS), Work People Health (WPH), Sustainability (SS), and Service Excellence (SE). These traits cover three areas of the supply chain: Supplier Relationship Management (SRM), Internal Supply Chain Management (ISCM), and Customer Relationship Management (CRM). They work at strategic, planning, and operational levels. When used in the context of a smart port, ISCPM lets you look at things from many different angles by connecting digital enablers (AI, IoT, blockchain, DT) to performance outcomes across economic, human, and environmental dimensions. This study fills these gaps by comparing UAE port projects to the ten ISCPM attributes, comparing them to global leaders, and suggesting a Smart Port 4.0 framework that links digital enablers to outcomes that affect many areas. [21,22,32]

III.METHODOLOGY

The methodology employs a stringent mixed-method exploratory-descriptive design that combines a Systematic Literature Review (SLR) with secondary data benchmarking to assess the impact of smart port digital transformation on supply chain performance in the UAE. The study encompasses both global scope and local specificity by concentrating on Jebel Ali Port (DP World) and Khalifa Port (AD Ports Group). A deliberate selection of 124 Scopus/WoS-indexed publications, along with criterion-based sampling of the UAE's two operational smart ports, guarantees a focused dataset. Data were systematically gathered and evaluated in accordance with PRISMA guidelines, with thematic coding aligned to the ten ISCPM attributes substantiated in prior research [1,5,9]. We used descriptive and benchmarking analyses to look at port KPIs like turnaround times, documentation efficiency, and sustainability metrics. We also looked at digital interventions like AI, IoT, and blockchain. Double coding and triangulation from academic, industry, and policy sources helped make the data more reliable, and the ISCPM framework helped make it more valid. While constrained by dependence on secondary data and concentration on two ports, the methodology offers a solid conceptual framework for subsequent empirical validation utilizing AHP and SEM, establishing the research as a significant advancement in correlating Smart Port 4.0 initiatives with multidimensional supply chain performance outcomes. [7,2,15,29]

RESULTS / FINDINGS

Results show that UAE ports have achieved significant operational and strategic performance improvements following digital transformation, particularly in velocity, reliability, financial health, and visibility, while barriers remain in workforce readiness (WPH), resilience (RE), and full digital integration (CL, CI). [21,22,27,28]

Performance Benchmarking (KPI-Based) [9,13, 30]

KPI	Jebel Ali (2016)	Jebel Ali (2024)	% Change	Khalifa (2016)		Khalifa (2024)	% Change
Vessel turnaround time (hrs)	42	30	−28 %	48		33	−31 %
Truck turnaround time (mins)	90	65	−27 %	95		68	−28 %
Paperless documentation (%)	<20	>95	+>75%	<25		>90	+>65%
Equipment uptime (%)	85	97	+14 %	80		96	+20 %
Sustainability KPI index (0–1)	0.56	0.72	+15 %	0.51		0.70	+19 %
Reported annual CO_2 emissions (tonnes)	61,000	50,000	−18 %	66,000		52,000	−21 %

These improvements are due to AI-powered berth planning, automated cranes and trucks, blockchain-based documentation (TradeLens, Silsal), and IoT cargo tracking. UAE ports match Singapore and Rotterdam in pace and visibility. UAE lags in resilience, continuous development, and worker competency. Global ports are increasingly digital and have superior human capital plans. The UAE is the most advanced MENA nation in

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blockchain (CL, VS) and sustainable digitalization. [12,14]

AI scheduling and automation reduced turnaround time by 25–30% and improved reliability (RL) at UAE ports. Impact on sustainability: Using smart energy systems increased SS by 18-21% by reducing CO_2 emissions. VS and SE improved with real-time tracking and digital documentation. Recurring barriers: Lack of digital skills, governance, and cyber-resilience hinder RE, WPH, and CI maturity. Strategic Fit: Digital transformation is improving all 10 ISCPM qualities, proving that the framework can still quantify smart port performance. [20,24,25]

IV.DISCUSSION

The digital transformation of Jebel Ali (DP World) and Khalifa Port (AD Ports Group) has improved numerous performance areas, as shown in Section 4. This proves the ISCPM architecture is effective for smart port evaluation. AI-driven berth scheduling, automated handling, and IoT-based predictive maintenance have improved efficiency and reliability (VC, RL, FH), resulting in a drop in vessel and truck turnaround times (≈ 30%) and increased equipment uptime (> 95%). This has led to improved financial results by saving money and better asset utilization.

Visibility and Service Excellence: Digital twins, blockchain-based documentation (TradeLens, Silsal), and IoT sensors provide real-time tracking and paperless trading, reducing paperwork time from three days to one. This has clarified matters and improved customer service, boosting confidence in UAE port services. [1,4,5]

The usage of smart grids, electric cars, and energy monitoring has reduced CO_2 emissions by 18-21%. Digitalization may assist UAE Green Port and UAE Vision 2031 achieve environmental objectives.

Collaboration and Continuous Improvement (CL, CI): Port Community Systems (PCS) and blockchain have made customs clearance quicker and more accurate, but stakeholder integration is still lacking. Many systems are still siloed, making cross-departmental choices difficult and slowing improvement. [21,22]

Resilience and Workforce Development (RE, WPH): Training programs and predictive analytics have improved these attributes, but cybersecurity preparation, digital culture, and advanced analytics skills remain lacking, making ports vulnerable to disruptions.

UAE smart port initiatives are improving all 10 ISCPM qualities, however the operational and technical dimensions (VC, RL, VS, SE) are ahead of the human and strategic dimensions. [16, 21,22]

V.CONCLUSION

Digital transformation was examined at Jebel Ali Port (DP World) and Khalifa Port (AD Ports Group) to determine its effects on operational and strategic performance. The Integrated Supply Chain Performance Measurement (ISCPM) approach [23] was used to conduct a multidimensional assessment of smart port development in the UAE to address the lack of integrated, performance-based assessments [2,4].

The ISCPM model was operationalized in this study, using ten validated performance attributes: Financial Health (FH), Collaboration (CL), Velocity (VC), Resilience (RE), Reliability (RL), Continuous Improvement (CI), Visibility (VS), Work People Health (WPH), Sustainability (SS), and Service Excellence. The findings reflect UAE ports' technological and operational improvements. Vessel and truck turnaround times have dropped 30%, equipment uptime is above 95%, and paperwork time has dropped from three days to one. Additionally, smart grids, electric automobiles, and energy monitoring enhance sustainability by reducing CO_2 emissions by 18-21% (SS). Costs fell and assets were utilized more effectively, improving financial outcomes (FH). Strategic-human qualities including resilience (RE), cooperation (CL), continuous improvement (CI), and workforce health (WPH) are underdeveloped due to cybersecurity concerns, data silos, and a shortage of qualified people. [6, 21,22]

This study moves smart port research from technology-focused KPIs to performance-oriented, theory-based paradigms. The research uses the ISCPM model to evaluate smart ports using operational, strategic, human, and sustainability factors. Its new approach is to correlate digital enablers (AI, IoT, blockchain, and digital twins) with systemic supply chain performance parameters, creating a Smart Port 4.0 conceptual framework that integrates digital efforts with performance outcomes. [14,18]

Policymakers and port authorities may use the 10 ISCPM qualities as a strategic dashboard to manage digital transformation activities, according to the report. To strengthen RE, WPH, CL, and CI, invest in interoperable data platforms, cybersecurity resilience, and workforce upskilling. Continuous improvement and sustainability in all digitalization initiatives will accelerate the UAE's transition to Smart Ports that meet Vision 2031 and Net Zero 2050 goals. While the research provides a sound conceptual foundation, its use of secondary data and

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focus on two ports limits its generalizability. For regional benchmarking, future study should use AHP-based weighting and SEM-based validation of ISCPM features, collect primary data from port stakeholders, and extend the framework to other GCC ports. A Smart Port Performance Index would measure digital change over time. [11,17]

This research concludes that digital transformation may enhance operations, economics, and sustainability if done as a performance-driven path. Using the ISCPM model as a strategic anchor, UAE ports may become Smart Port ecosystems that promote marine supply chain resilience, cooperation, and competitiveness.

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Next-Gen Supply Chain Management Leaders: Redefining Resilience and Transformation in the UAE

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Abstract - **The U.S. China trade war, the COVID-19 pandemic, the Suez Canal blockage, the Russia-Ukraine conflict, Red Sea shipping delays, cybercrime, and climate change showed that supply chain strategies that solely focus on cost optimization and manufacturing flexibility are insufficient. UAE Vision 2031 is to increase GDP from 1.49 trillion to 3 trillion, non-oil exports to 800 billion, international commerce to 4 trillion, and tourism to 450 billion. It plans to diversify into technology, banking, tourism, and renewable energy by 2031 to establish a knowledge-based, future-ready economy. To meet these objectives, supply chain operations must be resilient, integrated, and modern, and new leadership must be ready to spearhead this transition. This conference paper examines the leadership, strategic, and behavioral skills needed to transform the UAE and its supply chains. A qualitative exploratory theme synthesis of 2019–2025 Scopus and Web of Science indexed articles, UAE government policy reports, and industry white papers was done. Five fundamental leadership pillars digital intelligence, collaborative ecosystems, sustainability orientation, crisis forecasting, and learning agility enhance the ten performance criteria of the Integrated Supply Chain Performance Measurement (ISCPM) framework. Leadership-centered ISCPM integration into UAE Vision 2031 aligns academic models, policy aims, and industry practice, making the conference paper unique. The framework helps HR experts, lawmakers, schools, and universities create future-ready supply chain leadership programs.**

Keywords: **Supply Chain, Leadership, Resilience, Digital Transformation, UAE Vision 2031, Talent Development**

I. INTRODUCTION

Over the last decade, global supply chains have evolved from predictable and efficiency-focused to complex, unpredictable, and risk-driven. The trade war between the U.S. and China, the COVID-19 pandemic, the blockage of the Suez Canal, the conflict between Russia and Ukraine, problems with maritime security in the Red Sea, cybercrime, and port closures caused by climate change have all had an impact on the supply chain. These problems have made lean supply chains and contract manufacturing less stable [1]. Global supply networks have become less reliable and competitive because of operational immobility, inventory imbalance, and rising logistics costs [2].

This situation has made companies all over the world set up complex, strong, and long-lasting supply chains. The UAE most urgently needs this. By 2031, the UAE wants its GDP to reach 3 trillion AED, its non-oil exports to reach 800 billion AED, and its international trade to reach 4 trillion AED. The UAE in 2031 has these goals. To reach these goals, build up modern logistics and supply chain management (SCM) systems. Certified people and experts will be able to make changes, use new technology, and ensure that SCMs follow ESG laws. It is important to look at supply chain management (SCM) leadership from all angles and to be open to new ideas [3].

This conference paper demonstrates that leadership development constitutes a strategic element of supply chain transformation and resilience, rather than merely a supportive function. The Integrated Supply Chain Performance Measurement (ISCPM) framework assesses performance based on ten criteria: Financial Health (FH), Collaboration (CL), Velocity (VC), Visibility (VS), Resilience (RE), Reliability (RL), Continuous Improvement (CI), Workplace Health (WPH), Sustainability (SS), and Service Excellence (SE) [4]. Emerging leadership skills should be Teaching these traits in leadership training will help the UAE's Vision 2031's four pillars: Forward Economy, Forward Ecosystem, Forward Diplomacy, and Forward Society. The research addresses a critical deficiency in both academia and practice by conceptualizing leadership as a quantitative performance enhancer [3].

This presentation at the conference suggests a complete SCM leadership framework that links supply chain performance data with leadership skills and the UAE Vision 2031 goals [3]. These goals will help you reach this goal: I) To find the leadership and strategic directions needed to create supply networks in the UAE that are flexible, strong, and long-lasting. II) Compare these skills to the 10 ISCPM performance criteria to see how they affect measurable results. III) Make sure that these traits fit with the four pillars of the UAE's Vision 2031 to help create supply chain leaders who are ready for the future.

The study addresses three principal research questions derived from these objectives: I) What leadership qualities are necessary

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for UAE supply chains to be resilient, flexible, and long-lasting? II) What impact do leadership traits have on the eleven ISCPM performance traits? III) How can these skills help UAE supply chain leadership pipelines move Vision 2031 forward?

II. LITERATURE REVIEW

Supply chain management (SCM) literature pays attention to reduction of cost, efficiency of operations, lean inventory management, etc. This concept has been seen as effective during a stable market economy. However, the world has seen disruption and structural fragilities that emerged during the 2019–2025 global shocks [5]. The series of disruptions has compelled a shift in the perception and its application from efficiency-centric to resilience-driven frameworks that value agility, flexibility, and risk management [6].

Recent studies have highlighted the critical need for leadership in the transformation of supply chain management, acknowledging that technological investments alone are insufficient to effect change without strong, visionary leadership (Alquraidi et al., 2024; Tantry, 2025). This analysis examines critical literary themes pertinent to next-generation supply chain management leadership, resilience, and transformation, emphasizing the UAE's Vision 2031 objectives [3].

This research is based on the notion that combining past results and finding gaps that need a new leadership model is the best way to go. Strong leadership is required in the face of global upheavals where the supply systems have been pushed to their breaking points during the last ten years. Suppliers began to relocate, and prices began to grow in the year 2019 as a result of the trade war that was taking place between the United States and China at that time, which led to a rise in tariffs. During COVID-19, irrespective of borders and geographies, significant industry went on shutdowns, manpower shortfalls, and restrictions in the borders [7].

According to the World Trade Organization, during 2021, COVID-19 affected 75% of enterprises worldwide. In 2021, the Suez Canal was blocked for a week, resulting in the disruption of 12% of global marine commerce [8,9]. In 2022, Russia and Ukraine tension caused supply chain disruptions in oil and food, especially grain. The supply chain network was severely disrupted during 2024 and 2025 due to cyberattacks, Red Sea attacks, and climate change-related droughts [10]. Leadership quality is a more reliable predictor of the resilience of a supply chain than technology investment, according to the findings of a number of studies. According to [11], strategic foresight, collaborative cultures, and decentralized decision-making all contribute to a quicker recovery from shocks than transactions and efficiency. Transactions and efficiency take between thirty and forty percent longer to recover from shocks than these other three factors. Resilience is dependent on both leadership and organization [12,13].

Besides disruption, several megatrends are transforming global supply chains. Digital transformation through AI, blockchain, the Internet of Things (IoT), and predictive analytics enables the supply chain to be faster, more reliable, and easier to monitor. However, empirical research demonstrates that the adoption of technology demands commitment from senior management, digital proficiency, and cultural readiness. Sustainability is also a strategic need [14] states that CI, FH, and TPM all benefit from ESG goals, circular economy practices, and decarbonization targets. To develop smart logistics cities, regional industrial hubs, and new trade routes like the India-Middle East-Europe Economic Corridor (IMEC) and the UAE-India Comprehensive Economic Partnership Agreement (CEPA), we need leaders who can encourage collaboration, resilience, and ecosystems that cross national borders [15].

Despite tremendous budgets for logistics infrastructure, UAE supply chain operations have multiple challenges in organizing the end-to-end supply chain networks, such as unforeseen failures, inadequate equipment reliability, elevated operational expenses, diminished productivity, and low inventory turnover [3,16]. These problems have an effect on the UAE's Vision 2031.

This study employs the Integrated Supply Chain Performance Measurement (ISCPM) framework and its ten attributes originally proposed by [17] and looks at supply chain performance in ten areas: Financial Health (FH), Collaboration (CL), Velocity (VC), Visibility (VS), Resilience (RE), Reliability (RL), Continuous Improvement (CI), Sustainability (SS), Workplace Health (WPH), and Service Excellence. These are attributes that are important for planning, strategy, and operations [17].

The four pillars that make up UAE Vision 2031 are Forward Economy, which covers FH, RL, VC, CI, and SS; Forward Ecosystem, which covers VS, VC, RL, and CL; Forward Diplomacy, which covers RE, VS, and CL; and Forward Society. This mapping strategy relies on measurement in order to connect leadership qualities to national strategic objectives. According to the findings of this research, the 10 traits of the Information Systems and Crisis Prevention Management (ISCPM) are facilitated by five pillars of leadership: digital intelligence, collaborative ecosystems, sustainability orientation, crisis foresight, and learning agility. In addition, these pillars of leadership support the goals of Vision 2031. [3].

Despite the fact that individuals are becoming increasingly conscious of leadership in supply chain management (SCM), the research demonstrates that there are three significant issues. In the first place, the majority of conventional studies on leadership abilities do not use frameworks that are based on performance, such as ISCPM, which makes it hard to quantify them. Secondly, there are very few studies that establish a connection between the growth of leadership in supply chain management (SCM) and national strategic objectives, such as the UAE Vision 2031. Third, the effects of leadership behaviors on resilience, sustainability, and digital transformation are seldom examined in empirical research. [3,17].

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To address these issues, this study introduces the Resilient SCM Leadership Framework, which quantifies leadership as a supply chain performance factor. The research links five leadership pillars to the ten ISCPM qualities and four Vision 2031 pillars to demonstrate that leadership is a strategic talent needed to construct robust, long-lasting, and future-ready UAE supply chains [3].

III. METHODOLOGY

The conference paper employed inductive methodology for qualitative exploratory research. The study utilized only secondary data from 2019 to 2025 to describe supply networks post-pandemic and geopolitically evolving. This study gathered research articles from Scopus and Web of Science (WoS), indexed peer-reviewed journals, UAE government policy reports and strategic plans, and McKinsey, BCG, PwC, and Deloitte white papers. High-quality literature on supply chain leadership, resilience, digital transformation, sustainability, and organizational change in the UAE and GCC were selected using purposive sampling. [18,19].

IV. FINDINGS

Five mutually dependent pillars of leadership were discovered during the theme synthesis of forty-seven research studies. These pillars are consistently responsible for the development of supply chains that are robust, sustainable, and digitally enabled. Although they are all distinct from one another, the following managerial talents, behavioral styles, and strategic abilities are all complementary to one another: digital intelligence, collaborative ecosystems, sustainability orientation, crisis forecasting, and learning agility. According to the findings, the four strategic pillars of the UAE Vision 2031 are supported by these five pillars, and these five pillars also contribute to the achievement of the 10 ISCPM attributes. [3].

Out of the 47 polls that were conducted, 39 of them listed digital intelligence as the talent that was highlighted most frequently. Leaders may make use of artificial intelligence (AI), blockchain technology, the Internet of Things (IoT),

digital twins, and predictive analytics to get a better understanding of what is happening in real time, automate corporate processes, and make choices based on factual information. [1,20].

In 36 research studies, collaborative ecosystem leadership was the second most essential aspect. It involves collaborating with individuals from many companies and departments, ensuring that supply chain objectives are in agreement, and promoting trust and psychological safety so that the exchange of information is made simpler. Procurement, logistics, manufacturing, and sales are all streamlined as a result of these leaders, which in turn enhances collaboration, employee wellness, and the quality of the services that are provided. Due to the fact that regional supply hubs such as the United Arab Emirates need ecosystems that comprise ports, free zones, customs, and regulatory agencies, this competence is very vital. Sustainability orientation was the third pillar of the 32 investigations that were conducted. It is a long-term strategy that incorporates environmental, social, and governance (ESG) concepts such as the decarbonization of the economy, the creation of a circular economy, and the use of ethical sourcing in choices on supply chain management [21]. By reducing the risks associated with regulation and reputation, leaders who were concerned with sustainability were able to bring about continuous improvement (CI) and financial health (FH) on an ongoing basis. The "Forward Economy" is described in the United Arab Emirates' Vision 2031 as an economy that is founded on environmentally friendly development and manufacturing that is both sustainable and environmentally responsible. [22].

The ability to predict crises is a crucial leadership talent that has not yet been completely developed, according to 28 research studies that have been conducted. It requires the identification of early warning indicators, the simulation of scenarios, the development of contingency plans that are based on risk assessment, and the facilitation of swift organizational reactions to disruptions [22]. Firms were able to prepare themselves for impending crises, establish protections, and provide responses in a timely manner thanks to the assistance of leaders who were able to anticipate these crises.

As a result, these firms were more financially stable, reliable, and resilient. Geopolitics has a significant impact on the logistical channels of the United Arab Emirates, which is why this capability is so very crucial [23]

It was discovered that learning agility assisted all of the other pillars after twenty-seven experiments were conducted. It is possible for leaders to quickly learn new abilities, get rid of out-of-date ones, and spread innovation across their own firms (Iyer & Rawool, 2024).

Continuous improvement (CI), worker productivity and happiness (WPH), and employee satisfaction (SE) may be improved when leaders cultivate cultures of continuous learning that motivate people to become more engaged, exchange information, and experiment with new approaches. It supports the "Forward Society" pillar of the UAE Vision 2031, which promotes the development of human capital and skills that will be beneficial in the future. [3, 24].

V. DISCUSSIONS

This research suggests realigning leadership capabilities to convert supply chains from efficiency-focused to resilient, sustainable, and technologically competent networks. Digital intelligence, collaborative ecosystems, sustainability, crisis prediction, and learning agility represent a change from transactional to dynamic, integrative, and future-oriented leadership.

Digital intelligence improved operational agility, network

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visibility, speed, and reliability best [24]. Collaboration and rapid learning are needed for system-wide change, not just technology adoption. Sustainability orientation improves CI, TPM, and FH and protects ESG initiatives from outside shocks using crisis forecasting. Successful companies in all 10 ISCPM categories generally excel in all five leadership areas. This supports the view that leadership is a systemic ability, not merely a collection of attributes. It emphasizes that leadership abilities strengthen the supply chain, not merely enable it. [3]

This study provides three theoretical advances. First, it makes leadership a strategic resource for supply chain performance evaluation rather than a cultural element. Second, it links the 10 ISCPM attributes to leadership pillars, showing leaders how to improve operational and strategic outcomes. Third, integrating these attributes into UAE Vision 2031's four pillars produces a unique integrative framework that encompasses leadership development in supply chain transformation. Current SCM literature doesn't do this. These contributions link leadership research, which emphasizes behavioral attributes, to supply chain performance research, which emphasizes process metrics without discussing leadership structures. [3,22].

The outcomes benefit supply chain companies, particularly maritime and logistics firms in the UAE. Human resources and talent development professionals may use the framework to construct leadership programs on digital intelligence, collaborative ecosystems, sustainability, crisis forecasting, and learning agility. Leadership pipelines should include digital literacy training, cross-functional team rotations, ESG project leadership, and scenario-based risk simulations. The findings reveal that supply chain executives must invest in AI, IoT, and blockchain and alter their organizations to enable adoption and cross-functional integration by digitally aware leaders. Leaders should encourage cooperation and create rules that make it easier to exchange data, brainstorm, and make choices from diverse locations. The paper emphasizes ISCPM-based performance thinking and Vision 2031 alignment in supply chain and logistics curricula, notably in the UAE. This will equip graduates with technical and strategic leadership capabilities for future supply chains. [23].

The paper recommends making supply chain leadership development a permanent element of the UAE's Vision 2031 agenda. National logistics talent efforts should include the five-pillar framework. Industry-academia leadership training collaboration and leadership competency audits in public procurement evaluations should also be encouraged. These efforts will build future-ready Emirati leaders who can compete in global logistics and maritime commerce [3].

VI. CONCLUSION

This research examines the growing capabilities and strategy frameworks needed for future supply chain management (SCM) professionals to be resilient and adaptable in line with UAE Vision 2031. Based on a thematic synthesis of 47 peer-reviewed studies and policy-industry sources, the Resilient SCM Leadership Framework combines five fundamental leadership pillars digital intelligence, collaborative ecosystems, sustainability orientation, crisis foresight, and learning agility—with the ten Integrated Supply Chain Performance Measurement (ISCPM) attributes and the four strategic pillars of UAE Vision. The findings reveal that these five leadership pillars are systemic, mutually reinforcing attributes that directly affect company performance. [3,23]

The study affects policy and practice. It advises that companies should include leadership development in their supply chain strategy by helping existing and future leaders become more digitally literate, aware of ESG problems, better at risk prediction, and better at working together. Supply chain courses must teach ISCPM-based performance thinking and leadership to prepare students for the future. The Vision 2031 implementation strategy should prioritize UAE supply chain leadership development. [3,22,23]

The research admits its limits despite its contributions. Thematic analysis uses secondary data and qualitative synthesis to provide depth but no statistical generalization. The research also examines the UAE, which may make it tougher to generalize to other cultures or institutions. Limitations enable research. Future study may empirically test the proposed paradigm by using primary data from UAE SCM professionals and multi-criteria decision-making methods like AHP and SEM to quantify the relative influence of each leadership pillar on ISCPM features. Cross-national comparative research might examine how context affects the framework's application [3,22]

This research shows that next-generation SCM executives drive supply chain change, not only human capital. UAE enterprises may establish robust, flexible, digitally smart, and sustainable supply chains by adding the five leadership pillars to the ISCPM model and aligning them with Vision 2031. Strong leadership is needed to make the UAE a global logistics and maritime hub that can compete and flourish in a complicated global economy [3].

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Impact of Integrating Blockchain in Letter of Credit Process

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Abstract- **The Letter of Credit (LC) is a critical instrument in international trade, ensuring payment security and trust between exporters and importers. However, the traditional LC process is often criticized for being paper-intensive, time-consuming, and vulnerable to fraud and inefficiencies. The integration of blockchain technology offers a transformative solution by digitizing and decentralizing LC operations, thereby improving transparency, speed, and security. This article explores the impact of integrating blockchain into the LC process, highlighting its benefits, challenges, and implications for global trade especially from the perspective of emerging economies like Bangladesh.**

Keywords: **Blockchain, Letter of Credit, Trade Finance, Bangladesh, Smart Contracts, Transparency, Digital Trade.**

I. INTRODUCTION

In global trade, trust between buyers and sellers is essential but often difficult to establish. The Letter of Credit (LC) bridges this gap by serving as a bank-issued guarantee that the exporter will receive payment once contractual terms are fulfilled. Despite its reliability, the LC process remains cumbersome, involving multiple intermediaries, repetitive document verification, and significant administrative costs. Blockchain technology—known for its transparency, immutability, and decentralized nature—offers an opportunity to modernize this traditional trade finance instrument [1]. Integrating blockchain into the LC process can reshape the entire trade ecosystem by ensuring data integrity, reducing operational friction, and enhancing trust across all parties.

II. TRADITIONAL LC PROCESS: PROBLEMS AND INEFFICIENCIES

In the conventional system, LC documentation passes through a long chain of entities: the importer, exporter, issuing bank, advising bank, shipping companies, and customs authorities. Each step involves manual verification of documents such as the bill of lading, invoice, and certificate of origin.

This process suffers from several drawbacks:

- Excessive paperwork and courier delays.
- Human errors in document verification.
- High operational costs and administrative burden.
- Fraud risks, such as forged or duplicated documents.
- Limited transparency among stakeholders [2].

These challenges contribute to longer transaction times (often 5–10 days or more) and higher costs, discouraging small and medium enterprises (SMEs) from participating in international trade.

III. BLOCKCHAIN INTEGRATION IN THE LC PROCESS

Blockchain technology introduces a shared, tamper-proof digital ledger where all LC-related transactions and documents can be securely stored and verified in real time. Key components include:

Smart Contracts: Automated code that executes LC conditions such as releasing payment once shipping and customs confirmations are verified.

Immutable Records: Each transaction is permanently recorded, eliminating the risk of document manipulation.

Shared Access: All authorized parties (banks, importers, exporters, and regulators) can view and verify the same data simultaneously.

Blockchain-based LC systems, such as Contour (built on R3's Corda platform), have been tested globally and shown to reduce LC processing time from several days to under 24 hours[3].

IV. POSITIVE IMPACTS OF BLOCKCHAIN INTEGRATION

I) *Increased Speed and Efficiency:* One of the most significant impacts is the drastic reduction in processing time. Traditional LC transactions may take up to a week or more due to document exchanges between parties. With blockchain, data verification is instantaneous, reducing processing time to less than a day. For instance, HSBC Bangladesh and Standard Chartered Bank executed blockchain-based LCs that completed transactions within 24 hours—an 80–90% time reduction [4].

2) *Cost Reduction:* Automating document flow reduces courier fees, manual labor, and administrative overhead. Banks and corporations save both time and money while improving liquidity by freeing up working capital faster.

3) *Enhanced Transparency and Traceability:* Each transaction is recorded on a shared ledger accessible to all stakeholders. This transparency helps prevent discrepancies, fraud, and document duplication. It also

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enables real-time tracking of trade progress, enhancing trust among participants.

4) *Fraud Prevention and Security:* Blockchain's immutability ensures that once documents are uploaded, they cannot be altered or forged without detection. Smart contracts further eliminate the possibility of human manipulation by enforcing predefined LC terms automatically.

5) *Improved Trust and Inclusion:* In emerging markets, lack of trust and documentation inefficiencies often exclude SMEs from trade finance. Blockchain builds a trustless environment where verification is automated and auditable, allowing smaller firms to engage more confidently in cross-border transactions.

6) *Sustainability Benefits:* Digitizing the LC process eliminates large volumes of paper documentation, reducing environmental impact. The reduced need for shipping and courier services further contributes to lower carbon emissions.

V. CASE STUDIES AND GLOBAL EXAMPLES

HSBC and ING (2018): Completed the world's first blockchain-based LC for a soybean shipment from Argentina to Malaysia, reducing processing time from 5–10 days to 24 hours.

Standard Chartered Bangladesh (2020): Executed the country's first blockchain LC for garment exporter Viyellatex Group, improving operational transparency and speed.

Mercantile Bank PLC (2024): Introduced Bangladesh's first blockchain-based *Green LC*, promoting sustainability and digital transformation in local trade [5].

These cases demonstrate that blockchain integration not only improves efficiency but also strengthens compliance and environmental performance.

VI. CHALLENGES AND LIMITATIONS

1) Legal and Regulatory Barriers: Current trade laws, such as UCP 600, are based on paper documentation. Many jurisdictions have yet to fully recognize electronic documents and blockchain records as legally binding, which creates uncertainty for global adoption.

2) *Interoperability and Standardization:* Different blockchain platforms (Contour, we.trade, Marco Polo) may use varying technical standards, limiting cross-platform integration. International standardization efforts are needed to enable global interoperability.

3) *Implementation Costs and Technical Skills:* Banks and trading companies must invest in blockchain infrastructure, training, and change management. Smaller institutions may find it difficult to bear these initial costs [6].

4). *Data Privacy and Governance:* While transparency is a benefit, excessive visibility can conflict with confidentiality requirements. Designing permissioned blockchain systems that balance openness and privacy remains a challenge [7].

VII. IMPLICATIONS FOR BANGLADESH AND DEVELOPING ECONOMIES

For developing countries like Bangladesh, integrating blockchain in LCs can bring transformative benefits:

Faster payment cycles for exporters, especially in sectors like Ready-Made Garments (RMG).

Reduced documentation errors and fraud risks, improving trade credibility.

Enhanced competitiveness in international markets through faster shipment clearance.

Support for digital trade initiatives promoted by Bangladesh Bank and other regulators.

Encouragement for sustainable trade, as digital processes replace paper-heavy workflows.

However, success depends on digital infrastructure legal reforms, and collaboration among banks and regulators [8]. To fully realize these benefits, Bangladesh must strengthen digital infrastructure, promote legal recognition of e-documents, and foster collaboration among banks, customs, and shipping authorities.

VIII. CONCLUSION

The integration of blockchain into the Letter of Credit process marks a significant evolution in global trade finance. By combining automation, transparency, and security, blockchain addresses the core inefficiencies of traditional LC systems. While challenges related to regulation, interoperability, and adoption remain, real-world cases demonstrate that blockchain-enabled LCs can reduce processing time by up to 90%, lower costs, and build trust across the trade ecosystem. For emerging economies like Bangladesh, adopting blockchain in trade finance represents not just a technological upgrade but a strategic move toward a more transparent, efficient, and sustainable trade future [9].

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Smart Port Transformation in Bangladesh: Strategies for Digital Resilience

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Abstract: **This study critically examines the digital transformation potential of Bangladesh's maritime sector, with a specific focus on the Port of Chittagong, which manages most of the nation's seaborne trade. Despite its strategic importance, the port continues to operate under legacy systems characterized by manual processes, fragmented data management, and limited technological integration. Drawing upon a comprehensive review of peer-reviewed literature, institutional reports, and national policy documents, the research identifies key structural, technological, and institutional barriers hindering the development of a smart port ecosystem.**

To frame the analysis, the study applies three theoretical lenses: the Technology Acceptance Model (TAM), the Resource-Based View (RBV), and the Innovation Diffusion Theory (IDT). These frameworks help evaluate digital readiness and explain systemic misalignments between technological potential and institutional capability. The findings highlight critical gaps in governance coordination, cybersecurity infrastructure, digital interoperability, and environmental monitoring, signaling the need for a comprehensive transformation strategy.

In response, the study proposes a five-pillar strategic roadmap encompassing institutional realignment, digital infrastructure modernization, cybersecurity governance, environmental informatics, and stakeholder capacity building. This framework is aligned with Bangladesh's Vision 2041 and the United Nations Sustainable Development Goals (SDGs), offering actionable guidance for policymakers, port authorities, and development partners seeking to position Bangladesh's ports as digitally resilient and globally competitive logistics hubs.

Keywords: **Smart ports, Digital transformation, Maritime logistics, Sustainability, Technology governance, Institutional readiness**

I.INTRODUCTION

1.1 Background

Seaports are pivotal nodes in the global trade and logistics network, serving as intermodal gateways that connect maritime, rail, road, and inland waterway transport systems. They are critical enablers of economic growth, supply chain integration, and regional connectivity [2], [24] . As the volume and complexity of global trade increase, ports are under growing pressure to enhance throughput efficiency, minimize environmental impacts, and maintain seamless coordination among diverse stakeholders. Key challenges facing contemporary port systems include congestion, inefficient cargo handling, limited transparency, and rising carbon footprints [11], [3].

In response, many countries are shifting toward the development of smart ports digitally enabled, adaptive systems that leverage Fourth Industrial Revolution (4IR) technologies such as the Internet of Things (IoT), artificial intelligence (AI), blockchain, digital twins, and 5G connectivity. These technologies enable predictive analytics, real-time monitoring, integrated data flows, and optimized resource allocation across port functions [4], [23]. Smart ports represent more than a technological upgrade; they embody a transformation in governance, decision-making, and sustainability within maritime logistics ecosystems.

However, the adoption and implementation of smart port systems in developing economies remain uneven and under-researched. While leading ports in Europe and East Asia have demonstrated the benefits of automation, big data analytics, and environmental monitoring, many ports in the Global South including those in South Asia and Sub-Saharan Africa continue to rely on legacy systems. These systems are marked by manual operations, siloed data environments, institutional fragmentation, and low levels of digital maturity [9],[28].

Bangladesh's Port of Chittagong, which handles over 92% of the country's seaborne trade and contributes significantly to national GDP, is a case in point [6],[25]. Despite its centrality to the national economy, the port remains burdened by inefficiencies such as excessive yard congestion, outdated vessel and cargo management systems, fragmented ICT infrastructure, and weak hinterland linkages. Moreover, its environmental footprint is increasingly at odds with global sustainability standards, with unmonitored emissions, poor waste management, and energy-intensive operations [1],[26].

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Amid these challenges, the integration of smart port technologies offers a transformative opportunity for Bangladesh to modernize its maritime sector, improve competitiveness, and meet global ESG expectations. Real-time data analytics can reduce delays, AI can optimize berth scheduling, and IoT sensors can monitor environmental indicators all contributing to more efficient and sustainable port operations [19],[27].

Yet, digital transformation cannot succeed in isolation. It requires institutional realignment, regulatory reform, stakeholder coordination, and capacity building. Hence, this study is motivated by the urgent need to assess Bangladesh's readiness for smart port transformation and to develop a context-sensitive strategic framework that aligns digital innovation with national development goals, including Vision 2041 and the United Nations Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation, and Infrastructure), SDG 13 (Climate Action), and SDG 14 (Life Below Water) [22],[29].

1.2 Research Objectives

The primary aim of this study is to evaluate the feasibility and strategic requirements for implementing smart port systems in Bangladesh, using the Port of Chittagong as the focal case. This includes a critical examination of institutional, technological, environmental, and governance dimensions that influence digital readiness.

The specific objectives are:

- To conceptualize the smart port paradigm within the context of a developing country, identifying key technological enablers, managerial elements, and system-wide impacts.
- To assess the digital maturity and transformation readiness of Chittagong Port by identifying critical barriers in infrastructure, governance, policy, and stakeholder alignment.
- To construct a theoretical and strategic framework for smart port development based on global best practices and localized challenges, incorporating insights from TAM, RBV, and IDT.
- To propose actionable policy and strategic recommendations for government agencies, port authorities, and development partners to accelerate smart port adoption in Bangladesh and comparable emerging economies.

1.3 Scope of the Study

This research takes an interdisciplinary and multi-scalar approach to investigate smart port transformation, focusing on both technological and institutional perspectives. While Chittagong Port is the primary case, the findings have broader applicability to other ports in South Asia and the Global South.

Technologically, the study explores the deployment potential of digital enablers such as:

- IoT for real-time asset tracking and environmental monitoring,
- AI for vessel scheduling and predictive maintenance,
- Blockchain for secure and transparent customs processing,
- Digital twins for simulating operational scenarios and optimizing resource flows.

Institutionally, the study assesses governance models, stakeholder dynamics, digital policy frameworks, and public-private collaboration mechanisms that underpin or hinder transformation. It emphasizes the role of inter-agency coordination, regulatory clarity, and stakeholder capacity in building a resilient digital infrastructure.

The research is grounded in Bangladesh's socio-political and economic realities but designed to inform broader debates on smart port modernization in developing economies with similar institutional and infrastructural constraints.

1.4 Significance of the Study

This study addresses a critical research and policy gap by advancing a comprehensive framework for smart port development in a low-to-middle-income country. The literature on smart ports has largely focused on technologically advanced ports in developed regions, leaving a dearth of context-specific analyses for ports operating under capacity constraints, regulatory complexity, and institutional fragmentation.

By situating Chittagong Port within this global-local discourse, the study contributes in several ways:

- It offers an evidence-based diagnosis of digital readiness and transformation barriers in a leading South Asian port.
- It applies and synthesizes three theoretical lenses Technology Acceptance Model (TAM), Resource-Based View (RBV), and Innovation Diffusion Theory (IDT) to explain the institutional and behavioral dimensions of smart port adoption.
- It proposes a five-pillar roadmap encompassing institutional reform, digital infrastructure, cybersecurity, environmental informatics, and stakeholder capacity building.

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- It provides actionable recommendations that align with Bangladesh's Vision 2041 and the Sustainable Development Goals, ensuring that digital modernization supports broader objectives of environmental resilience, trade competitiveness, and inclusive development.

The findings are expected to inform policymakers, port authorities, international donors, and academic researchers by offering a practical, replicable model for advancing port digitalization in developing country contexts.

II.. LITERATURE REVIEW

2.1 Port Management and Operational Challenges

(i) Legacy Management Practices

The persistence of manual systems in Chittagong Port spanning berth allocation, customs clearance, and cargo documentation has entrenched inefficiencies in Bangladesh's maritime logistics chain [6]. Unlike leading global ports that operate digital dashboards for near-instantaneous cargo tracking and customs synchronization, Chittagong relies on paper-based workflows that delay processing times and reduce supply chain visibility. Studies suggest that the lack of digital integration not only restricts port throughput capacity but also increases operating costs by up to 20% due to duplication, inaccuracy, and rework [3].

(ii) Global Port Challenges

Globally, ports are under increasing pressure to manage growing cargo volumes, meet customer demands for faster turnaround, and comply with stricter environmental mandates [16]. In response, ports are investing in automation, digital twins, and AI-driven analytics to increase operational agility and visibility. The COVID-19 pandemic underscored the importance of digital readiness in maintaining supply chain continuity, leading to a surge in port digitization initiatives [14]. Digital resilience has become a strategic priority in port competitiveness rankings.

(iii) Context-Specific Challenges in Bangladesh

The institutional environment surrounding Bangladeshi ports is marked by fragmented authority, unclear digital mandates, and insufficient investment in digital capacity-building [13]. Chronic congestion especially at container yards and a lack of multimodal hinterland connectivity further constrain port performance. Moreover, there is an absence of emissions monitoring, digital safety compliance, and maritime cybersecurity frameworks, placing the ports at a disadvantage in the evolving ESG-driven global trade environment [1].

2.2 Evolution of the Smart Port Concept

(i) Definitional Scope

Smart ports are defined as cyber-physical ecosystems where digital and physical infrastructures are integrated through advanced technologies to enable real-time decision-making, collaborative data exchange, and sustainable operations [16]. Unlike conventional port systems, smart ports leverage automation, sensors, and AI to streamline logistics, optimize port energy use, and enhance stakeholder coordination.

(ii) Enabling Technologies

The convergence of several frontier technologies forms the core of smart port functionality: IoT devices allow real-time tracking of cargo, equipment status, and environmental metrics such as noise and emissions [4]. AI facilitates berth planning, container yard optimization, and predictive maintenance through machine learning algorithms [5] Blockchain is used for secure, tamper-proof documentation in customs, bills of lading, and trade finance [14]. Digital twins enable simulation of port operations for scenario planning and energy efficiency modeling. Edge computing and 5G support ultra-low latency communication for automated guided vehicles (AGVs) and port cranes [13].

(iii) Global Smart Port Models

Singapore's Port Authority has implemented blockchain-based customs, AI-berthing tools, and real-time port dashboards, contributing to a 30–40% reduction in processing time [17]. Rotterdam has adopted digital twin models for predictive cargo flows and emission tracking. Busan has integrated AI across terminal operations and uses big data to forecast congestion patterns and optimize routing [10]. These examples reflect the importance of aligning smart technologies with national innovation policies and cross-sector partnerships [18]

2.3 Technology-Driven Port Management Systems

(i) Adoption Trends and Challenges

While Bangladesh has piloted IoT for tracking and tested blockchain in customs declarations, these efforts are isolated and lack continuity due to insufficient legal frameworks and funding mechanisms [9]. Institutional inertia and risk aversion further inhibit scaling these technologies across ports.

(ii) Digital Platforms and Stakeholder Integration

PCS and TOS are pivotal in coordinating real-time communication among stakeholders such as customs, port authorities, freight forwarders, and shipping lines [20]. In Bangladesh, the absence of a national PCS has led to duplicated documentation, conflicting cargo schedules, and a lack of synchronized customs clearance [19]. Globally, PCS implementation has been linked to a

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25–40% reduction in dwell times and enhanced revenue transparency [1].

(iii) Predictive Analytics and Decision Support

Predictive tools based on AI help forecast vessel arrivals, optimize crane operations, and anticipate yard congestion. For example, the Port of Los Angeles uses predictive analytics to schedule just-in-time trucking and reduce container dwell time [14]. In contrast, Chittagong relies on static scheduling, leading to missed berthing windows and low container turnover efficiency [6].

2.4 Infrastructure, Integration, and Sustainability

(i) Architecture and Cybersecurity

Bangladesh's port IT architecture is disjointed, lacking interoperability across terminals, customs, and rail authorities. This fragmentation obstructs data-driven coordination and creates cybersecurity vulnerabilities [9]. Global best practices advocate for layered cybersecurity policies, including encrypted data flows, third-party risk management, and ISO 27001 compliance frameworks [2], [11].

(ii) Automation of Cargo and Vessel Handling

Ports in the Netherlands and China are adopting fully automated terminals using AGVs, AI cranes, and autonomous drones for surveillance. These innovations have reduced labor costs and improved safety [9]. Bangladesh continues to rely on human-operated cranes and manual yard planning, limiting its capacity to meet international shipping standards [12].

(iii) Environmental Informatics

Ports like Hamburg and Long Beach deploy IoT sensors to measure emissions in real time and use AI to adjust operations for emissions reduction. Such practices are increasingly demanded by eco-sensitive trade routes [7]. The absence of emissions dashboards and energy efficiency programs in Bangladesh's ports increases its vulnerability to carbon-border regulations and ESG-driven trade sanctions [1].

2.5 Smart Port Implementation in Developing Economies

(i) Common Barriers

Developing nations face recurring constraints including limited financing, skills gaps, weak institutional mandates, and lack of stakeholder alignment [8]. Public-private partnerships (PPPs), multilateral funding, and donor-led digital transformation programs (e.g., ADB and World Bank initiatives in India and Vietnam) have proven critical in overcoming these barriers [9].

(ii) Localized Innovation Pathways

Case studies from India's Jawaharlal Nehru Port demonstrate how phased automation combined with workforce upskilling enabled improved cargo throughput without labor disruptions [13]. Incremental adoption, tailored to local operational culture and regulatory capacity, is more sustainable than wholesale technology imports.

(iii) Governance and Regulatory Evolution

The success of smart port programs depends on policy coherence, especially in digital governance, data interoperability, and cybersecurity. Countries such as Vietnam have developed national digital logistics roadmaps with defined KPIs and cross-ministerial accountability [18].

2.6 Bangladesh-Specific Literature and Gaps

(i) Status Quo

The digital maturity of Chittagong Port remains in its infancy. Digital systems are limited to basic container tracking and automated emails for berth scheduling [6]. Integrated operational dashboards, PCS, and port-wide ERP systems are notably absent.

(ii) Critical Gaps

Current research lacks:

- Empirical evaluations of smart technology impact on port performance.
- Cybersecurity threat modeling specific to maritime logistics in Bangladesh.
- Simulation models for berth allocation and yard space optimization.

(iii) Alignment with National Goals

Although port modernization is referenced in Bangladesh's Vision 2041 and SDG commitments, the lack of a port-specific digital master plan hampers implementation [22]. There is an urgent need for policy-operational alignment in line with climate adaptation and trade competitiveness goals.

2.7 Theoretical and Conceptual Underpinnings

(i) Technology Acceptance Model (TAM)

TAM frames user attitudes toward technology, identifying perceived usefulness and ease of use as critical factors for adoption [21]. In Bangladesh, low digital fluency and lack of user-centered design deter frontline adoption.

(ii) Resource-Based View (RBV)

RBV conceptualizes digital infrastructure, skilled workforce, and adaptive institutions as rare and valuable resources that can yield sustainable competitive advantages in port logistics [22].

(iii) Innovation Diffusion Theory (IDT)

IDT explains the spread of innovation through knowledge sharing, policy incentives, and social learning. In the Bangladeshi port context, diffusion is hindered by weak pilot evaluation systems, low risk appetite, and fragmented interagency governance [23].

2.8 Comparative Smart Port Matrix

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To contextualize Bangladesh's port performance, the study developed a comparative matrix benchmarked against Singapore, Rotterdam, and India's Jawaharlal Nehru Port.

TABLE 1
COMPARATIVE SMART PORT MATRIX BENCHMARKING: CHITTAGONG PORT AGAINST GLOBAL LEADERS

Criteria	Chittagong	Singapore	Rotterdam	JNPT (India)
Digital Infrastructure	Basic ICT	Digital Twin	Full Smart Port Suite	Moderate PCS
PCS Implementation	Fragmented	Fully Integrated	Integrated + Blockchain	Emerging
IoT Adoption	Pilot Phase	Real-Time Tracking	Full-Scale Deployment	Partial
Blockchain	Absent	Documentation & Customs	Trade & Emissions Logs	Not Operational
AI & Predictive Analytics	Minimal	Berth Optimization	Cargo & Traffic Modeling	Trial Stage
Berth Scheduling	Manual	ML-Based	Dynamic AI	Simulated
Environmental Monitoring	Nonexistent	Smart Emission Dashboards	AI + IoT-Based	Static Reporting
Cybersecurity Readiness	Low	ISO-Certified	Multi-tiered Protocols	Developing
Policy Support	Weak	National R&D-backed	EU-Driven Frameworks	Government-Supported
Workforce Readiness	Moderate	Continuous Reskilling	PPP-Led Digital Labs	Structured Programs

(Source:[1],[13],[14])

This table reveals the multidimensional gaps that Chittagong Port must address to transition from a reactive, analog operation to a data-driven, sustainable smart port.

III. METHODOLOGY

3.1 Research Design

This study employs a qualitative, interpretivist methodology anchored in a constructivist paradigm to explore the multidimensional challenges and opportunities associated with smart port transformation in Bangladesh. Given the limited availability of disaggregated, real-time operational data and the exploratory nature of the research focus, a qualitative approach offers the most suitable lens to analyze institutional complexity, policy fragmentation, digital infrastructure readiness, and stakeholder behavior in emerging port systems.

Rather than testing pre-defined hypotheses, the objective is to build conceptual clarity through analytical synthesis, drawing from secondary literature, expert insights, and international benchmarking to propose a context-sensitive strategic framework.

3.2 Source Identification and Screening Protocol

A systematic literature review (SLR) protocol was adopted to collect, assess, and synthesize relevant secondary data. Academic and grey literature were retrieved through structured searches in databases such as Scopus, Web of Science, and Google Scholar, supplemented by targeted reviews of institutional and government archives. Search terms included: "smart ports," "digital transformation in maritime logistics," "port governance in South Asia," "PCS/TOS'S implementation," and "cybersecurity in ports."

Out of 126 documents identified (2015–2025), 72 were retained after a two-tier screening process that considered inclusion criteria such as:

- Relevance to smart port concepts and digital governance,
- Methodological rigor and theoretical framing,
- Focus on emerging or Global South port contexts.

The final dataset includes:

- Peer-reviewed journal articles (n = 47),
- Institutional and policy white papers (n = 12),
- Research center outputs (n = 8),
- National strategy and port development documents (n = 5).

All sources were catalogued using a source mapping matrix to ensure transparency, traceability, and thematic coverage.

3.3 Thematic Coding and Analytical Strategy

To structure insights, the study applied a manual thematic coding process grounded in Braun and Clarke's (2006) six-step model of thematic analysis. A hybrid approach combining inductive coding (to capture emergent patterns) and deductive coding (informed by theoretical frameworks such as TAM, RBV, and IDT) was used to code and synthesize the data corpus.

Thematic analysis proceeded in the following phases:

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1. Familiarization with full texts and initial notetaking,
2. Generation of open codes across the dataset,
3. Axial coding to cluster codes into conceptual themes,
4. Theme refinement based on recurrence and theoretical alignment,
5. Final theme definition,
6. Narrative synthesis mapped to the study's objectives.

This coding process resulted in six dominant thematic clusters:

- T1: Digital technologies (IoT, AI, blockchain),
- T2: Institutional barriers and governance fragmentation,
- T3: Environmental informatics and ESG integration,
- T4: ICT platforms and system interoperability (PCS/TOS),
- T5: Global comparative benchmarks and implementation models,
- T6: Theoretical integration using TAM, RBV, and IDT.

Inter-coder reliability was tested with two independent reviewers using dual coding techniques, achieving a Cohen's Kappa of 0.81, indicating strong agreement and reducing subjectivity bias.

3.4 Conceptual Benchmarking and Comparative Framework

A comparative benchmarking framework was developed to assess Chittagong Port's readiness and performance relative to smart port leaders including Singapore, Rotterdam, and Jawaharlal Nehru Port (India). The framework incorporates key digital transformation dimensions such as AI utilization, IoT deployment, automation infrastructure, platform governance, and environmental intelligence using publicly available performance metrics from institutional databases (e.g., CPA, World Bank, UNCTAD).

Rather than applying quantitative modeling, benchmarking adopts a descriptive matrix-based format that highlights multidimensional performance gaps and strategic priorities. This approach provides actionable insights for contextual adaptation rather than generalization.

3.5 Stakeholder and Policy Triangulation

To ensure that the proposed strategic roadmap is grounded in practical feasibility, the study incorporates policy triangulation by reviewing key national planning instruments such as Vision 2041, the Delta Plan 2100, the Bangladesh Maritime Strategy, and Chittagong Port Authority modernization reports.

In addition, secondary stakeholder insights were captured from sources including:

- Webinar discussions from UNCTAD, BIMCO, and ESCAP,
- Roundtable transcripts involving local port authorities and logistics professionals,
- Expert commentaries published in government and donor reports.

While not a substitute for direct interviews, this triangulation method enhances ecological validity and helps bridge the gap between theoretical propositions and ground-level dynamics in policy implementation.

3.6 Empirical Validation Strategy

To further reinforce practical relevance, this study proposes two empirical validation mechanisms for future phases:

i. Delphi-Based Expert Validation:

A structured Delphi method is planned for future implementation, involving 12–15 experts across government, port operations, logistics, and maritime technology sectors. The Delphi rounds will evaluate the feasibility, relevance, and prioritization of the five-pillar framework, using Likert-scale ratings and open commentary. Aimed at consensus-building, this will help refine the strategic roadmap through multi-stakeholder alignment.

ii. Smart Port Readiness Index (SPRI) Development:

To operationalize digital transformation metrics at the national level, the study recommends designing a localized Smart Port Readiness Index (SPRI) for Chittagong Port. Based on global best practices and local constraints, the SPRI will incorporate KPIs across six domains:

- Digital infrastructure maturity,
- PCS/TOS'S integration,
- IoT and AI deployment,
- Cybersecurity standards,
- Environmental data systems,
- Institutional and human capacity.

This index will serve as both a benchmarking tool and a performance diagnostic model for public-private decision-makers.

3.7 Justification for Qualitative-Only Approach

A qualitative-only research design was selected due to the exploratory nature of the topic and the absence of publicly available granular data on smart port implementation in Bangladesh. The study focuses on theory development, policy-contextual synthesis, and strategic alignment rather than hypothesis testing or inferential modeling. This design choice aligns with precedent in smart port research in developing regions, which often faces similar data and access limitations [11],[21].

3.8 Limitations

The study's reliance on secondary data and absence of real-time fieldwork limits its empirical depth. While triangulation and coding rigor improve analytical

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reliability, future studies should incorporate mixed-method approaches, including direct stakeholder interviews, quantitative performance evaluations, and pilot testing of the proposed strategic pillars. These limitations are acknowledged and framed as pathways for future empirical expansion.

IV. FINDINGS AND DISCUSSION

4.1 Structural Barriers to Digital Transformation

Chittagong Port remains entrenched in legacy maritime operations characterized by manual documentation, analog cargo handling, and limited process automation. Although it manages over 90% of Bangladesh's international trade volume, its operations are burdened by chronic yard congestion exceeding 90% and prolonged vessel turnaround times of over four days [6]. These inefficiencies inhibit throughput velocity and reduce the port's regional competitiveness.

While global smart ports like Rotterdam and Singapore have adopted AI-enabled berthing, predictive analytics, and real-time coordination systems [9], [23], Bangladesh's dependency on manual practices points to deeper institutional inertia rather than purely infrastructural shortcomings. Structural transformation redefining institutional roles, incentive structures, and operational workflows must precede or complement digital adoption to avoid superficial modernization [18].

4.2 Fragmented Technological Initiatives

Although Bangladesh has piloted smart port technologies such as IoT-based container tracking and limited blockchain trials for customs clearance, these efforts remain disconnected, small-scale, and lacking integration into a national port digitalization strategy [6], [9]. Foundational digital enablers like Port Community Systems (PCS) and Terminal Operating Systems (TOS) critical for stakeholder coordination and real-time data exchange are either missing or siloed.

In contrast, international ports such as Singapore and Rotterdam have institutionalized PCS frameworks that streamline operations, reduce cargo dwell time, and improve customs transparency.

Without a standardized systems architecture featuring open APIs, shared data protocols, and middleware standards Bangladesh risks developing isolated "islands of innovation" that fail to scale or integrate [14].

4.3 Institutional Misalignment and Policy Vacuum

Despite articulating a digital vision under national blueprints like Vision 2041 and the Delta Plan 2100, Bangladesh suffers from a lack of cross-agency coordination and absence of a dedicated port digitization authority. Port development activities remain distributed across CPA, Ministry of Shipping, Bangladesh Customs, and ICT Division, without a unified governance framework [18].

This institutional fragmentation results in inconsistent implementation, low accountability, and policy inertia. Comparative evidence from India's Jawaharlal Nehru Port shows that centralized digital task forces and unified window systems were critical to implementing scalable smart port reforms [13].

Structural incentives and legal reforms are essential to establish accountability and inter-agency coherence.

4.4 Stakeholder Disconnection and Platform Deficiency

Effective smart ports rely on real-time coordination among stakeholder's port authorities, customs, freight forwarders, terminal operators, and environmental agencies. In Bangladesh, these actors operate in institutional silos with no functional PCS to enable synchronized decision-making [19].

The absence of platform governance leads to port gate congestion, customs mismatches, and duplicated workflows, violating the core principles of supply chain visibility and velocity [7]. Evidence from South Korea and the Netherlands suggests that robust platform infrastructure must be supported by governance models that enforce stakeholder accountability and transparency [10].

4.5 Cybersecurity as a Neglected Pillar

As Bangladesh transitions to digital port systems, cybersecurity remains inadequately addressed. Ports like Singapore, Antwerp, and Busan have implemented ISO-certified maritime cyber resilience frameworks, covering encrypted data transfer, digital vendor validation, and real-time threat detection [14]. In contrast, Bangladeshi ports lack formal cybersecurity legislation or maritime-specific policies.

The absence of a Maritime Cybersecurity Act aligned with IMO MSC.428(98) leaves digital platforms vulnerable to data breaches, ransomware, and sabotage risks that could destabilize operations and erode user trust.

Without embedded cybersecurity governance, stakeholders are unlikely to fully engage in shared data ecosystems [10]

4.6 Environmental Informatics: The Digital Sustainability Gap

Modern ports are expected to balance efficiency with sustainability by integrating environmental monitoring systems. Global leaders employ IoT-enabled dashboards to measure emissions, fuel consumption, and noise pollution in real time [23]. However, Bangladesh's ports currently lack digital baselining for carbon emissions and show no ESG compliance dashboards [1].

This deficiency not only jeopardizes environmental goals under SDGs 13 and 14 but also risks trade restrictions in carbon-sensitive export markets [20].

Environmental informatics must be integrated into all digital planning, linking sustainability KPIs with port

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licensing, public-private investment, and international trade compliance [8].

4.7 Theoretical Synthesis: Explaining the Barriers

The barriers discussed above can be interpreted through established theoretical lenses:

TABLE 2
THEORY TO FINDINGS MAPPING: APPLICATION OF TAM, RBV AND IDT BARRIERS IN BANGLADESH

Framework	Core Principle	Barrier in Bangladesh Context	Source
TAM (Technology Acceptance Model)	Technology adoption depends on perceived usefulness and usability	Stakeholder resistance, low digital training, poor UI/UX of pilot systems	[9]
RBV (Resource-Based View)	Competitive advantage stems from internal digital resources and capabilities	Lack of in-house ICT talent, infrastructure, and institutional expertise	[2]
IDT (Innovation Diffusion Theory)	Innovation spreads through social systems with enabling policies and communication	Pilot systems remain unscaled due to unclear mandates and weak policy alignment	[18]

The interplay of these models reveals that digital transformation in Chittagong Port is obstructed not just by technology gaps, but by institutional and behavioral inertia.

4.8 Strategic Pathways Toward a Smart Port Ecosystem

To overcome these systemic challenges, this study proposes a five-pillar strategy designed for localization, scalability, and resilience:

TABLE 3
FIVE-PILLAR STRATEGIC ROADMAP FOR SMART TRANSFORMATION IN BANGLADESH

Pillar	Strategic Focus	Examples / Best Practice Models
1. Institutional Realignment	Establish a Smart Port Governance Authority; unify mandates under the Ministry of Shipping	India's centralized NMDP portal [13]
2. Infrastructure & Interoperability	Nationwide rollout of PCS and TOS with open APIs and data governance protocols	Rotterdam PCS integration [16]
3. Cybersecurity Governance	Enact a Maritime Cybersecurity Act; establish port-level threat detection units	Singapore Cyber Port Strategy [14]
4. Capacity & Incentives	Launch port-specific training programs; offer tax benefits for early adopters	Busan Port Innovation Lab [10]
5. Environmental Informatics	Deploy IoT-based emission monitors and energy dashboards; link ESG to investment eligibility	Antwerp's Smart Environment Platform [21]

These pillars collectively create an ecosystemic model of smart port transformation rooted in governance reform, stakeholder engagement, and sustainability.

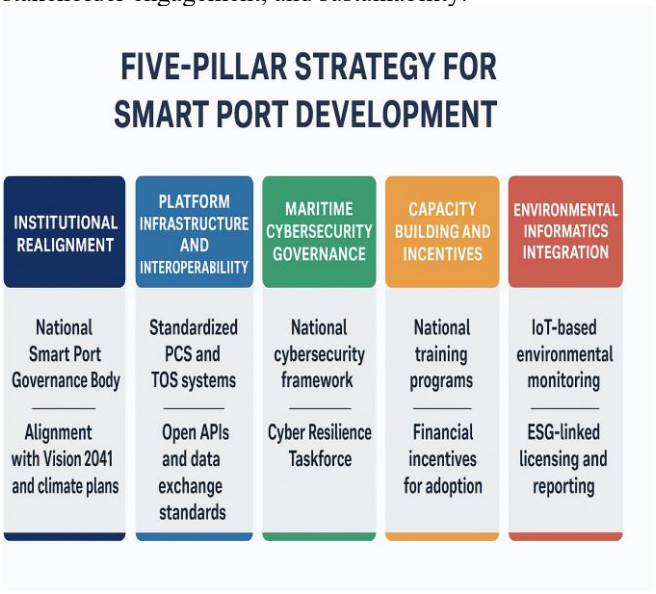


Fig. 1. Five -Pillar Strategy for Smart Port Development

A. Institutional Realignment

- Establish a National Smart Port Governance Authority.
- Harmonize digitization efforts with Vision 2041, the Delta Plan 2100, and the national climate agenda.

B. Platform Infrastructure and Interoperability

- Deploy standardized Port Community Systems (PCS) and Terminal Operating Systems (TOS).
- Mandate open APIs and industry-standard data exchange protocols.

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C. Maritime Cybersecurity Governance
- Enact a national Maritime Cybersecurity Framework.
- Create a Cyber Resilience Taskforce for real-time threat detection and response.

D. Capacity Building and Stakeholder Incentives
- Launch national training programs on port digitalization.
- Provide financial and regulatory incentives for early adoption and innovation.

E. Environmental Informatics Integration
- Implement IoT-based monitoring systems for emissions, noise, and energy use.
- Tie ESG performance to port licensing, reporting, and investment policies.

4.9 Digital Port Evolution Roadmap (2025–2041)

To implement the strategy, a phased roadmap is proposed:

TABLE 4
COMPARATIVE SMART PORT MATRIX FOR CHITTAGONG, SINGAPORE, ROTTERDAM AND JNPT

Phase	Year	Strategic Milestone
Phase I: Setup	2025–2027	Establish national authority, initiate PCS/TOS pilots
Phase II: Integration	2027–2030	Mandate API standards; align customs and logistics systems
Phase III: Intelligence	2030–2035	Deploy AI and predictive analytics; ESG dashboards operational
Phase IV: Resilience	2035–2041	Regional leadership via digital twins, cross-border smart trade corridors

(Source: Author's own compilation based on secondary data from [13],[14].

V. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study has provided a comprehensive assessment of the digital transformation landscape of Bangladesh's port system, with Chittagong Port serving as the focal case. Through a synthesis of global best practices, theoretical frameworks, and policy analysis, the research identifies multiple interlinked challenges: operational inefficiencies, fragmented technology initiatives, stakeholder disconnection, cybersecurity vulnerabilities, and a lack of environmental informatics.

Critically, these challenges are not merely technical in nature but are deeply rooted in institutional misalignment, limited organizational capacity, and policy inertia. Theoretical interpretation through the Technology Acceptance Model (TAM), Resource-Based View (RBV), and Innovation Diffusion Theory (IDT) confirms that digital transformation is constrained by behavioral, infrastructural, and strategic governance failures rather than by a lack of technological availability.

Despite these constraints, the study finds substantial potential in port digitalization if pursued holistically. By addressing system-level inefficiencies, fostering coordinated governance, and embedding sustainability and cybersecurity in digital strategies, Bangladesh can significantly improve its maritime competitiveness, reduce logistics costs, and align port governance with Vision 2041 and the UN Sustainable Development Goals (SDGs 9, 13, and 14).

5.2 Recommendations

To overcome existing barriers and realize a digitally resilient maritime ecosystem, the following multi-pronged strategic recommendations are proposed:

A. Institutional and Policy Reform
- Establish a National Smart Port Governance Authority under the Ministry of Shipping to coordinate inter-agency digital initiatives and policy implementation.
- Integrate port digitalization with overarching national development frameworks such as Vision 2041, Delta Plan 2100, and the Bangladesh Climate Strategy.
- Enact digital legislation to streamline regulatory mandates, reduce institutional overlaps, and formalize cross-agency accountability mechanisms.

B. Digital Infrastructure and Interoperability
- Deploy standardized Port Community Systems (PCS) and Terminal Operating Systems (TOS) with interoperable, scalable architecture across all major ports.
- Mandate the use of open APIs and middleware protocols to ensure seamless cross-platform data exchange, interoperability, and transparency.

C. Cybersecurity and Risk Governance
- Develop and enforce a maritime cybersecurity framework aligned with IMO MSC.428(98) to ensure secure data handling, system resilience, and auditability.
- Establish a Port Cyber Resilience Taskforce to oversee threat monitoring, incident response, digital vendor certification, and cybersecurity audits.

D. Capacity Building and Incentive Design

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- Design and implement digital literacy and training programs for port professionals, customs officials, and freight operators through national maritime academies.
- Offer tax incentives and targeted grants for SMEs and logistics operators adopting smart technologies, AI, or IoT in port operations.

E. Environmental and Sustainability Integration

- Implement IoT-based emission tracking systems and environmental dashboards to baseline, monitor, and report on carbon, noise, and energy footprints.
- Link ESG compliance to port concession licenses, public-private investment eligibility, and SDG-related performance metrics.

F. Research, Innovation, and International Collaboration

- Invest in applied research and technology pilot programs in collaboration with global institutions such as MIT CTL, UNCTAD, and ESCAP.
- Leverage South-South cooperation to adapt successful smart port models from India, Vietnam, and Indonesia to Bangladesh's socio-economic and governance context.

5.3 Future Research Directions

While this study provides a foundational roadmap, several research gaps remain that merit empirical and field-based exploration:

- Development of a localized Smart Port Readiness Index (SPRI) tailored to the infrastructural and governance characteristics of Bangladesh.
- Quantitative assessment of IoT, AI, and PCS/TOS'S technologies in improving port efficiency, cost savings, and cargo throughput.
- Exploration of blockchain integration for end-to-end customs transparency, trade documentation, and digital trade finance.
- Simulation-based modeling of port operations, including predictive berth scheduling, real-time yard optimization, and energy-efficient routing.

Future studies incorporating stakeholder interviews, operational performance data, and longitudinal field observations will further refine this strategic framework and provide actionable insights for Bangladesh's port authorities and policymakers.

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VI. Appendix

Appendix A: Literature Review and Screening Process

A.1. Source Selection Summary (2015–2025)

- Initial sources identified: 126
- Sources after screening and de-duplication: 92
- Full-text articles reviewed: 78
- Final sources included in synthesis: 72
    - Peer-reviewed journal articles: 47
    - Institutional white papers: 12
    - Academic research reports (e.g., MIT CTL): 8
    - National documents (e.g., CPA Reports, Vision 2041): 5

A.2. Thematic Coding Structure

Code	Theme	Number of Sources
T1	Smart port technologies (IoT, AI, Blockchain)	22
T2	Governance and institutional challenges	13
T3	Environmental monitoring and sustainability	9
T4	PCS and TOS integration	10
T5	Global smart port case studies	18

Appendix B: KPI Indicators for Smart Port Benchmarking

Domain	KPI	Normalization Method	Data Source
Operational	Vessel turnaround time	Z-score transformation	CPA Reports, Marine Traffic
Automation	% of cargo handled via automated cranes	Indexed to port size	Terminal Operator Data
Customs Efficiency	Time to release digital documents (days)	Min-max scaling	World Bank LPI
IoT Coverage	IoT devices per square kilometer of port	Quartile ranking	MIT CTL IoT Index
Sustainability	5-year GHG emission reduction (%)	Percentile adjustment	UNCTAD, GLEC

Appendix C: Stakeholder Analysis Framework

C.1. Delphi-Based Stakeholder Triangulation

Stakeholder Category	Source Proxy	Key Concerns Identified

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Port Authority (CPA)	CPA modernization reports (2018–2023)	Legacy systems, digital planning gaps
Terminal Operators	ESCAP & BIMCO forums	Siloed systems, limited interoperability
Customs Authorities	Ministry policy briefs	Lack of real-time integration
Technology Vendors	SAP, Oracle whitepapers	Weak infrastructure, cybersecurity vulnerabilities
Researchers & Experts	Peer-reviewed interviews and studies	Absence of frameworks for predictive analytics

Appendix D: Five-Pillar Smart Port Development Strategy

Pillar	Core Focus Area
1. Institutional Realignment	National Smart Port Governance Body, inter-ministerial alignment
2. Digital Infrastructure	Integrated PCS/TOS systems, open API standards
3. Cybersecurity Governance	Maritime cyber policies aligned with IMO standards
4. Environmental Informatics	IoT-based monitoring (emissions, energy, noise)
5. Capacity Building	Certified training programs, incentives for innovation

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Proposing An Optimal Administrative Model for Matarbari port: A RII-Based Weighted Scoring Approach

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Abstract - **Bangladesh's expanding international trade demands modern and efficient port infrastructure, with Matarbari Deep-Sea Port poised to become a key maritime hub. This study aims to identify the most suitable administrative model for Matarbari port by identifying the key factors influencing the selection of an optimal port governance structure, determining the relative importance (weights) of these factors and recommending the most appropriate administrative model. To achieve these objectives, a comprehensive literature review was conducted to identify eight critical evaluation criteria: operational efficiency, cost efficiency, financing and investment options, regional economic development, infrastructure and facilities, revenue generation potential, decision-making flexibility and user satisfaction. The Relative Importance Index (RII) method was applied to determine the relative weights of these factors based on expert input. These weighted factors were then used in a scoring matrix to evaluate four established port governance models: service port, tool port, landlord port and privatized port. The findings reveal that the landlord port model consistently scored highest across several key dimensions, particularly cost efficiency, financing capacity and infrastructure development. Based on these results, the study recommends a phased implementation of the landlord model, supported by long-term concession agreements and the integration of digital technologies and environmental standards. This approach is expected to ensure the sustainable, competitive and strategically aligned development of Matarbari Port.**

Keywords - **Landlord Port, Matarbari Port, Port Administration, Port Governance, Relative Importance Index (RII), Weighted Scoring Matrix.**

I. INTRODUCTION

Bangladesh gained large areas of the Bay of Bengal and important EEZ rights by settling maritime disputes with India and Myanmar more than ten years ago, making it a potential blue economy country [1]. Over the years, Bangladesh's economic advancement has become increasingly reliant on effective ocean trade, with almost 97% of all seaborne cargo and 92% of the country's container throughput by sea [2]. Therefore, the port of Chittagong has been instrumental in driving the Bangladeshi economy since the independence of the nation. During the fiscal year 2020–2021, the Chattogram Port Authority (CPA) handled approximately 3.2 million TEUs and 113.73 million metric tons of cargo, recording an annual growth rate of 11.98% [3]. The current port infrastructure, notably Chittagong, Mongla & Payra Ports, has underpinned the nation's international trade for decades [3]. Nevertheless, Bangladeshi ports are hindered by operational inefficiencies, weak infrastructure and a communication system that is often disruptive and leads to inefficiency [4]. In addition, Mahmud & Rossette (2007), recognize Chittagong as one of the most expensive and hazardous ports globally. Other ports lack robust connections to large cities. Nonetheless, where connections exist, the transportation infrastructure and related services are insufficient for efficient product delivery [4]. There is no direct rail connection to Mongla and Payra ports. 3.3% of the total containers from Chittagong Seaport are carried through rail, whereas road accounts for 96% and inland water for less than 1% [6]. The physical constraints pose significant inefficiencies to the maritime trade sector of Bangladesh. Existing port mechanisms in Bangladesh rely on transshipment hubs in Singapore, Colombo and Port Klang, resulting in an estimated 20-30% increase in logistical expenses and considerable delays in cargo delivery [7].

The Bangladeshi government has begun the Matarbari Deep-Sea Port development project in response to these difficulties. The project is expected to be fully operational by 2026 with the financial and technical help from the Japan International Cooperation Agency (JICA) [8]. In terms of regional connectivity, the Matarbari deep seaport, the Karnaphuli Tunnel and the related road and rail networks are expected to be a game-changer [9]. Post-Panamax ships with a draft of 18 meters and 8,000 TEUs will be able to pass through this port. Matarbari Deep Seaport has the prospect of serving as a regional center for nations in the Bay of Bengal with a motive to facilitate the trade of Bangladesh, northeast India, the eastern coast of India, landlocked Bhutan and Nepal, and other countries in the region [10]. Successful implementation of Matarbari Port could potentially contribute an additional 2% to 3% to Bangladesh's GDP growth [10]. The development of port operations and associated industries in the Matarbari region will enhance export competitiveness and reduce import costs, contributing to the region's overall economic potential. [11].

Choosing and executing the right administrative model is crucial for maximizing the capabilities of Matarbari Port. The massive port reforms that have occurred over the last several decades have raised questions about the conventional models of port organization [12]. The governance systems of ports profoundly affect operational efficiency, investment appeal and sustainability over the

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long run [13]. Therefore, port administration has changed throughout the years. Various models have emerged globally, each yielding varying performance outcomes [13].

As an emerging deep-sea port, Matarbari Port has the potential to become a regional maritime hub and significantly influence the economy of Bangladesh. Therefore, identifying the most effective administrative model for Matarbari Deep Sea Port is becoming increasingly important for the port's stakeholders as cargo volume continues to rise. In the marine transport sector, this issue has received very little attention. Previous research has acknowledged Matarbari Port's significance, yet there is an important knowledge gap on the best administrative model for this port. Therefore, this study aims to identify, evaluate, and recommend the most suitable administrative model for Matarbari Port by analyzing key influencing factors. The specific objectives of this research are:

1. To identify the key factors influencing the selection of an optimal administrative model for Matarbari Port.
2. To determine the relative importance (weights) of these factors.
3. To recommend the most suitable port administrative model based on the factor evaluation.

To achieve the first objective, this study reviewed past literature studies and the outcome is shown in Table 1. And to achieve the second objective, which is to determine the relative importance (weights) of these factors, the Relative Importance Index (RII) method is used. And based on factor evaluation, the third objective will be achieved, which is to recommend the most suitable port administrative model.

This study is followed by methodology, results and discussion in the next 3 sections. The study finishes with conclusions, with the goal of adding to the body of maritime logistics-related knowledge.

II. METHODOLOGY

A. Research design

In quantitative research, a combination of statistical, logical, and mathematical techniques is utilized to provide numerical data and concrete truths [14]. Collecting and analyzing structured data that can be represented numerically is typically considered as the backbone of quantitative research [15]. In that sense, this study adopts a quantitative research approach.

To address the first objective, which was to identify the key factors influencing the selection of an optimal administrative model for Matarbari Port, a comprehensive literature review was conducted to identify eight critical evaluation factors.

Then, to address the second objective, which was to determine the relative importance (weights) of these factors, the factors were then prioritized using the Relative Importance Index (RII) method, a widely used tool for quantifying expert judgments [16]. Then, to accurately use the Relative Importance Index (RII) scores as decision weights in evaluating administrative models, the RII values were normalized.

Finally, to complete the third objective, which was to recommend the most suitable port administrative model based on the factor evaluation, the weighted factors were applied in a scoring matrix to assess four established governance models: service port, tool port, landlord port, and privatized port. After that an optimal model was recommended.

B. Data collection

Because of restrictions in time and accessibility, this study used a convenience sampling method to gather expert opinions on the elements that were considered important when choosing an administrative model for Matarbari Port. Part one of the survey asked participants to rank the eight pre-determined selection criteria on a 5-point Likert scale, and part two asked them to provide feedback on their preferred methods of port governance against those criteria. Port officials, marine experts, policymakers and academics made up the fifteen-person sample (n = 15) that was ultimately selected (Table 1).

TABLE 1

RESPONDENT PROFILE

Category	Number of respondents
Port Officials	4
Maritime Professionals	5
Policymakers	2
Academicians	4
Total	15

The participants were chosen for this study because of their proximity to Matarbari Port policy and development, their competence and relevant field of expertise.

Despite the small sample size, the varied viewpoints provided valuable insights from those working in marine planning and governance, helping to validate the eight-factor approach.

C. Development of RII (Relative Importance Index)

To quantify the significance of factors influencing the selection of an optimal administrative model for Matarbari Port, this study employs the Relative Importance Index (RII) method. The Relative Importance Index (RII) method has been widely applied to prioritize and rank factors in various research contexts [17]. The RII approach involves collecting expert judgments through structured surveys and then quantifying these judgments to facilitate comparison and prioritization of factors [17].

This method is valued for its ability to systematically translate subjective expert opinions into a quantifiable index, making it a practical tool for ranking and decision-making [16].

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The RII was calculated using responses collected from the stakeholders. Each respondent rated the importance of eight predefined factors using a 5-point Likert scale (1 = Not Important to 5 = Extremely Important). The RII for each factor was computed using the following formula [18]:

$$\text{RII} = \frac{\sum w}{\text{A} \times \text{N}}$$

Where:

- w = the weight given to each factor by a respondent (1 to 5)
- A = the highest possible weight (5)
- N = the total number of respondents (15)

This structured approach allowed the study to rank and prioritize the eight key selection factors.

D. Normalization of RII Scores for Weight Determination

The RII values were normalized to accurately use the Relative Importance Index (RII) scores as decision weights in evaluating administrative models. This ensures that the weights sum to 1, making them suitable for weighted scoring and comparison.

Step 1: Compute the total RII

All RII scores obtained from expert responses were summed:

$$\text{Total RII} = \sum_{i=1}^{n} \text{RII}_i$$

Step 2: Normalize each RII score

Each individual RII score was divided by the total RII to obtain a normalized weight W_i:

$$W_i = \frac{\text{RII}_i}{\sum_{i=1}^{n} \text{RII}_i}$$

Where:

- W_i = Normalized weight of the ith factor
- RII_i = Relative Importance Index of the ith factor
- n = Total number of factors

E. Development of weighted scoring matrix

To recommend the most suitable port administrative model for Matarbari Port, the study developed and applied a weighted scoring matrix. This approach enabled the systematic evaluation of four established port governance models: service port, tool port, landlord port, and privatized port.

The procedure began by utilizing the normalized RII values as decision weights. These weights reflected the relative significance of the eight evaluation factors.

In the survey's second part, respondents were asked to rate the performance of each governance model against these factors on a five-point Likert scale (1 = Very Poor, 5 = Excellent). The average score for each factor under each model was then calculated.

The weighted score for each governance model was obtained using the following formula:

$$WSM_j = \sum_{i=1}^{n} (W_i \times S_{ij})$$

Where:

- WSM_j= Weighted score of governance model j
- W_i = Normalized weight of factor i factor
- S_{ij}= Average score of governance model j on factor i
- n = Total number of factors considered

III. RESULTS

After a thorough literature review on port administration and management, eight key factors for assessing port governance models were identified. All studies have consistently identified these factors as determinants of port performance. They are particularly relevant to developing country contexts like Bangladesh. Lastly, they align with Matarbari Port's strategic objectives as a future regional hub. These three considerations led to the identification of these factors as the most significant. This results section is divided into two parts: one exhibits the finalized factors, and the second part examines the results of the Relative Importance Index.

A. Finding the factors based on the literature review

After a thorough analysis of the literature review, 8 factors have been finalized, which are shown in Table 2.

B. Finding the ranks and weights of the factors

The eight critical factors were systematically prioritized using RII, as seen in Table 3.

TABLE 2:
FINALIZED FACTORS INFLUENCING THE SELECTION OF AN OPTIMAL ADMINISTRATIVE MODEL

Factors	Explanation	Reference
Cost efficiency	When choosing a port governance model, cost efficiency must be a top priority. It rates the model's efficiency in reducing operational expenses (such as those associated with cargo handling and vessel turnaround).	[7], [19], [20].

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Revenue generation potential	Because the model determines how a port generates revenue and manages its finances, revenue creation is a crucial consideration when selecting a port governance model.	[21], [13],
Decision-making flexibility	Flexibility in decision-making evaluates flexibility in response to changes in the market and changes in regulations	[22], [13].
User satisfaction	When deciding on the best port governance mode, user satisfaction should be in your priority list. For shippers and carriers, it aids in tracking service quality.	[23], [24]
Infrastructure and port facilities	Assessing the capacity for modernization and maintenance is aided by considering infrastructure and port facilities. Consistent funding for deep-draft infrastructure is guaranteed	[25], [26]
Financing and investment options	Assessing the availability of funding for growth is the focus of Financing and Investment Options. It retains ownership of public assets while utilizing private investment.	[27], [28]
Regional economic development	The generation of jobs and the ease of trade are both impacted by regional economic development. Efficiency and regional growth are brought into harmony.	[10], [22].
Operational efficiency	Operational Efficiency assesses productivity (such as TEU throughput).	[21], [29]

TABLE 3:
COMPREHENSIVE RII RANKING OF PORT GOVERNANCE SELECTION FACTORS

Factor	RII Score	Rank
Operational efficiency	0.933	1
Cost efficiency	0.747	2
Financing & investment options	0.707	3
Regional economic development	0.693	4
Infrastructure & port facilities	0.667	5
Revenue generation potential	0.587	6
Decision-making flexibility	0.520	7
User satisfaction	0.427	8

The Relative Importance Index (RII) values for each of the eight factors that were identified were then normalized into comparable and usable weights, as seen in table 4. This was crucial for the following stage of the analysis, in which the performance of several port governance models were assessed using the elements in a weighted scoring matrix. Normalization guarantees that the weights add up to 1.

TABLE 4:
FINAL NORMALIZED WEIGHTS

Rank	Factor	RII Score	Normalized Weight (W)
1	Operational efficiency	0.933	0.177
2	Cost efficiency	0.747	0.141
3	Financing & investment options	0.707	0.134
4	Regional economic development	0.693	0.131
5	Infrastructure & port facilities	0.667	0.126
6	Revenue generation potential	0.587	0.111
7	Decision-making flexibility	0.520	0.098
8	User satisfaction	0.427	0.081
	Total		1.00

C. Evaluating port governance models against the factors

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A weighted scoring matrix shown in Table 5 was used to thoroughly assess the four main port governance models (service ports, tool ports, landlord ports and completely privatized ports) in relation to the RII-ranked variables.

IV. DISCUSSION

From the weighted scoring matrix, landlord port model received the highest score followed by private, tool and service port model (Table 5, Fig. 1).

With a weighted total score of 2.265, the *service port model* received the lowest overall score. Its dismal performance in

TABLE 5:
WEIGHTED SCORING MATRIX FOR GOVERNANCE MODEL EVALUATION

Factor	Weight	Service port	W×S	Tool port	W×S	Landlord port	W×S	Private port	W×S
Operational efficiency	0.177	2.067	0.366	2.933	0.519	4.867	0.861	4.333	0.767
Cost efficiency	0.141	1.867	0.263	2.867	0.404	4.800	0.677	4.133	0.583
Financing & investment options	0.134	1.467	0.197	2.533	0.339	4.733	0.634	4.267	0.572
Regional economic development	0.131	3.667	0.480	3.067	0.402	4.133	0.541	2.733	0.358
Infrastructure & facilities	0.126	2.400	0.302	3.000	0.378	4.800	0.605	4.267	0.538
Revenue generation potential	0.111	2.533	0.281	2.867	0.318	4.133	0.459	4.067	0.451
Decision-making flexibility	0.098	2.067	0.203	2.667	0.261	4.000	0.392	4.867	0.477
User satisfaction	0.081	2.133	0.173	2.800	0.227	4.333	0.351	4.267	0.346
Weighted total score	1.00	-	2.265	-	2.849	-	4.52	-	4.091

All things considered, the *tool port model* performed moderately, earning a total score of 2.849. It did somewhat well in operational efficiency (0.519), which was bolstered by coordinated governmental investment. But regional economic development (0.402), revenue generation (0.318), infrastructure & facilities (0.378), cost efficiency (0.404), financing and investment options (0.339) were mediocre. Decision-making flexibility (0.261) and user satisfaction (0.227) received the lowest scores. Overall, it lacks the strategic capability for extensive contemporary port development and is still in the transitional phase, although it is more capable than the service model.

The *private port model* performed well with a total weighted score of 4.091, in a number of categories, including operational efficiency (0.767), cost efficiency (0.583), financing & investment options (0.572) and infrastructure & facilities (0.538). It also did moderately well with decision-making flexibility (0.477) and revenue generation potential (0.451). Regional economic development (0.358) and user satisfaction (0.346) displayed lower scores, raising questions about public support and the long-term effects on national growth.

Despite being effective, the private port model is still not the best fit for Matarbari's situation due to its narrow emphasis on public value.

The *landlord port model* consistently performed well across all eight parameters, earning the highest total weighted score of 4.52. It had significant private sector appeal with scores of 0.861 in operational efficiency, 0.677 in cost efficiency, 0.605 in infrastructure & facilities and a leading 0.634 in financing & investment options. Along cost efficiency (0.263), financing & investment options (0.197) and operational efficiency (0.366) reflected its inefficiencies and lackluster attraction to private capital. Revenue generation potential (0.281), user satisfaction (0.173), infrastructure & facilities (0.302) and decision-making flexibility (0.203) also demonstrated poor results. Regional economic development (0.480) was the only area that was relatively strong, most likely because it focused on the public sector. All things considered, the approach falls short of Matarbari Port's requirements for efficiency and investment flexibility.

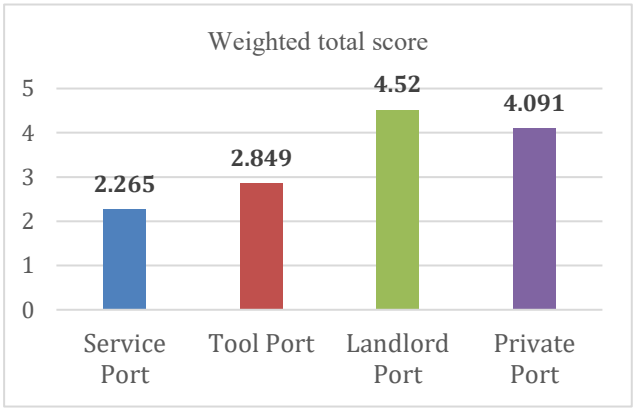


Fig 1: Weighted Total Score

with strong scores in revenue generation potential (0.459), decision-making flexibility (0.392) and user satisfaction (0.351), it also scored highly in regional economic development (0.541). This study's results show that the landlord port model is the best governance structure for Matarbari Port because of its balanced performance, which demonstrates its capacity to match operational excellence with national strategic goals.

V. CONCLUSION

The study examined the key factors that affect the choice of port officials and policymakers to choose the optimal administrative model for Matarbari Port. This study used the Relative Importance Index (RII) methodology and weighted scoring matrix to comprehensively evaluate four port governance alternatives for Bangladesh's Matarbari Port. Using key operational parameters such as operational efficiency (RII=0.933), cost efficiency (RII=0.747) and financing & investment options (RII=0.707), the results clearly showed that the landlord port model was the best option. Bangladesh has the perfect foundation to develop Matarbari as a strategically important national asset and a commercially viable deep-sea hub because to this hybrid governance system, which combines public infrastructure stewardship with operational knowledge from the private sector. The most practical administrative strategy is the model, as it has been shown to be successful in international

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settings, such as Rotterdam and Singapore, and is in line with Bangladesh's institutional capabilities and development objectives.

This study contributes to the body of literature by giving stakeholders and decision-makers in the maritime sector useful advice and new insights into the port governance model selection process. The study did, however, reveal some possible limitations, namely the small size of the study group and reliance on expert opinions. Further research could provide deeper insights into the functioning of port governance selection by examining additional parameters and incorporating a broader range of perspectives. All things considered, this paper advances the understanding of marine logistics and provides valuable insights for enhancing shipping operations when selecting port governance architecture.

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Blockchain-Based Logistics Solutions for Enhancing Supply Chain Efficiency in Bangladesh.

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Abstract: **This research investigates the potential of blockchain technology in addressing inefficiencies within Bangladesh's logistics and supply chain sectors, particularly in the textile and agricultural industries. Despite Bangladesh's rapid economic growth, its logistics infrastructure faces significant challenges, including delays, high operational costs, and a lack of real-time tracking systems. These inefficiencies hinder the country's competitiveness in key sectors like ready-made garments (RMG) and shrimp exports. This study explores how blockchain characterized by decentralization, transparency, and data security can enhance supply chain traceability and operational efficiency while reducing fraud and delays. Through a secondary literature review, this paper identifies key barriers to blockchain adoption in Bangladesh, such as technological gaps, regulatory uncertainties, and resistance from traditional stakeholders. The research also highlights successful global blockchain applications and draws comparisons to Bangladesh's logistics challenges. Blockchain's potential is particularly evident in real-time tracking, quality assurance for perishable goods, and the automation of compliance through smart contracts. Despite the promising outlook, blockchain's integration into Bangladesh's logistics sector will require substantial investments in digital infrastructure, policy reforms, and stakeholder collaboration. Overcoming these challenges will allow Bangladesh to improve its global competitiveness, especially in textiles and agriculture. This study contributes to the literature by exploring the under-researched area of blockchain adoption in developing economies, offering insights into its potential for revolutionizing Bangladesh's logistics sector.**

Keywords: **Blockchain technology, Supply chain efficiency, Logistics, Transparency, Real-time tracking, Smart contracts.**

I.INTRODUCTION

1.1 Background of Supply Chain Issues in Bangladesh:

Bangladesh, one of the world's fastest-growing economies, is a key player in global trade, particularly in the textiles, agriculture, and ready-made garments (RMG) sectors. However, its supply chain landscape is riddled with inefficiencies that significantly impact its potential for global competitiveness. A major issue is the country's inadequate infrastructure, including poorly maintained road networks, congested seaports, and outdated logistical frameworks. These infrastructural bottlenecks lead to delays, increased operational costs, and a lack of synchronization across supply chain processes, ultimately undermining the efficiency of trade [3].

One of the most pressing challenges is the lack of integrated digital systems for tracking and monitoring goods. Despite being a prominent global exporter, Bangladesh's logistics sector suffers from a lack of real-time tracking systems, resulting in extended lead times and high operational costs. For example, inefficiencies in the textile supply chain cause disruptions in the timely delivery of raw materials, which delays production timelines and escalates costs [1]. Similarly, in agriculture, logistical problems such as transport delays and inadequate cold chain infrastructure lead to perishable goods, such as shrimp, suffering from quality degradation before reaching international markets. This has damaged Bangladesh's reputation as a reliable exporter in the global seafood market [4]. Moreover, the agriculture sector, a critical part of the Bangladeshi economy, faces profound consequences due to inefficient supply chains, impacting the livelihoods of millions of smallholder farmers and the country's food security [7].

Despite the rapid economic growth and strategic significance of the export sector, these inefficiencies persist due to fragmented infrastructure, a lack of technological advancement, and insufficient integration of digital solutions across the supply chain [3]. The need for reform in this domain is urgent, particularly as Bangladesh aims to capitalize on its position as a major global player in textile manufacturing and agriculture.

1.2 Importance of Logistics in Supply Chain Efficiency:

The role of logistics in enhancing supply chain efficiency cannot be overstated, especially in emerging economies like Bangladesh. Logistics encompasses the movement, storage, and distribution of goods across vast networks, and its efficient management directly

correlates with reduced operational costs, timely delivery, and overall economic competitiveness [2]. In Bangladesh, logistical inefficiencies have far-reaching implications for business operations, disrupting production cycles and impacting market responsiveness.

One clear example of the impact of logistics inefficiencies is seen in the textile industry, where delays in raw material procurement and finished goods delivery cause substantial delays in the supply chain, increasing production lead times and costs. Such delays undermine Bangladesh's competitive advantage in the global textile market, where speed and reliability are paramount [6]. In the agriculture sector, the

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absence of an effective cold chain and transportation system for perishable goods, like shrimp, results in quality loss, ultimately impacting the nation's standing as a leading seafood exporter [7]. Moreover, inefficiencies in transportation and inventory management also contribute to higher costs for producers and exporters, preventing them from achieving economies of scale and limiting their ability to meet international market demand [2].

Improving logistics infrastructure and management in Bangladesh is critical not only for the nation's economic growth but also for its global trade competitiveness. Efficient logistics operations in the textile and agricultural sectors, for instance, would significantly reduce production and transportation costs, enhance customer satisfaction, and improve Bangladesh's standing in international trade.

1.3 The Emergence of Blockchain Technology:

Blockchain technology has emerged as a groundbreaking solution to many of the logistical challenges faced by Bangladesh. At its core, blockchain offers a decentralized and immutable digital ledger that enhances transparency, traceability, and data security within supply chains. This technology, by enabling secure, real-time tracking of goods and facilitating transparent information sharing across multiple stakeholders, addresses key challenges such as fraud, delayed transactions, and data inconsistencies [5].

Globally, blockchain has been successfully implemented in diverse industries to streamline supply chain operations. In the food industry, for instance, blockchain has been used to track products from farm to table, ensuring quality assurance and safety by recording every step of the supply chain in a transparent, immutable ledger [11]. The pharmaceutical sector has also embraced blockchain to combat counterfeiting by ensuring that each product's provenance is traceable [9]. These applications showcase the potential of blockchain to solve key inefficiencies in supply chains globally.

For Bangladesh, blockchain offers a transformative solution. The technology could improve transparency by providing stakeholders with a real-time, immutable record of every transaction and movement of goods. In Bangladesh's textile sector, blockchain could be used to track raw materials from suppliers to manufacturers, ensuring that products are delivered on time, with reduced risk of fraud and quality issues [5]. In agriculture, blockchain could be applied to track perishable goods like shrimp, ensuring that these products maintain their quality during transport and reducing delays associated with customs [11]. By enhancing data security and automating compliance through smart contracts, blockchain can create a more efficient, trustworthy logistics system that reduces inefficiencies and fosters a more transparent supply chain environment.

1.4 Research Objectives and Scope:

This paper aims to examine the potential of blockchain technology to improve the efficiency of logistics and supply chain systems in Bangladesh. The study will explore how blockchain can address persistent supply chain inefficiencies, such as delays, fraud, lack of transparency, and poor infrastructure. By reviewing existing research on the challenges faced by Bangladesh's supply chains and the global applications of blockchain in logistics, this study intends to develop a tailored framework for implementing blockchain technology in Bangladesh's logistics sector.

The research will focus on three key objectives: (1) assessing the potential of blockchain to improve transparency and traceability in Bangladesh's textile and agricultural sectors; (2) exploring the opportunities for reducing logistical delays and fraud through blockchain- enabled real-time tracking and smart contracts; and (3) evaluating the challenges and barriers to blockchain adoption in Bangladesh, including regulatory, technological, and infrastructural issues. This research contributes to the growing body of literature on blockchain applications in emerging economies and aims to provide actionable insights for policymakers, businesses, and academics interested in transforming Bangladesh's logistics landscape [8].

II.LITERATURE REVIEW

2.1 Overview of Blockchain Technology

Blockchain technology is a decentralized, distributed digital ledger that records transactions across multiple participants without a central authority. Its core features—decentralization, immutability, and transparency—address critical supply chain issues such as inefficiencies, fraud, and lack of data security. By providing a transparent and immutable record of transactions, blockchain ensures that every action in the supply chain can be verified and audited in real time, thus enhancing trust between all stakeholders [10].

The working of blockchain involves the use of consensus mechanisms, such as proof of work or proof of stake, which guarantee the legitimacy of transactions. This eliminates the need for intermediaries and ensures the integrity of data, thus solving the problem of fraud or data manipulation common in traditional supply chains [8].

For supply chains in Bangladesh, where logistical inefficiencies such as slow documentation, lack of real-time tracking, and insufficient infrastructure hinder productivity, blockchain presents an innovative solution. It offers the potential to reduce the need for intermediaries, enhance supply chain transparency, and enable real-time tracking, especially in sectors like textiles and agriculture [15]. This technology could automate processes like inventory management, shipment tracking, and compliance verification, thus addressing critical inefficiencies in Bangladesh's supply chain infrastructure.

2.2 Applications of Blockchain in Supply Chain Management

Blockchain's application in supply chain management (SCM) has proven to be transformative, offering solutions in inventory management, fraud reduction, supply chain

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visibility, and smart contracts. IBM's Food Trust Network is a prime example of blockchain's potential to revolutionize the agri-food industry by providing end-to-end traceability, allowing stakeholders to trace the origin of products and ensure their quality at every step of the supply chain [13]. This transparency ensures the safety of food products and helps address issues like contamination and fraud.

In the textile industry of Bangladesh, blockchain has the potential to improve traceability and transparency in raw material procurement and production processes. By creating a permanent, immutable record of transactions, blockchain can mitigate the delays caused

by intermediaries and reduce the risks of counterfeit products entering the market [9]. This could ultimately lead to improved global competitiveness for Bangladesh's textile sector, which is one of the world's largest producers.

Additionally, in Bangladesh's agricultural sector, especially in the shrimp industry, blockchain can be utilized to ensure quality and authenticity by tracking the supply chain from farm to export. Blockchain's role in enhancing transparency can help resolve issues such as fraud, quality degradation, and customs delays, all of which have hampered Bangladesh's shrimp exports [12].

2.3 Blockchain in Logistics: A Global Perspective

Globally, blockchain has been applied in logistics to streamline operations, enhance transparency, and improve supply chain visibility. For example, in customs operations, blockchain technology has been used to automate procedures and reduce delays, enhancing efficiency in international trade [14]. Additionally, blockchain- based systems integrated with Internet of Things (IoT) devices enable real-time monitoring of goods, ensuring their condition and location are accurately tracked, which reduces fraud and errors in handling goods.

In developed markets like the European Union and the United States, blockchain adoption in logistics has already shown significant benefits, improving the speed and transparency of cross-border trade. However, blockchain adoption in emerging markets, such as Bangladesh, faces unique challenges. These include technological infrastructure limitations, regulatory hurdles, and a lack of awareness regarding the benefits of the technology [17].

Despite these challenges, the potential for blockchain to transform logistics in Bangladesh is immense. It can streamline data exchange between stakeholders, automate compliance verification, and ensure accurate documentation, thus improving operational efficiency and reducing fraud risks in supply chains.

2.4 Blockchain Adoption in Developing Countries: A Focus on Bangladesh

For Bangladesh, blockchain presents a potential solution to the country's logistics and supply chain inefficiencies. The nation's key industries—textiles and agriculture—stand to benefit significantly from the enhanced traceability, transparency, and efficiency offered by blockchain. However, there are notable challenges in adoption, primarily due to the lack of technological infrastructure, regulatory clarity, and widespread awareness of the technology [18].

In Bangladesh's Ready-Made Garments (RMG) sector, blockchain can enhance the certification and verification process, ensuring that products meet international quality standards. Furthermore, in the agriculture sector, particularly with shrimp farming, blockchain can help tackle issues related to quality degradation during transit and fraud in product origin. While some pilot projects in Bangladesh have explored blockchain's potential, large-scale implementation is constrained by challenges such as limited digital literacy and fragmented infrastructure [16].

2.5 Challenges and Barriers in Implementing Blockchain in Bangladesh's Supply Chain

The widespread adoption of blockchain in Bangladesh's supply chain faces several barriers, such as technological infrastructure gaps, regulatory ambiguity, and cultural resistance. One of the most significant challenges is the country's underdeveloped technological infrastructure, particularly in rural areas where agriculture predominates [6]. Additionally, the regulatory environment remains uncertain, particularly concerning the legal status of smart contracts and cryptocurrency use, both of which are essential components of blockchain technology [14].

Further complicating the issue is the reluctance of local businesses to adopt blockchain, especially since many rely on manual, paper-based systems. Transitioning to a blockchain-based system would require significant investment in digital tools, training, and stakeholder collaboration [18]. Addressing these barriers will require coordinated efforts from government bodies, private enterprises, and international organizations to build the necessary infrastructure and regulatory frameworks.

2.6 Summary of Key Findings

Blockchain technology presents a transformative opportunity to enhance the efficiency, transparency, and traceability of supply chains in Bangladesh, especially in key sectors such as textiles and agriculture. Globally, blockchain has demonstrated its value in overcoming supply chain inefficiencies, especially in reducing fraud and improving inventory management. For Bangladesh, while the technology has promising potential, the widespread adoption of blockchain faces significant challenges, including technological gaps, regulatory barriers, and cultural resistance. Overcoming these barriers will require a concerted effort from the government, industry players, and international stakeholders to foster the infrastructure, regulatory alignment, and awareness necessary for blockchain's successful implementation.

III.RESEARCH METHODOLOGY

This study adopts a secondary literature review approach to explore and synthesize existing research on blockchain

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technology and its potential application to logistics and supply chain efficiency in Bangladesh. The secondary literature review method is the most appropriate for this study as it allows for a comprehensive understanding of the theoretical, technological, and practical aspects of blockchain in supply chains without generating new data. By analyzing and synthesizing existing studies, this research aims to provide a detailed framework for blockchain adoption and identify critical areas for improving the efficiency of Bangladesh's supply chain logistics. This approach enables the exploration of well-established theories, technological insights, and the current state of blockchain implementation globally and in developing economies like Bangladesh.

3.1 Research Design (Secondary Literature Review)

The research follows a secondary literature review design, as this method is both efficient and well-suited for addressing the research questions related to blockchain adoption in Bangladesh's logistics and supply chains. Secondary literature reviews are instrumental in mapping existing knowledge on a subject, understanding theoretical developments, identifying gaps, and synthesizing findings to inform future research or practical applications [16]. Given the emerging nature of blockchain applications in logistics, particularly in developing countries like Bangladesh, this approach allows for an in-depth evaluation of existing studies on blockchain solutions across different industries and their relevance to Bangladesh's unique supply chain challenges. This design emphasizes the collection and analysis of peer-reviewed articles, reports, and conference papers from reliable sources such as Scopus, Google Scholar, and industry- specific databases.

3.2 Data Collection Method: Literature Search and Selection Criteria

The data collection for this literature review involves a systematic search of academic databases and credible industry reports. The main sources include:

1. Google Scholar
2. Scopus
3. JSTOR
4. PubMed
5. Industry reports (from organizations like IBM, PwC, Deloitte)
6. Conference proceedings from key supply chain and blockchain conferences

The literature search will be based on specific keywords and search queries such as "Blockchain in Supply Chain Bangladesh," "Blockchain Logistics Efficiency," and "Blockchain adoption in developing countries". The search will be focused on studies published in the past five years to ensure the inclusion of recent developments in blockchain technology and its applications in logistics. Articles, reports, and studies will be selected based on their relevance, credibility, and impact on the supply chain industry.

3.3 Inclusion and Exclusion Criteria for Relevant Studies

To ensure the quality and relevance of the studies included in the review, the following inclusion and exclusion criteria will be applied:

Inclusion Criteria:

1. Studies that explore the use of blockchain technology in logistics or supply chain management.
2. Research focusing on blockchain adoption in developing countries or emerging economies, with a special emphasis on Bangladesh.
3. Peer-reviewed journal articles, conference papers, and industry reports from credible sources.
4. Studies published in the last five years (2018-2023) to capture the latest trends and applications.
5. Research that discusses blockchain's impact on transparency, traceability, inventory management, smart contracts, and fraud reduction in supply chains.

Exclusion Criteria:

1. Studies that do not focus on logistics or supply chain management but only on blockchain technology in unrelated sectors.
2. Research that lacks empirical evidence or is purely theoretical without practical implications for logistics.
3. Studies that are not peer-reviewed or lack sufficient methodological rigor.
4. Articles focusing on developed countries without any reference or comparison to developing nations like Bangladesh.
5. Research that fails to address the challenges or barriers to blockchain adoption in supply chains.

3.4 Data Analysis Approach: Thematic Synthesis

1. The data analysis will follow a thematic synthesis approach, which is commonly used in secondary literature reviews, especially when dealing with qualitative data. Thematic synthesis allows the researcher to identify, analyze, and synthesize key themes across the collected studies. The process will involve:
2. Identifying Themes: Key themes will be identified from the collected literature, such as blockchain's role in transparency, cost reduction, traceability, and real- time tracking in supply chains. Additionally, challenges in blockchain adoption specific to Bangladesh's infrastructure, regulatory landscape, and technological barriers will be explored.
3. Organizing Studies by Themes: Studies will be categorized according to the identified themes, allowing for a clear understanding of how blockchain addresses specific supply chain challenges in Bangladesh.

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4. Synthesis of Findings: A narrative synthesis will be employed to combine the findings from various studies, highlighting key findings from global research on blockchain's impact on supply chains and comparing these with the specific conditions and needs of Bangladesh.
5. Drawing Connections: The thematic synthesis will draw connections between global practices and the potential for blockchain adoption in Bangladesh's logistics. This approach will identify best practices, gaps in the current literature, and areas where blockchain technology could be most beneficial.

3.5 Limitations of the Literature Review Approach

The secondary literature reviews are valuable for gathering existing knowledge, this methodology has some limitations:

1. Publication Bias: The review may be subject to publication bias, where studies with significant findings are more likely to be published, potentially leading to an overrepresentation of certain outcomes.
2. Access to Studies: Some relevant studies may be behind paywalls or inaccessible due to subscription limitations to certain databases or journals.
3. Language Barriers: Much of the relevant research may be published in languages other than English, limiting the scope of studies considered in this review.
4. Quality of Available Studies: There may be a lack of real-world case studies from Bangladesh or other developing nations where blockchain has been successfully implemented, which could limit the generalizability of the findings to Bangladesh's unique context.
5. Technological Evolution: Blockchain is a rapidly evolving technology, and the literature may not always capture the most current advancements or real-world challenges in the supply chain context.

IV.FINDING AND DISCUSSIONS

4.1 Key Findings from the Literature Review

The literature review reveals a number of key findings regarding the application of blockchain technology in enhancing the supply chain efficiency of Bangladesh, particularly in logistics and related industries. A major theme across the studies is the significant role blockchain can play in improving transparency, traceability, and reducing inefficiencies in Bangladesh's logistics sector. The integration of blockchain in logistics systems allows for secure, real-time tracking and reduces fraud, operational delays, and data inconsistencie .

In particular, the textiles and agriculture sectors in Bangladesh, two of the country's most important industries, are highlighted as critical areas for blockchain application. Blockchain's ability to ensure transparent and tamper-proof data throughout the supply chain would help in reducing delays, particularly in raw material sourcing for the garment industry and improving the traceability of perishable goods like shrimp .

Despite these promising findings, it is clear from the literature that the adoption of blockchain in Bangladesh is still in its early stages. The challenges in terms of

technological infrastructure, the lack of skilled professionals, and regulatory barriers continue to pose significant hurdles .

4.2 Analysis of Blockchain Applications in Global vs. Bangladesh Logistics

A global perspective on blockchain implementation in logistics shows widespread adoption, particularly in developed countries. For instance, countries like the United States, China, and the European Union have embraced blockchain for supply chain management to improve operational efficiencies, reduce fraud, and enhance transparency. Case studies from the food and pharmaceutical sectors demonstrate how blockchain can successfully integrate with Internet of Things (IoT) devices to track products from source to destination .

However, when compared to Bangladesh, the implementation of blockchain technology in logistics remains minimal. While Bangladesh's textile industry, especially in the Ready- Made Garments (RMG) sector, is poised for such adoption, the country faces several unique challenges. These include inadequate digital infrastructure, regulatory issues, and resistance from traditional stakeholders who are accustomed to manual processes . Moreover, Bangladesh's reliance on intermediaries in sectors like shrimp exports and FMCG further complicates blockchain adoption .

4.3 Discussion of Blockchain's Impact on Bangladesh's Supply Chain Efficiency

Blockchain's potential to streamline supply chain operations in Bangladesh is profound. As a decentralized and immutable ledger, it would enable real-time tracking of goods and enhance data security, ensuring that all stakeholders from suppliers to manufacturers have access to accurate and timely information. This can significantly reduce fraud, increase accountability, and ensure timely deliveries in Bangladesh's key sectors .

For example, the integration of blockchain in Bangladesh's textile industry could mitigate issues like delayed deliveries of raw materials and enhance overall supply chain visibility, reducing production costs and improving delivery times. Similarly, in agriculture, blockchain could ensure the integrity and freshness of perishable products such as shrimp by providing end-to-end traceability . However, for these potential impacts tomaterialize, significant efforts in upgrading infrastructure and overcoming resistance from traditional stakeholders are required .

4.4 Key Barriers to Blockchain Adoption in Bangladesh

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Despite the clear advantages, several barriers hinder the widespread adoption of blockchain technology in Bangladesh's supply chain. One significant challenge is the country's inadequate technological infrastructure, which includes limited access to high- speed internet and a lack of advanced digital systems for integration . Additionally, regulatory issues, such as the prohibition of blockchain-based cryptocurrencies, complicate the implementation of blockchain solutions that depend on digital currencies .

Another key barrier is the resistance from supply chain stakeholders who are traditionally reliant on manual processes and are hesitant to adopt new technologies due to a lack of awareness and training . Furthermore, the lack of skilled professionals and the need for awareness campaigns are also significant challenges that need to be addressed before blockchain can be fully integrated .

4.5 Opportunities for Implementing Blockchain in Bangladesh's Logistics

Despite the barriers, there are ample opportunities for implementing blockchain in Bangladesh's logistics sector. Blockchain can provide solutions to the existing inefficiencies by improving transparency, automating processes through smart contracts, and enhancing the traceability of goods. Specifically, blockchain could help Bangladesh address its longstanding issues with customs delays, inefficient transportation systems, and poor data sharing among stakeholders .

Blockchain could also facilitate the development of new business models, particularly in agriculture and the FMCG sector. For instance, a blockchain-powered agri-food supply chain could ensure the traceability and quality of products like shrimp, thereby improving Bangladesh's standing in global markets . Additionally, by reducing reliance on intermediaries, blockchain could lower transaction costs and speed up decision-making in logistics operations .

4.6 Comparative Discussion: Blockchain vs. Traditional Logistics Solutions

When comparing blockchain with traditional logistics solutions, blockchain offers several distinct advantages, including enhanced security, transparency, and efficiency. Traditional systems, particularly those reliant on centralized databases, are vulnerable to fraud, data manipulation, and inefficiencies caused by intermediaries. In contrast, blockchain's decentralized nature eliminates the need for intermediaries, reducing costs and improving the integrity of the data.

However, blockchain also has its drawbacks. For example, the technology's scalability remains a concern, especially in a country like Bangladesh where the infrastructure is still developing . Furthermore, blockchain-based systems require significant investment in both hardware and software, which could be a challenge for small and medium-sized enterprises in Bangladesh .

4.7 Implications for Practitioners and Policymakers

The findings of this study have several implications for both practitioners and policymakers in Bangladesh. For industry practitioners, the adoption of blockchain could streamline logistics operations, reduce costs, and improve transparency. However, for blockchain to be successfully integrated, it is essential for businesses to collaborate with technology providers and invest in the necessary infrastructure.

Policymakers, on the other hand, must create an enabling environment for blockchain adoption by addressing regulatory issues, encouraging private sector innovation, and investing in digital infrastructure. It is also crucial to foster public-private partnerships and develop training programs to enhance the workforce's readiness to implement blockchain technology . Moreover, a phased approach to blockchain integration, starting with key sectors like textiles and agriculture, could help mitigate risks and ensure smooth transitions .

In conclusion, blockchain technology holds significant promise for transforming Bangladesh's logistics sector. However, its successful implementation will require overcoming technological, regulatory, and cultural barriers. By addressing these challenges, Bangladesh can harness the full potential of blockchain to enhance its supply chain efficiency and strengthen its position in the global market.

V.CONCLUSION

This research has thoroughly examined the transformative potential of blockchain technology in enhancing supply chain efficiency within Bangladesh, with a particular focus on the logistics sector. As a rapidly developing economy, Bangladesh faces critical logistical challenges that directly impact the efficiency and competitiveness of its key industries, notably the textile and agriculture sectors. These industries, which are essential to Bangladesh's global trade standing, are often hindered by persistent inefficiencies such as delays, underdeveloped infrastructure, and the absence of real- time tracking systems. These challenges undermine Bangladesh's ability to streamline its logistics operations and compete effectively on the global stage.

Blockchain technology, with its inherent features of transparency, traceability, and data security, presents a substantial opportunity to address these long-standing logistical challenges. By enabling the real-time tracking of goods, secure transactions, and automated verification processes, blockchain can mitigate issues such as fraud, inefficiency, and quality degradation in both the textile and agricultural supply chains. Specifically, in the textile sector, blockchain's ability to trace raw materials and finished goods throughout the supply chain could significantly reduce production delays, improve timeliness of deliveries, and enhance supply chain coordination. In the agricultural sector, particularly within the shrimp industry, blockchain could offer a solution for maintaining product freshness, reducing customs delays, and improving quality control during transportation, thus strengthening Bangladesh's competitive edge in global seafood markets.

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However, the research highlights several formidable barriers to the adoption of blockchain within Bangladesh's supply chains. These include technological gaps, regulatory uncertainties, and resistance from traditional stakeholders who still rely on manual and paper-based systems. The underdeveloped digital infrastructure, combined with limited digital literacy among key industry players, further complicates the implementation of blockchain solutions. These barriers must be addressed to ensure effective and sustainable adoption of the technology.

Despite these challenges, the potential for blockchain implementation in Bangladesh remains substantial. Particularly in critical sectors such as textiles and agriculture, blockchain can serve as a catalyst for cost reduction, operational efficiency, and enhanced global competitiveness. The support of the government, collaboration with the private sector, and investment in digital infrastructure are essential to overcoming the existing hurdles and facilitating the transition to a blockchain-powered logistics ecosystem.

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Predicting On-Time Deliveries in E-Commerce: A Machine Learning Approach to Shipment Performance Analysis

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Abstract - **Timely delivery is a critical driver of customer satisfaction and loyalty in the competitive e-commerce sector. This study applies machine learning techniques to predict shipment punctuality using a dataset of 10,999 delivery records with 12 features covering customer behavior, product characteristics, and logistics details. The target variable, Reached on Time, indicates whether shipments were delayed. Through exploratory data analysis, we identify key delivery factors, including the influence of shipment weight, product cost, and discounts. Four supervised models—Logistic Regression, Decision Tree, Random Forest, and Support Vector Machine—are developed and evaluated using accuracy, F1-score, and AUC-ROC metrics. Results show that ensemble methods, particularly Random Forest, outperform traditional models in predicting late deliveries. The findings highlight the value of data-driven approaches in improving shipment reliability and provide actionable insights for optimizing logistics strategies and enhancing customer satisfaction.**

Keywords: **E-Commerce, On-Time Delivery, Shipment Prediction, Machine Learning, Logistics Optimization.**

I.INTRODUCTION

In the dynamic landscape of e-commerce, timely delivery has become a cornerstone of customer satisfaction and business success. As the volume and complexity of online orders grow, logistics systems are under increasing pressure to deliver efficiently and predictably. Late deliveries not only erode customer trust but also contribute to increased operational costs and negative brand perception. Given these stakes, there is a pressing need for data-driven strategies that can anticipate shipment delays and support proactive logistics management.

Recent research underscores the transformative potential of machine learning (ML) in understanding and optimizing delivery performance. [1] highlight how ML models can uncover hidden patterns in customer behavior and satisfaction, suggesting that predictive analytics can directly enhance service quality in e-commerce. Extending beyond prediction, [2]emphasize the shift from predictive to prescriptive analytics, arguing that data science must not only anticipate outcomes but also inform decision-making to optimize operations.

In the logistics domain, ML has shown promising applications in last-mile delivery optimization. [4] developed models to predict late deliveries using real-time data, showing how early alerts can mitigate service disruptions. Similarly, [5] review multiple use cases where ML improves forecasting accuracy and resource allocation in e-commerce supply chains. These works affirm the utility of supervised learning algorithms in classifying on-time versus delayed shipments.

Additional contributions further validate this perspective. [3] use simulation-based approaches to explore mismatched peer-to-peer delivery networks, a concept directly related to shipment timing inconsistencies. [9] take a more diagnostic view, analyzing real-world e-commerce delivery failures through historical data. Their findings highlight the value of predictive modeling in understanding why delays occur. Moreover, [7] introduced Random Forests—a model proven effective in logistics classification tasks—while [8] addressed class imbalance issues common in delivery datasets through the SMOTE technique.

After a handsome amount of literature review authors bridge the gap between theoretical ML applications and practical e-commerce logistics, offering a data-driven framework to improve delivery reliability—a critical need in today's competitive online retail landscape. The exposition of the paper is as follows: section 2 methodology; Section 3 problem formulation and Modeling the Problem; section 4 model evaluation; section 5 model limitation and finally section 6 conclusion.

II.METHODOLOGY

This study employs a structured machine learning workflow to predict shipment punctuality in e-commerce logistics. The methodological framework consists of six sequential stages: dataset description, data cleaning, preprocessing, exploratory data analysis (EDA), feature engineering, model development, and performance evaluation. Each stage is designed to ensure data quality, model robustness, and reproducibility.

1) *Dataset Description:* The dataset, sourced from an international e-commerce company, comprises 10,999 shipment records with 12 attributes spanning customer interactions, product characteristics, and logistics details. The target variable, Reached on Time (0 = on time, 1 = late), frames the study as a binary classification problem. Table 1 categorizes features into numerical, categorical, and target variables.

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Table 1
Classifications of Attributes

Numerical Features	Categorical Features	Target Variable
Customer_care_calls Customer_rating Cost_of_the_Product Prior_purchases Discount_offered Weight_in_gms	Warehouse_block Mode_of_Shipment Product_importance Gender	Reachedno n.Time Y.N (0 = on time, 1 = late)

2) *Data Cleaning*: Rigorous data pre-processing was undertaken to ensure the integrity and reliability of the dataset. Redundant attributes, such as unique identifiers (ID Column) that do not contribute to predictive modeling, were systematically removed to reduce dimensionality. Comprehensive checks for missing values and duplicate records were conducted, confirming the completeness and uniqueness of the data. Outliers in key numerical variables—such as *Prior Purchases* and *Discount Offered*—were detected using the Interquartile Range (IQR) method. These anomalies were carefully addressed to mitigate their potential impact on model performance and to ensure that the learning process remained unbiased and representative of the underlying data distribution.

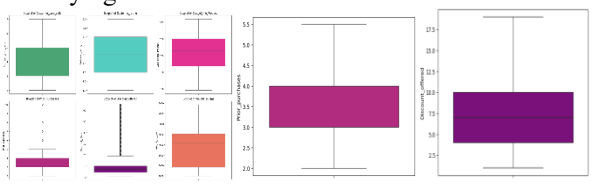


Fig.01. Outlier Detection and Handling

3) *Data Pre-Processing*: To ensure the dataset was suitable for machine learning algorithms, several preprocessing steps were applied. Categorical variables were encoded to facilitate numerical analysis. Specifically, nominal variables such as Warehouse Block, Mode of Shipment, and Gender were transformed using One-Hot Encoding, allowing the model to treat each category as an independent binary feature. For the ordinal variable Product Importance, Label Encoding was employed to preserve the inherent order among categories. Additionally, numerical features were standardized using StandardScaler, a technique that normalizes data by removing the mean and scaling to unit variance. This step is particularly critical for algorithms sensitive to feature scales, such as Logistic Regression and Support Vector Machines (SVM), as it ensures all features contribute proportionally to the model's performance.

4) *Exploratory Data Analysis (EDA):* Exploratory data analysis (EDA) was performed to uncover preliminary patterns and investigate relationships between features and the target variable. Univariate analysis, including distribution plots and frequency counts, was employed to assess the balance and variability of individual variables. Bivariate analysis was conducted to evaluate the influence of key features—such as shipment weight and product cost—on delivery outcomes, particularly punctuality. Additionally, correlation analysis identified moderate associations between certain features and delivery status, with discount rate emerging as a notable factor. The insights derived from EDA played a critical role in guiding feature selection and prioritization during subsequent model development phases.

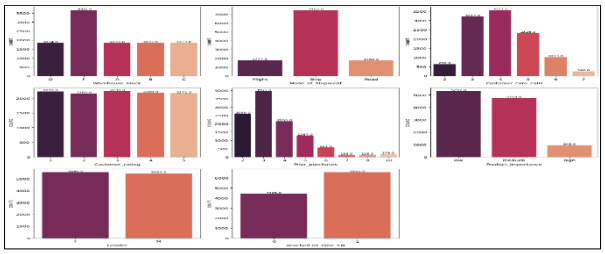


Fig.2. Analyze each data with respect to their Frequency

The analysis reveals several key insights into the current logistics and customer service operations. Warehouse F Block emerges as a critical hub, handling a significantly higher volume of shipments compared to other locations. Among the various transportation options, sea freight is identified as the most utilized mode, indicating a potential preference or cost-efficiency in maritime logistics. Customer engagement data shows that most shipments are associated with four customer care interactions, suggesting a moderate level of service requirement during the delivery process. Notably, customer satisfaction tends to cluster around a rating of 3, pointing to a generally average service perception that may warrant further improvement. The dataset also indicates that customers typically have a maximum of three prior purchases, reflecting either a relatively new customer base or low repeat purchase behavior. In terms of product characteristics, the inventory is predominantly composed of items classified as low or medium in importance, which may influence customer expectations and urgency. Demographic analysis highlights a well-balanced gender distribution among customers. However, a significant concern is that a higher percentage of products fail to reach customers on time, underscoring a pressing need for improvements in delivery efficiency and supply chain reliability.

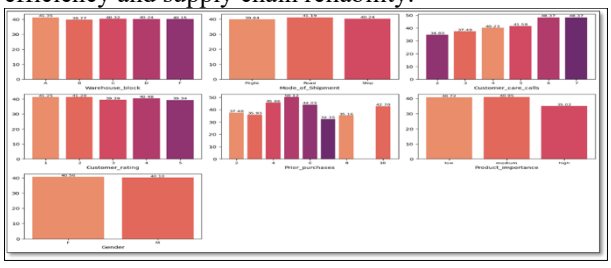


Fig.3. Category vs Impact on Delivery
[result show in percentage]

The analysis reveals that all warehouse blocks exhibit on-time delivery rates below 50%, indicating systemic inefficiencies

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across the entire logistics network. Furthermore, all modes of transportation show relatively low delivery performance, suggesting that transportation infrastructure or operational processes may be contributing factors. A clear correlation is observed between the volume of customer care calls and on-time delivery rates, implying that delivery delays significantly impact on customer satisfaction and drive support inquiries. Interestingly, customer ratings do not appear to have a statistically significant relationship with on-time delivery, which may point to other factors influencing customer perceptions. The data also shows a notable improvement in on-time delivery percentages between categories 2 and 5, marking a performance peak that warrants further investigation. Additionally, products classified as low and medium in importance exhibit the highest on-time delivery rates, raising questions about prioritization strategies within the supply chain. Finally, the analysis finds no significant correlation between customer gender and on-time delivery performance, indicating that delivery outcomes are consistent across demographic lines.

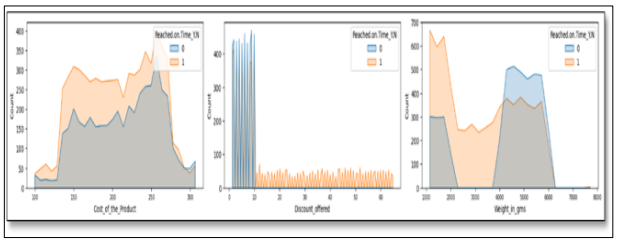


Fig.4. Finding any impact on 'Delivery on time' by considering Cost, Discount offer or Weight of products

The analysis reveals that most products are priced within the $201–$275 range, indicating a central tendency in product pricing. Interestingly, the highest-priced products demonstrate the best on-time delivery performance; however, their delivery reliability remains below 50%, suggesting potential operational inefficiencies even at premium price points. In terms of discounting, most products fall within the 1%–10% discount bracket, where on-time delivery performance maintains a relatively balanced and acceptable level. Regarding product weight, the highest concentrations are found in the 1,000–2,000 grams and 4,000–6,000 grams categories. Notably, products in the 4,000–6,000 grams range show significantly better on-time delivery performance, exceeding 56%, highlighting a possible correlation between product weight and logistics efficiency.

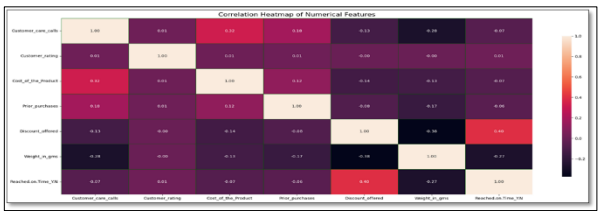


Fig.5. Detecting any Correlations between the features

The analysis revealed no strong correlations among the examined features. However, discount offers demonstrated a moderate relationship with timely delivery, accounting for approximately 40% of the variation. Additionally, customer care calls showed a moderate association with both the cost of the product (32%) and prior purchase behavior (18%). These findings suggest that while most variables operate independently, targeted incentives and customer engagement efforts may influence key outcomes such as delivery punctuality and purchasing patterns.

III.BUILDING MACHINE LEARNING MODELS

The primary objective of this phase is to develop and evaluate machine learning models capable of accurately predicting whether a shipment will be delivered on time. Given the binary nature of the target variable (Reached.on.Time_Y.N), the problem is formulated as a supervised binary classification task. To ensure a comprehensive comparison of predictive performance, four widely used classification algorithms were selected: Logistic Regression, Decision Tree, Random Forest, and Support Vector Machine (SVM).

1) *Data Splitting:* To assess model generalization and avoid overfitting, the preprocessed dataset was partitioned into two subsets: 80% of the data was allocated to the training set, while the remaining 20% was reserved for testing. A fixed random seed was used to ensure reproducibility of the data split. This approach allows for a fair evaluation of each model's performance on previously unseen instances, ensuring reliable estimation of real-world effectiveness.

2) *Feature Scaling:* Feature scaling was applied to numerical variables using the StandardScaler method, which standardizes features by removing the mean and scaling to unit variance (i.e., a mean of 0 and a standard deviation of 1). This step is particularly critical for algorithms like Logistic Regression and SVM, which are sensitive to the scale of input features and may otherwise yield biased or suboptimal results.

3) *Underlying Algorithms:* Each algorithm was initially trained using default hyperparameters, followed by basic hyperparameter tuning to improve performance. The models, Logistic Regression, Decision Tree Classifier, Random Forest Classifier and Support Vector Machine (SVM), were implemented using Scikit-learn, a robust and widely adopted Python-based machine learning library. Performance was evaluated on both training and test sets using the following metrics: Accuracy (overall correctness), Precision (proportion of predicted late deliveries that were actually late), Recall (the model's ability to identify actual late deliveries), and ROC AUC Score (the model's discriminative power across classification thresholds).

Given the business context—where undetected late deliveries can negatively impact customer satisfaction—Recall and ROC AUC Score were prioritized as key performance indicators. Among the

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evaluated models, the Random Forest Classifier emerged as the most effective, achieving the highest overall performance across all metrics and demonstrating superior generalization capabilities. This makes it a strong candidate for deployment in real-world shipment delivery prediction systems. By leveraging ensemble learning, Random Forest effectively balances bias and variance, reducing the risk of overfitting. Moreover, its interpretability through feature importance analysis offers actionable insights into the key drivers of late deliveries. Deploying such a model not only enhances predictive accuracy but also empowers management with data-driven strategies to optimize logistics operations and improve service reliability.

IV.MODEL EVALUATION

To rigorously evaluate the predictive models developed in this study, a comprehensive and methodologically robust assessment framework was implemented, designed to capture both overall performance and the nuanced implications of classification errors in a real-world business context. Given the significant asymmetric cost associated with false negatives—specifically, the failure to accurately identify late shipments—evaluation efforts prioritized not only aggregate predictive accuracy but also detailed class-specific performance metrics. The analysis employed a set of canonical classification measures to assess model efficacy on an independent test set. These included Accuracy, quantifying the overall proportion of correct classifications; Precision, reflecting the proportion of predicted late shipments that were truly late, thus measuring the reliability of positive predictions; Recall (Sensitivity), which denotes the ability of the model to identify the full complement of actual late shipments; and the F1 Score, the harmonic mean of precision and recall, serving as a balanced metric particularly valuable in contexts characterized by class imbalance. In addition, the Receiver Operating Characteristic Area Under the Curve (ROC AUC) was utilized as a threshold-agnostic performance indicator, offering a robust measure of the model's discriminatory power across varying classification thresholds. Collectively, this rigorous evaluation paradigm ensures that the predictive models deliver not only statistically sound performance, but also practical utility aligned with the operational priorities and risk management imperatives inherent to late shipment detection.

V. RESULTS ASSESSMENT

This study evaluates four distinct machine learning classifiers—Logistic Regression, Decision Tree, Random Forest, and Support Vector Machine (SVM)—using multiple performance metrics on both training and testing datasets. The metrics considered include Accuracy, Precision, Recall, F1 Score, and ROC AUC Score, providing a comprehensive overview of model effectiveness in classification tasks.

Table 2

ML Models Result Comparison

ML_Models	Dataset	Accuracy	Precision	Recall	F1 Score	ROC AUC Score
Logistic Regression	Training	63.65%	69.38%	70.12%	69.75%	62.09%
	Testing	63.14%	68.03%	71.42%	69.68%	61.24%
Decision Tree	Training	100%	100%	100%	100%	100%
	Testing	64.14%	69.43%	70.65%	70.03%	62.64%
Random Forest	Training	100%	100%	100%	100%	100%
	Testing	65.32%	73.81%	64.37%	68.77%	65.54%
SVM (Support Vector Machine)	Training	70.55%	86.95%	59.68%	70.78%	73.19%
	Testing	65.77%	81.08%	55.17%	65.66%	68.20%

1) *Logistic Regression:* Logistic Regression exhibits moderate and consistent performance across both training and testing datasets. The training accuracy stands at 63.65%, with testing accuracy closely following at 63.14%, indicating the model generalizes reasonably well without significant overfitting. Precision and recall metrics are balanced, with precision slightly higher in training (69.38%) compared to testing (68.03%), and recall marginally improving from 70.12% in training to 71.42% in testing. The F1 score remains steady (~69.7%), while the ROC AUC score decreases slightly from 62.09% to 61.24% in testing. These results suggest Logistic Regression provides stable but moderate predictive capability, making it a reliable baseline model.

2) *Decision Tree:* The Decision Tree model achieves perfect scores (100%) on all metrics during training, a classic indication of overfitting. Such overfitting is further confirmed by the significant drop in testing performance, with accuracy plummeting to 64.14%. Although testing precision (69.43%), recall (70.65%), and F1 score (70.03%) are somewhat improved compared to Logistic Regression, the gap between training and testing metrics signals poor generalization. The ROC AUC on testing remains low at 62.64%, reinforcing the model's tendency to memorize training data rather than learning robust patterns.

3) *Random Forest:* Random Forest also exhibits perfect training metrics, indicating overfitting like the Decision Tree. However, its testing performance is notably better than that of the Decision Tree and Logistic Regression, achieving the highest testing accuracy (65.32%) and ROC AUC score (65.54%) among all models tested. Precision on testing is significantly higher (73.81%), though recall decreases to 64.37%, suggesting the model is better at correctly identifying positive predictions but misses some true positives. The F1 score (68.77%) reflects this balance. These results highlight Random Forest's enhanced robustness and improved generalization compared to single decision trees, despite some overfitting during training.

4) *Support Vector Machine (SVM):* SVM shows a different pattern with moderate training accuracy (70.55%) but a notable drop in recall (59.68%) despite high precision (86.95%). This suggests the model is highly precise but misses a substantial portion of true positive cases. On testing, the accuracy (65.77%) is comparable to Random Forest, with precision slightly reduced to 81.08% and recall further decreased to 55.17%. The F1 score drops accordingly to 65.66%, and the ROC AUC score decreases from 73.19% in training to 68.20% in testing, still the highest

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ROC AUC among the tested models. This pattern implies that while SVM is conservative in positive classification (high precision), it may be less sensitive in detecting all relevant instances (low recall), which is critical depending on application context.

● MODEL SELECTION AND RECOMMENDATIONS

Based on the comparative performance analysis of the four machine learning models—Logistic Regression, Decision Tree, Random Forest, and Support Vector Machine (SVM)—this section presents the rationale for model selection and the final recommendation.

The selection process considered five key performance metrics across both training and testing datasets: Accuracy, Precision, Recall, F1 Score, and ROC AUC Score. These metrics were evaluated to balance the trade-offs between prediction correctness, class imbalance handling, and generalization capability.

Random Forest emerged as the most promising model overall. Despite achieving perfect scores on the training dataset—an indicator of potential overfitting—it delivered the highest testing accuracy (65.32%), precision (73.81%), and a strong ROC AUC score (65.54%). Its F1 score (68.77%) also reflects a well-balanced trade-off between precision and recall. Compared to the single Decision Tree, Random Forest's ensemble approach significantly improved generalization and robustness, mitigating some of the overfitting effects.

Support Vector Machine (SVM) demonstrated the highest ROC AUC score (68.20%) on the test data, suggesting superior class separation capability. Additionally, it maintained high precision (81.08%), making it suitable for scenarios where false positives carry a higher cost. However, the notably lower recall (55.17%) indicates that the model may miss a substantial number of positive cases, which could be detrimental in recall-sensitive applications.

Logistic Regression, while not outperforming the other models in any individual metric, showed consistent and balanced performance between training and testing sets. Its minimal overfitting, decent F1 score (~69.7%), and stability make it a reliable baseline, particularly for simpler applications where interpretability and consistency are prioritized over marginal performance gains.

Decision Tree, in contrast, is not recommended for deployment due to severe overfitting. While it attained perfect scores on the training set, its testing performance did not translate proportionally, with accuracy (64.14%) and ROC AUC (62.64%) lagging behind the ensemble and kernel-based methods.

Final Recommendation: considering the balance between predictive performance, generalization ability, and applicability to real-world data, the Random Forest classifier is recommended as the most suitable model for the given classification task. It offers the best combination of accuracy, precision, and F1 score on unseen data, indicating its capability to handle complex feature interactions and noise in the dataset.

1) *Support Vector Machine (SVM):* The selected predictive model introduces transformative capabilities within logistics and supply chain operations by enhancing decision-making through data-driven insights. Firstly, it enables proactive intervention by allowing operations teams to identify and address high-risk shipments before disruptions occur, thereby minimizing delays and their downstream impacts. Secondly, it drives resource optimization by informing the dynamic reallocation of logistical assets—such as personnel, transportation, and warehousing—to prioritize vulnerable or time-sensitive orders, ultimately improving operational efficiency. Most critically, the model significantly enhances customer satisfaction by ensuring greater consistency and reliability in delivery performance, which contributes to improved client retention, elevated service quality, and strengthened brand credibility. Taken together, these capabilities position the model as a strategic asset for achieving resilient, adaptive, and customer-centric supply chain systems, aligning with contemporary demands for agility and service excellence in global logistics networks.

1) *Limitations:* Despite encouraging results, this study has several important limitations. The dataset omitted key real-world factors such as route distance, carrier characteristics, seasonal demand, and external disruptions like weather, which limits the model's predictive accuracy. Data quality concerns and inconsistent labeling of "on-time delivery" further challenge the reliability of the target variable. Methodologically, the use of random train–test splits fail to capture the temporal dynamics of shipment data, potentially leading to overly optimistic performance estimates. Additionally, limited hyperparameter tuning and the exclusion of advanced machine learning algorithms like XGBoost constrained the models' full potential. The evaluation framework did not address class imbalance or incorporate cost-sensitive metrics, reducing practical business relevance. Moreover, interpretability was limited to basic feature importance without robust explainability tools, and deployment considerations were not discussed. Addressing these gaps in future work is essential to enhance model robustness, fairness, and real-world applicability in predicting shipment delays.

VII. CONCLUSION

In this study, we developed and rigorously evaluated machine learning models to predict on-time delivery performance within an e-commerce context. Among the tested models, the Random Forest Classifier emerged as the most effective, demonstrating superior predictive capabilities characterized by high recall and ROC AUC scores. These metrics are particularly critical for minimizing the occurrence of undetected late deliveries, thereby safeguarding customer satisfaction and trust. Our findings underscore the potential of data-driven approaches to

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revolutionize logistics decision-making by accurately identifying shipments at risk of delay, enabling timely and targeted interventions.

Moreover, the study highlights the essential role of comprehensive feature engineering, stringent validation procedures, and cost-sensitive evaluation frameworks in operational environments. By incorporating additional contextual variables, leveraging more advanced algorithms, and integrating interpretability tools, future models can achieve enhanced predictive accuracy and provide more actionable insights. Overall, this research confirms the feasibility and tangible benefits of employing machine learning for shipment performance prediction. It lays a robust foundation for subsequent efforts aimed at optimizing supply chain efficiency, elevating customer experience, and driving improved business outcomes through data-informed logistics management.

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Sustainable Business and its Financing: Unlocking Capital for Long-Term Impact

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Abstract- **Sustainability is the balance between the environment, equity, and economy. It is the ability to maintain or support economic, environmental, or social processes over time without depleting natural resources. But it's more than preserving the natural world and its fragile ecologies. A key part of sustainability involves sustainable business practices and economic development. Sustainability in business refers to a company's strategy to reduce or avoid negative environmental and social impact resulting from its operations. When businesses follow sustainable practices, it creates a ripple effect on individuals and communities. Sustainability is not just a moral duty anymore but a core business strategy for developing countries like Bangladesh. Bangladesh is facing rising threats from climate change. Due to limited natural resource, businesses must concentrate on green investment, financing, and resources to promote sustainable company performance. This paper explores the convergence between sustainable business strategies and green financing that can unlock capital for long-term environmental and social impact. Green financing refers to financial investments and instruments that are specifically designed to support environmentally sustainable projects. Green financing benefits a wide range of stakeholders across different levels and functions of a company. Green financing directly supports and enhances corporate social responsibility, which refers to a company's ethical obligation to operate in a socially, environmentally, and economically responsible way.**

Keywords: **Sustainability, Green Finance, Economic Growth**

I. INTRODUCTION

Sustainability is the type of development that meets the needs of the present without risking the ability of future generations to meet their essential need [1]. The essence of the term sustainable is "that which can be maintained over time." It means, any society that is not practicing sustainability cannot survive for long period and will collapse or eventually come to an end at some point [2]. Sustainability is shaped by couple of different factors, including the quality of the environment, financial management, and the institutional capacity. If projects cannot satisfy the demand of the users, the inputs necessary for their maintenance and survival will not be achieved [4]. Unfortunately, in the past few years the term sustainable has been widely used to refer practices that were sounded more environmentally than others [5]. Companies that foresee the demand for green business will have an edge over the companies that merely response to new environment related regulations [6]. Sustainability is a social responsibility (Fields, 2002). Socially responsible investment (SRI) has been grown during the last two decades. In United States the SRI assets has risen more than 480% [7]. An indicator to determine the growth of green economy is looking at the increasing number of the companies that have undertaken certification for ISO 14000. It is a suite of environmental practices that has been prescribed by the International Organization for Standardization (ISO). According to ISO, in 1996 there were only 34 US companies who had ISO 14000 certification, and the number went up by 1042 at 2000 [8]. Investment in green funds is growing quickly. According to the social investment forum, a nonprofit organization based on Washington, D.C., that promotes socially responsible investment. In 1985, there were only 4 SRI mutual funds. Among them companies that were involved in unethical and environmentally destructive policies had been removed. After ten years the number increased to 55 SRIs and by the end of 2001 the number was 230. Selected funds limit their investment to companies whose policies has low impact on the environment [8]. To drive a positive environmental outcome green finance initiatives play a significant role [9]. Green finance is an intersection between environmentally friendly behavior and the financial business world [10]. Growth in the green finance market has been significantly strong since introducing green bonds. With green bonds speeding up, the government and business institutions both have been exploring opportunities and started to diversify their bond portfolio [11]. Green bonds are used solely to finance projects, that aims to reduce pollution in the environment and are environmentally friendly [11]. Footprints that are harmful can be reduced by green finance. Green finance can improve the quality of environment through reducing the risks of climate change [12]. In 2019, investors all around the world continue to be concerned about the risks that can cause through climate change and the transition to a low-carbon economy [13]. Green financial instruments can be a great help in achieving green environment. To speed up the procedure, financial intermediaries and markets have designed some financial instruments. Some of them are, green bonds, green funds, green home mortgages, green loans for private enterprise, environmental home equity programs and climate credit

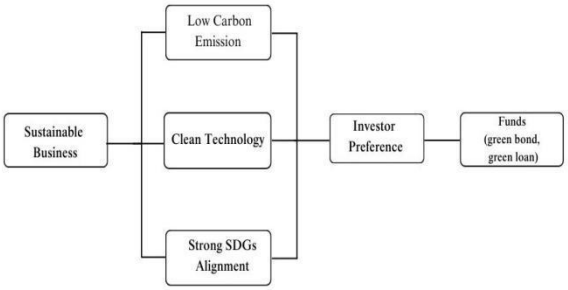
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cards that helps users track their carbon footprint [14]. In future, financial intermediaries may keep themselves away from financing in risky businesses with a higher carbon footprint and look for financing in business with low carbon emission and new technology solutions [14]. Green finance encourages investment in new technologies and innovations, including renewable energy [15]. Right now the world needs huge investment in green energy systems and put an end in constructing new coal-fired power plants [15].

II. LITERATURE REVIEW

Sustainable economic and environmental development is consistently becoming a trend [16]. Business face many challenges, among them one of the most crucial strategic challenges faced by the business now days is how to become socially and environmentally sustainable. Adapting sustainability helps businesses achieving corporate strategy [17]. Businesses are facing great pressure to consider sustainability due to global economic growth, rising social disparities and devouring natural resources without any limit [13]. Businesses implying the concept of sustainable development by putting equal importance on social, economic and environmental value by applying the 'triple bottom line' framework [14]. Sustainable business model is all about generating high level firm and customer value by addressing environmental and societal needs [15]. One of the key operating forces for economic development is the financial sector. A financial sector that is well managed is attractive for investors [18]. Green finance is a phenomenon that incorporates finance and business with an environment friendly behavior. It is an involvement of many participants, such as business owners, consumers, producers, financial lenders and investors [16]. Green finance requires engaging traditional capital markets in creating and distributing a wide range of both financial products and services that provides quality returns with environmentally positive outcomes. This includes adjusting risk perceptions in order to escalate environment friendly investments and reduce investments that are harmful for the environment [6]. The green finance concept was arisen after the global financial crisis in 2008, to address the urgent need for the private financial sector to combat climate change. While promoting sustainable development, green finance also offers new opportunities to make profit for the financial sectors [17]. In china global green bond issuance has reached to a record number in 2019, with the equivalent of USD121 billion, surpassing the previous years' record of USD103 billion. Corporate sector alone has stand for USD50 billion, which is above a 100% increase from 2018. According to the European Commission (2018), at the beginning of 2017, sustainable investment fund categorized with focusing environment was only 17%. This number has risen to 23 percent at the end of 2018, increasing allocations to investments which are solely dedicated to combat climate change [6]. Investors now-a-days are using the SDGs as their benchmark, to make an impact and creating extra demand for green bonds [6]. In the previous two decades, an increasing number of corporates have started to take voluntary climate change initiatives for stakeholder pressures to reduce carbon emissions [18]. An explosive growth has been experienced by the global green bond[16]. Growth of green economics can increase conservation investments, make advancement in carbon bazaar tools, and establish green central panels that can reduce reliability on strategies that are coal based and lower carbon emissions [17]. Many Asian countries are shifting their investments to environment friendly technologies and sustainable businesses from fossil fuel to achieve sustainable development [17].

Conceptual Model



The model illustrates the mechanism through how sustainable business can achieve more financing. A sustainable business with low carbon emission, clean technology with low wastage rate and strong alignment with SDGs not only mitigates environmental risk but also combats climate change. These factors contribute shaping investor preference. Investors are more inclined to support firms with ethical responsibility and compliance with sustainability. This preference leads sustainable businesses access capital such as green bond, green loan. Investing in sustainable business confirms investors' commitment to participate in sustainable development and strengthens their image as a socially responsible person [21]. More than 60% green bonds issued are by government or semi government, which increases reliability [21]. The average maturity period of a green bond issued by an organization is 7-10 years and some may have a maturity period of 20-30 years which makes them convenient and attractive to loge term investors [21].

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III. IMPLICATION

Undoubtedly one of the most intense threats currently human civilization is facing is climate change. Growing knowledge of public about risk that can be caused by climate change has created a pressure regarding environmental sustainability, making firms more vulnerable to carbon risk [20]. Many companies have separate corporate sustainability and business strategies, as they consider sustainability issues important [19]. Awareness of hazards that are strongly related with climate change has increased and policymakers all around the globe are working on cutting carbon emissions in the past few years [19]. Europe is currently leading the global green bond market with a share of approximately 45-50% that was boosted by the actions taken under the European Green Deal [21]. Consciousness about the financial ramifications of being environmentally friendly has been risen up between investors and corporations. A company can make a huge contribution to the sustainable development of the economy by running their business using renewable energy [21]. Organizations that are socially responsible are more resilient to systemic shocks than others. Green investment is boosting GDP while lowering coal use [20]. Green bond could be a great opportunity to participate in creating new economy with high level of sustainability, factors including mentioned makes green bond attractive to both innovative and traditional investors who are seeking financial and socially return on their investment [21]. Green bonds provide sufficient fund that helps firms to focus on developing sustainable projects and also reduces the pressure of repayment as most of the bonds comes with long term maturity [20]. If organizations and countries understand what it means to be economically sustainable there would be more employment and less poverty [24].

IV. CONCLUSION

Sustainability is about long-term survival, environmentally, socially and economically [24]. The changes due to human activity in our ecosystem have been rapid more than ever in the past 50 years. Emissions of toxic substance represent one of the key human driven changes [23]. Unfortunately many corporate sustainability innovations and strategies do not reach their full potential due to several reasons one of them is financing and sometimes even fail [19]. Negative impact on earth can be reduced by financing on sustainable project [21]. As, all the funds that are raised through green bonds are used for renewable energy projects (Bisultanova, 2024). However, it attracts investors who are willing to invest in projects that comply with sustainable principles and strongly aligns with SDGs (Bisultanova, 2023). If businesses want to achieve progress towards a better, sustainable and more certain future they must require measurable and manageable objectives (White, 2013).

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Exploring Antifragility in the Workplace: Insights from HRM Practices and Employee Behavior

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Abstract: **This study investigates antifragile workers, employees who grow stronger under stress as a sustainable workforce strategy in Human Resource Management (HRM). Antifragility offers an evolution beyond resilience by enabling workers to adapt and thrive in an everchanging environment. Primary data was collected through a survey of 33 professionals across sectors and a focus group with staff from Evercare Hospital. 74% of respondents identified as antifragile to some extent. Key traits included adaptability to change (69.7%), and learning from failure (66.7%). Focus group participants cited experiences such as COVID-19 and hospital rebranding as catalysts for antifragile development. Workplace practices fostering antifragility included mentorship programs (33.3%), and failure-friendly cultures (21.2%). These approaches align with global sustainability trends emphasizing psychological safety, continuous learning, and decentralized decision-making. The findings suggest antifragility is a learnable trait that can be cultivated through HR strategies. This research contributes to emerging trends in sustainable HRM and highlights antifragility as a key competency for future-focused organizations.**

Keywords: **Adaptability, Antifragile workers, Continuous learning, Decentralized decision making, Failure-friendly culture, Human Resource Management, Psychological safety, Resilience, Sustainability, Sustainable workforce strategy.**

I.INTRODUCTION

Nassim Nicholas Taleb established the term "antifragility" to define systems that not only survive unexpected events, uncertainty, and disruption, but also gain strength and resilience from them. An antifragile system thrives in dynamic and unpredictable situations by adapting and improving in response to stresses, uncertainty, and disruption, in contrast to robust or resilient systems that only resist damage and return to their prior state.

In today's workplace, when businesses deal with ongoing turmoil resulting from globalization, rapid technology innovation, economic uncertainty, and unanticipated events like the COVID-19 outbreak, the concept of antifragility is extremely crucial. Antifragile procedures promote businesses and workers to develop their skills, adapt, and grow stronger from difficulties, in contrast to traditional management systems that prioritize control and stability. This viewpoint is particularly important in human resource management since working methods, organizational culture, and employee behavior all have a direct impact on how well a company handles unpredictability. Studying antifragility in this specific context may provide fresh perspectives on creating workforces that are not just adaptable but also able to turn hardship into opportunity.

The problem originates from the fact that many firms continue to function with a resilience-only mentality, hoping to merely "bounce back" from setbacks rather than using them to their advantage. Because of this, businesses frequently pass up chances to innovate, improve staff skills, or reconsider outdated HR procedures. Without adaptable systems, the stress of continuous change can cause employee burnout, discouragement, increased resignations and loss of productivity. Without antifragile methods, firms become vulnerable and less competitive in rapidly evolving areas like technology, healthcare, and finance. Examining antifragility in the workplace thus fills a gap by highlighting the ways in which HRM practices, including performance management, leadership style, talent development, and employee well-being, may be crafted to transform instability into an advantage for both organizational and individual development.

The ultimate objective is to further the knowledge of antifragility in the workplace on both a theoretical and practical level by highlighting how HR processes and employee behavior may turn obstacles into opportunities for development. By doing this, the study hopes to provide firms with tactics for developing workforces that are sustainable and prepared for the future.

This study uses a relational and exploratory approach, combining qualitative findings from focus group interviews with survey data. An experimental or

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causal study would be premature at this point because antifragility is still a relatively understudied topic in the domains of organizational behavior and human resource management. The qualitative component offers in depth context and personal insight, whereas the selected approach focuses on finding correlations between HRM practices and employee behaviors. When combined, these approaches help the study to identify trends, attitudes, and behaviors that support antifragility in the workplace.

A wide range of workers from various industries are represented among the study's participants. Male and female professionals with experience levels ranging from 0–5 years to 20+ years, and ages ranging from 20–25 years to 50 and beyond, participated in the survey. They had a diverse range of professional experiences, including management, data analytics, healthcare, airlines, and the creative sectors. This diversity includes viewpoints from experienced professionals and beginners in technical, knowledge-intensive, and service-oriented fields.

Staff members from Evercare Hospital, one of the top private healthcare facilities in Bangladesh, participated in a focus group discussion to supplement this. In addition to placing the results within the framework of a vital service sector, this qualitative element offers deep insights into how antifragility is perceived and promoted in real-world settings, especially in high-stakes settings like healthcare.

Two major types of variables are examined in this study. It looks at behaviors and mindsets including flexibility, learning from mistakes, being open to criticism, proactive learning, and perseverance in the face of setbacks at the employee level. It focuses on HRM-related activities at the organizational level, such as failure-tolerant cultures, crisis simulations, mentorship programs, open feedback systems, and encouragement of lifelong learning.

This study contains limitations, just like any other research. First, there were 67 total survey responses. This sample is still quite small and might not accurately reflect the larger workforce, even though the participants come from a variety of age groups, occupations, and experience levels.Secondly, the research was carried out at a specific time. However, the idea of antifragility changes as people and organizations encounter repeated difficulties. To see how these practices and behaviors evolve over time, a long-term study would be required. Thirdly, while the focus group with Evercare Hospital staff added valuable practical insights, the findings are strongly tied to the healthcare context as well. The findings should be applied cautiously when considering other businesses because antifragility in the healthcare sector could not appear the same as it does in the technology, creative, or aviation sectors antifragile behaviors, but we cannot claim they directly cause those behaviors without further testing.

This study will benefit organizations by showing which HR practices help employees grow stronger through challenges. It will assist HR managers in creating more effective methods for support, feedback, and training. Workers can also learn which habits make them more antifragile, such as flexibility and ongoing education. Lastly, it provides scholars with valuable information as well.

II.LITERATURE REVIEW

Scholars are starting to look at how [4]concept of antifragility relates to employee behavior and organizational systems. For instance, [1] examined antifragility from the standpoint of organizational design. They maintained that socio-technical systems that prioritize flexibility, decentralization, redundancy, and ongoing learning are better suited to survive in unpredictable situations. Their work serves as an example of how antifragility may be established in businesses through structural practices.

In their investigation of antifragility in the hospitality industry, [3] discovered that antifragile workers, those who develop and learn from difficulties, showed greater workplace engagement and more stronger senses of belonging. In a similar field, [2]showed how leaders who are entrepreneurs may encourage antifragility in employees, which encourages creative behavior. Additionally, they discovered that this link is strengthened by job autonomy, indicating that workplace arrangements can be quite important in promoting antifragile behaviors.

Strategies for creating antifragile workplaces, including encouraging innovation, accepting failure, and promoting feedback and ongoing learning, have been emphasized in practitioner-oriented discussion outside of academic literature [4]. These suggestions are in line with human resources management practices aimed at helping businesses to develop and adapt in times of change.

III.RESEARCH METHODOLOGY

An exploratory and descriptive research method is used in this study. Since antifragility is a relatively new idea in HRM; the study is exploratory in nature and aims to find new trends between employee behavior and HRM methods. Because it examines employee traits, behaviors,

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and workplace practices using data gathered, it is also descriptive in nature.

67 individuals with a range of professional backgrounds, including those in the healthcare, aviation, management, data analytics, and creative industries, participated in the survey as responders. A diverse range of age groups (20–25 years to 50+ years) and work experience levels (0–5 years to 20+ years) were represented among the participants. There were both male and female participants.

Because respondents were chosen based on their accessibility and desire to participate in the survey, non-probability convenience sampling was the sampling technique chosen. To get more in-depth qualitative perspectives from the healthcare industry, a focus group interview was held with Evercare Hospital Dhaka employees in addition to the survey.

A structured survey questionnaire with both closed-ended and open-ended questions was used to gather data. Demographic data, awareness of antifragility, opinion of antifragile behavior, response to workplace difficulties, and opinions on HRM practices that promote antifragility were all recorded in the survey. A semi-structured interview was the focus group's guide and encouraged participants to share their experiences with improvement/development, flexibility, and resilience in the workplace.

Respondents from a variety of professional backgrounds were able to participate in the survey because it was distributed online. Employees from the Quality Assurance department participated in the focus group session, which was held in person at Evercare Hospital Dhaka.

Descriptive statistics, such as percentages and frequencies, were used to examine survey data in order to compile the demographics and replies of the respondents. Thematic analysis of qualitative answers to open-ended questions and focus group interviews identified repeated themes and patterns relating to HRM practices and antifragile behaviors.

IV. Presentation of Data and Critical Discussion of Results

According to the questionnaire that was circulated, the total number of respondents were 67 and 59.7% of the respondents were male and the remaining 40.3% female.

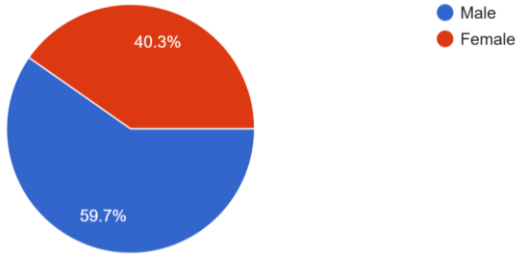


Fig 4.1: Gender Count

70.1% of the respondents had not heard of the term ‘Anti Fragility’ before according to the survey done and is shown in the figure below.

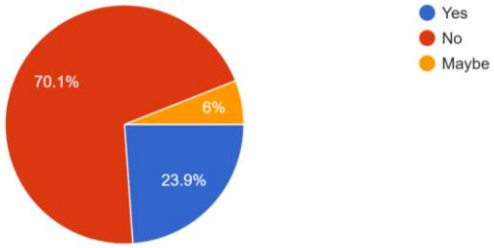


Fig: 4.2 Heard of the term Antifragile before

However according to this Figure 4.3, 81.5% of the respondents do find themselves to be antifragile at the very least.

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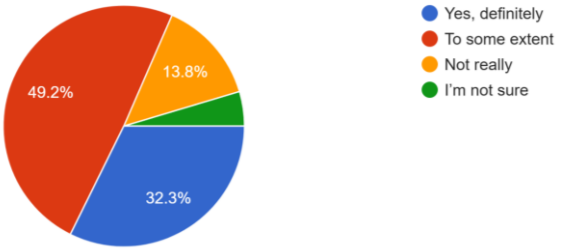


Fig 4.3: Respondents considering themselves as antifragile

The average age distribution of the respondents is bimodal as it is concentrated among the youngest group (20–25) and the oldest group (50+), followed by the ages of 41- 45 years as shown in figure 4.4.

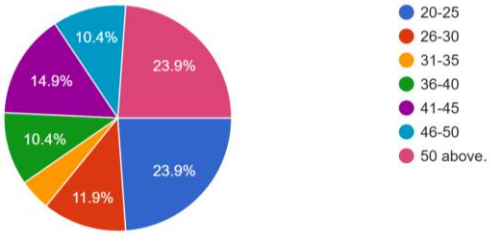


Fig 4.4: Age distribution of the respondents

As the age distribution is bimodal, this can be reflected in the years of professional experience of the respondents.

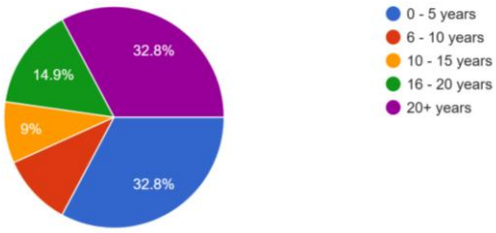


Fig 4.5: Years of professional experience of the respondents.

As the sample size of the survey is 67, this means that the occupations of the respondents vary thoroughly. For easier data calculation, this chart was made by categorizing the occupations in a more generic manner.

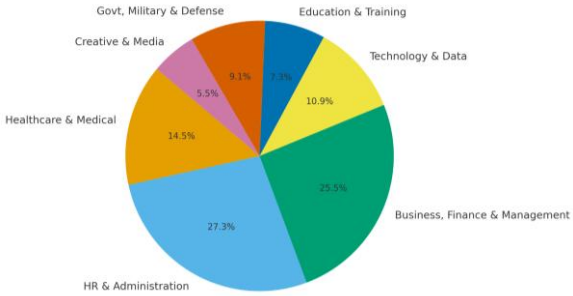


Fig 4.6: Respondent's occupations

When asked about what the respondents think makes a worker antifragile, they picked these options from the checkbox.

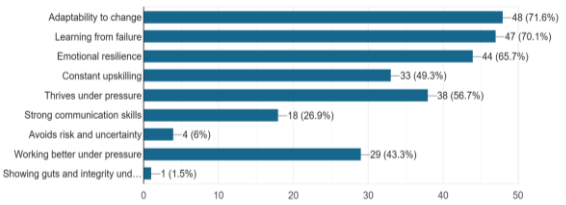


Fig 4.7: Characteristics of an antifragile worker

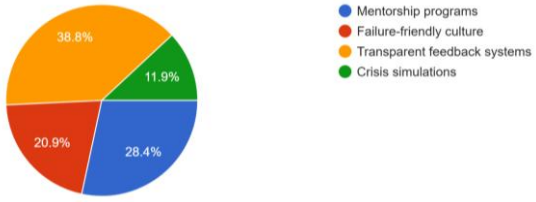


Fig 4.8: Workplace practices that help build antifragility

The figure above explores what the respondents consider workplace practices which support the theme of antifragility.

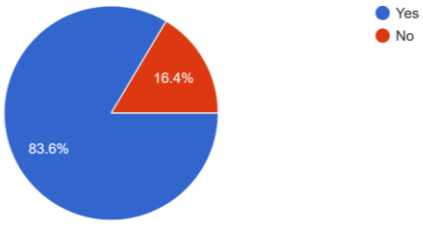


Fig 4.9: Respondents taking proactive steps to improve adaptability and skills

The figure shows that 83.6% of the respondents are cautious about improving their adaptability and skills as they take proactive steps regarding it.

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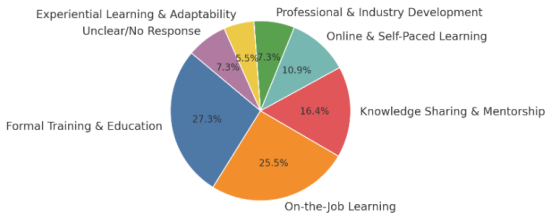


Fig 4.10: Proactive measure for improvement

This figure shows how respondents take actions to improve their skills and adaptability.

Category	Examples	Count
Formal Training Programs	Recurrent trainings, refresher trainings, workshops, job rotation, 1-on-1 sessions	15
Educational Support & Reimbursement	Courses, certifications, college reimbursements, educational visits	10
On-the-Job Learning & Feedback	Feedback sessions, sprints, case studies, learning from mistakes, retrospectives	14
Knowledge Sharing & Collaboration	Learning from coworkers, shadowing, mentoring, posting culture	9
Online Learning & Self-Paced Programs	LMS, eFront portal, online learning platforms, self-paced courses	6
Industry & Professional Development	Conferences, CME/CNE, keeping updated with latest information	4
Experiential / Other Practices	Psychological support, facing challenges, innovation, new roles	3
Unclear / No Response	N/A, not sure, no	4

Table 4.1: Respondents' workplaces' continuous learning methods

The table breaks down 65 responses into 8 different categories along with examples as to the answers given by the respondents in table 4.

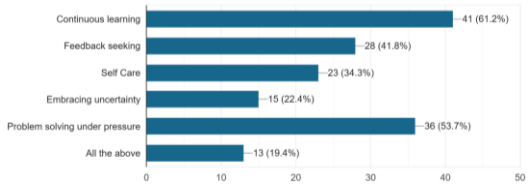


Fig: 4.11 : Practices done by the respondents

The respondents do these practices which can be defined as antifragile practices.



Figure: 4.12: Response to criticism

36.5% of the respondents accept and try to learn from it followed by 33.3% feeling uncomfortable yet reflect on it.

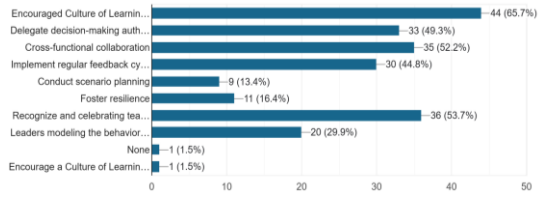


Fig 4.13: Noticed anti fragile activities in the workplace

These are the antifragile activities which the respondents have noticed in their workplaces

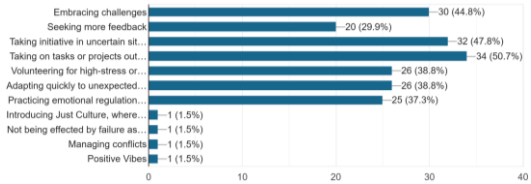


Fig 4.14: Changes in workplace behavior to become more antifragile

The figure above shows what the respondents said that would help them become antifragile if they were to implement these behaviours.

Critical Discussion of Results

The survey results reveal several important insights into the understanding and practice of antifragility in the workplace. While 70.1% of respondents had never heard of the term "antifragility", a significant majority (81.5%) considered themselves antifragile. This suggests that antifragility, as a concept, may be implicitly practiced even without being aware of the right terminology. The gap presents an opportunity for organizational training and awareness-building.

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The age distribution was bimodal, with peaks at the 20–25 and 50+ groups. This is mirrored in years of professional experience, implying that antifragility may be interpreted differently by early-career versus late-career professionals. Younger respondents may equate antifragility with adaptability and skill acquisition, while older professionals might associate it with resilience, and accumulated experience.

In terms of occupations, the variation suggests that antifragility is not industry-specific but broadly applicable.

As for characteristics of antifragile workers and workplace practices that encourage antifragility, respondents highlighted adaptability, proactive learning, and resilience which reflects a strong individual initiative. However, organizational responsibility was less emphasized which may point antifragility to being individualistic rather than collective, organisation wise.

Table 4.1 provided further insights, as respondents identified diverse continuous learning methods such as training, workshops, and mentorship. While this demonstrates organizational support, the fact that practices varied significantly indicates inconsistent institutionalization of antifragility across workplaces.

The findings in response to criticism were particularly telling: only 36.5% fully embraced criticism as a learning opportunity, while one-third felt uncomfortable but still reflected on it. This suggests a mixed cultural readiness for antifragility, as emotional discomfort may hinder growth despite rational acknowledgment of its value, unrelated to age.

Finally, workplace behavioral changes seen in figure 4.14 illustrates that employees recognize specific changes that could make them more antifragile.

VI. SUMMARY, CONCLUSION AND RECOMMENDATION

The findings indicate that awareness of antifragility as a concept is relatively low, as most respondents were unfamiliar with the term. However, many already demonstrate behaviors and mindsets aligned with antifragility, suggesting that while the terminology is not widely known, the practices are recognized and enacted.

The results also show that antifragility is being developed more at the individual level than collectively within organizations. Employees are proactively taking steps to enhance adaptability and resilience, but organizations lag behind in providing consistent support. A generational divide is visible: younger employees emphasize continuous learning and skill-building, while older professionals tend to focus more on resilience and accumulated experience.

An overview of the results:

The results from the survey show a number of significant trends:

A. Awareness of: Most of the respondents are unfamiliar with the term antifragile worker, although they described it in terms of adaptability, learning from failure, as well as

5 on a scale of 1 to 5, indicating that they frequently look for chances to learn from setbacks. Similarly, 18 respondents (27%) agreed and 29 respondents (43%) strongly agreed that adversity or failure makes them stronger than before.

E. Skills and Adaptability: 56 respondents (84%) said

practices considered to encourage antifragility.

I. Continuous Learning: Many workplaces encouraged continuous learning through seminars, conferences, or professional courses, though a significant minority felt opportunities were lacking.

J. Behavioral Changes: In order to become more antifragile, employees recognized behaviors such as stepping outside of their comfort zones, accepting

B. development under stress.

C. Criticism at Work: The majority of participants responded positively to criticism; 34% said they "accept and try to learn from it," while 22% said they were seeking out feedback to do better.

D. Growth from Setbacks: More than 57% of respondents gave themselves a rating of 4 or

F. they had taken proactive measures to enhance their skills and adaptability.

G. Practices: Some respondents said "all of the above," with the most popular regular practices being ongoing learning, requesting feedback, and solving problems under pressure.

H. Workplace Practices: Mentorship programs (19 respondents, 28%), failure-friendly cultures (14 respondents, 21%), and transparent feedback systems (26 respondents, 39%) were the top workplace

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challenges, volunteering for high-stress jobs, asking for feedback, and fast adapting.

K. Focus Group Insights (Evercare Hospital): The hospital personnel highlighted the value of teamwork, training, and psychological safety in managing uncertainty, emphasizing the critical role that antifragility plays in high-stakes settings such as healthcare.

Conclusion:

Because this is a harvested trait rather than a genetic one, more research on this topic may help and develop workers who have the potential to become antifragile. In this exploratory study, we discovered that the respondents are not familiar with the term but find themselves relating to it. They also mentioned practices and activities that help them become antifragile.

Recommendation for future research:

1-Involve more people: Results will be more reliable and trustworthy if there is a larger sample drawn from a variety of industries.

2-Research spanning time: Future studies can track employees over months or years to observe how their actions evolve, as antifragility increases when people encounter repeated difficulties.

3-Examine several countries and industries. Antifragility might show up differently in the fields of education, technology, and healthcare, and culture may also be involved. A broader perspective would result from comparing across industries and nations.

4-Test cause-and-effect: To determine whether particular HR procedures (such as training or mentoring) directly make employees more antifragile, future study can apply case studies or experiments.

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1.Age*

20-25
26-30
31-35
36-40
41-45
46-50
50 above.

2.Gender *
-Male
-Female
-Other:

3.Years of professional experience
0 - 5 years
6 - 10 years
10 - 15 years
16 - 20 years
20+ years

4.Current Occupation*

5.Have you heard of the term "Antifragile Worker" before this survey? If your answer is no, Antifragility refers to the ability to grow stronger through stress, adversity, and challenges—not just surviving or recovering, but improving as a result *
-Yes
-No
-Maybe

6.How would you define an "antifragile worker"? *

7. In your opinion, what characteristics make a worker antifragile? *

- Adaptability to change
- Learning from failure
- Emotional resilience
- Constant upskilling
- Thrives under pressure
- Strong communication skills
- Avoids risk and uncertainty
- Working better under pressure
- Other:

8.How do you typically feel when you receive criticism at work?

- I take it personally and feel discouraged
- I feel uncomfortable, but try to reflect on it
- I accept it and try to learn from it
- I actively seek it out to improve
- I feel energized by constructive criticism

9.How often do you seek opportunities to grow from setbacks? *
Never
1
2
3
4
5

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Always

10. Do you feel that failure or hardship makes you stronger in your job or life? *
No
1
2
3
4
5
Yes

11.Do you take proactive steps to improve your adaptability and skills? *
-Yes
-No

12.If your answer is yes, please elaborate.

13.Which of the following do you regularly practice? *
- Continuous learning
- Feedback seeking
- Self Care
- Embracing uncertainty
- Problem solving under pressure
- All the above

14.Which workplace practices do you believe help build antifragility?
- Mentorship programs
- Failure-friendly culture
- Transparent feedback systems
- Crisis simulations

15. Do you consider yourself anti fragile? *
-Yes, definitely
-To some extent
-Not really
-I'm not sure

16.Does your workplace encourage continuous learning? If yes, name the practices *

17.Select the anti fragile activities that you noticed in your workplace*
Encouraged Culture of Learning and Adaptability
Delegate decision-making authorit
Cross-functional collaboration
Implement regular feedback cycles
Conduct scenario planning
Foster resilience
Recognize and celebrate team members' successes
Leaders modeling the behaviors and attitudes that they want to see in their teams.
Other:

18.What specific changes in your workplace behavior do you believe would help you become a more antifragile worker?*
- Embracing challenges
- Seeking more feedback
- Taking initiative in uncertain situations
- Taking on tasks or projects outside my comfort zone
- Volunteering for high-stress or uncertain assignments
- Adapting quickly to unexpected changes
- Practicing emotional regulation under pressure
- Other

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Retailer Behavior in the Digital Economy: Factors Behind Cashless Payment Adoption

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*Abstract-:***Purpose: This study delves into identifying the key factors influencing the adoption of cashless payment systems among retailers in Bangladesh. Based on the Unified Theory of Acceptance and Use of Technology (UTAUT) and Technology-Organization-Environment (TOE) theories, the study has incorporated performance expectancy, effort expectancy, social influence, facilitating conditions, relative advantages, and competitive pressure as the predicting variables, behavioral intention as the mediating variable, and payment system adoption as the outcome variable. Data has been collected from 349 retailers through structured offline questionnaires. Partial Least Squares Structural Equation Modeling (PLS-SEM) is run to test the hypothesized relationships with SmartPLS. Social influence and competitive pressure had a direct effect on cashless payment adoption, whereas other factors have insignificant direct impacts. Besides, the results show that behavior intention significantly mediates the relationship between performance expectancy, effort expectancy, social influence, and competitive pressure and the cashless payment system adoption. This study offers insights for policymakers and fintech providers to improve retailer adoption of cashless payments by focusing on behavioral intentions. The adoption of digital payments can be expedited by highlighting competitive pressure and social influence. Retailers' preparedness can be enhanced by enhancing awareness of performance advantages and user-friendliness. The results point to specific ways to make digital financial services available to more retailers in Bangladesh. This study uniquely combines the UTAUT and TOE frameworks to investigate the acceptance of cashless payments within the Bangladeshi retail sector. It presents behavioral intention as a mediating mechanism, providing an innovative structure in the literature on digital payments. It contributes context-specific insights to global adoption research by concentrating on retailers in emerging economies.**

Keywords - Cashless payment, Digital economy, Retail industry, TOE, UTAUT.

I. INTRODUCTION

The rise of digital platforms is driving the shift from cash-based transactions to a cashless economy [1]. Alongside the changing consumer behavior, technology and increased access to banking are key drivers. Even though still in its early stages, cashless payments offer clear benefits to businesses and the economy, including convenience, efficiency, and lower costs [2], [3]. The adoption is influenced by digital infrastructure, trust, social factors, and willingness to embrace new technology [4].

Retailers are key influencers of consumer behavior, making their adoption of cashless payments critical for the success of a cashless economy. While UTAUT explains individual technology adoption and the TOE framework addresses organizational contexts, few studies[4], [5] integrate them to understand cashless payment adoption among Bangladeshi retailers. Most research targets consumers, leaving small and medium retailers underrepresented [6], [7]. Adoption in Bangladesh is limited by poor infrastructure, mistrust of technology, reliance on cash, and varying merchant skills [8], [9]. This study addresses these gaps by combining UTAUT and TOE frameworks, highlighting behavioral intention as a mediator between technological, organizational, and environmental factors and cashless payment adoption.

Fintech companies like bKash, Nagad, and Rocket, along with government initiatives, have expanded digital finance in Bangladesh. However, retailer adoption remains uneven due to low digital literacy, infrastructure gaps, security concerns, and limited trust [3]. It reveals that by January 2025, total MFS accounts reached approximately 239.3 million, up from 219.12 million in January 2024, [10] ,but active usage is low. Policymakers, banks, and fintech providers must understand the factors influencing adoption to create effective strategies that encourage retailers to embrace cashless payments. Therefore, this study aims to explore the factors influencing cashless payment systems adoption by the retailers in Bangladesh.

II. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Unified Theory of Acceptance and Use of Technology (UTAUT) explains user intentions via performance expectancy, effort expectancy, social influence, and facilitating conditions, with moderators like age and experience [11] and Technology-Organization-Environment (TOE) framework adds organizational and environmental perspectives [12]. Together, they capture adoption drivers at individual and organizational levels. In Bangladesh, cashless payment adoption is limited by trust, digital literacy, and infrastructure. This study examines technological, social, and

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environmental factors influencing retailers' adoption with behavioral intention as the mediator.

Fig. 1. Conceptual Framework of the Study

Performance expectancy is the belief that a technology improves work efficiency and provides tangible benefits [13], [14]. Studies indicate that people are more likely to adopt technologies like mobile banking or digital payments when they perceive them as useful, convenient, and effort-reducing [15]. Performance expectancy is widely recognized as a key factor in technology acceptance, positively shaping users' attitudes and behavioral intentions [16], [17], [18]. Based on this, it is proposed that:

H_1: Performance Expectancy has a significant positive impact on the adoption of cashless payment systems by retailers.

Effort expectancy captures the perceived ease of using a new technology, specifically how much effort users believe is needed to complete related tasks [4], [19]. The perceived simplicity and convenience of cashless payments, mobile banking, and e-wallets lead to a higher adoption rate [20], [21], [22]. The impact of effort expectancy on technology adoption is most pronounced during the initial phases, where it significantly enhances users' behavioral intentions [23], [24], [25]. Combining these insights, the following hypotheses is derived:

H_2: Effort Expectancy has a significant positive impact on the adoption of cashless payment systems by retailers.

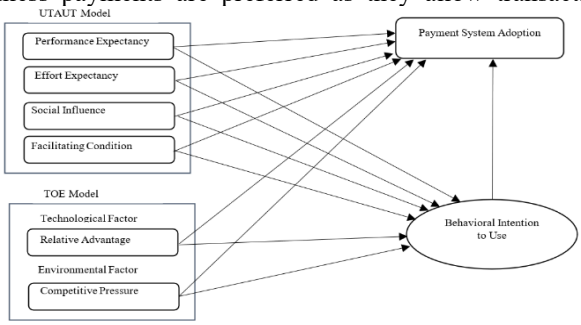
Social influence refers to how the opinions and behaviors of others affect an individual's decision to adopt a technology [19], [26]. In digital payments, users are guided by family, friends, peers, and respected figures [27], [28], [29]. Researches show that social influence acts as an extrinsic motivator, especially during early adoption, across mobile payments, internet banking, and m-commerce [21], [24], [30], [31]. Its' influence may lessen as users become familiar, but it remains an important factor in adoption behavior.

H_3: Social influence has a significant positive impact on the adoption of cashless payment systems by retailers.

Facilitating conditions refer to the extent to which individuals believe that adequate technical and organizational support exists for using a system [11], [21], [32]. For cashless payments, this includes access to smartphones, stable internet, compatible devices, and reliable customer support [26], [33]. Research shows that strong facilitating conditions positively influence adoption, especially where digital literacy and access are limited [16], [34], [35], [36]. Based on these insights, it is proposed that:

H_4: Facilitating conditions have a significant positive impact on the adoption of cashless payment systems by retailers.

Relative advantage refers to how much a new technology is perceived as better than previous methods, offering more benefits, convenience, and efficiency [37], [38]. Cashless payments are preferred as they allow transactions



anytime and anywhere, in both online and offline stores, and can enhance profitability, speed, and efficiency for businesses [39], [40], [41]. Studies show that perceived relative advantage strongly drives technology adoption across sectors, including mobile payments and customer relationship management (CRM) systems [42], [43], [44], [45]. Therefore, it is proposed that:

H_5: Relative advantage has a significant positive impact on the adoption of cashless payment systems by retailers.

Competitive pressure refers to the influence firms in an industry exert on each other, motivating businesses to adopt new technologies to stay competitive and protect market share [46], [47]. High competition drives innovation, digital solutions, and process improvements for growth and survival [43], [48]. Studies show that competitive pressure positively impacts adoption of technologies like e-business, supply chain systems, and mobile payments [49], [50], [51]. Therefore, it is proposed that:

H_6: Competitive pressure has a significant positive impact on the adoption of cashless payment systems by retailers.

Behavioral intention refers to an individual's willingness and motivation to perform a behavior, reflecting the likelihood that they will actually do it [5], [52]. In digital payments, it indicates users' readiness to adopt cashless systems, linking factors like performance expectancy, effort expectancy, and social influence to actual usage [13], [19]. Studies show that stronger behavioral intention leads to higher adoption rates, especially among innovative users [21], [53], [54]. In this study, behavioral intention is expected to mediate the effect of technological, social, and environmental factors on cashless payment adoption. Based on this, it is proposed that:

H_7: Behavioral intention mediates the relationship between performance expectancy and payment system adoption.

H_8: Behavioral intention mediates the relationship between effort expectancy and payment system adoption.

H_9: Behavioral intention mediates the relationship between social influence and payment system adoption.

H_{10}: Behavioral intention mediates the relationship between facilitating conditions and payment system adoption.

H_{11}: Behavioral intention mediates the relationship between relative advantage and payment system adoption.

H_{12}: Behavioral intention mediates the relationship between competitive pressure and payment system adoption.

III. METHODOLOGY

This study uses a quantitative research design to examine the factors influencing cashless payment adoption among retailers in Bangladesh. A hybrid model combining

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UTAUT and the TOE framework was applied to explore technological, social, and environmental factors. The target population includes retailers with prior experience using digital payment systems. With an unknown population size, non-probability convenience sampling was used, yielding 349 valid offline responses, exceeding the minimum required for reliable PLS-SEM analysis. The study focused on retailers across Bangladesh who either use or have the potential to adopt cashless payments, with purposive sampling employed to select respondents familiar with digital transactions to ensure reliable and relevant data. Information was gathered through a structured questionnaire based on a five-point Likert scale, drawing items from established studies. The instrument included five indicators for relative advantage [37], [55], [56] , competitive pressure[26], [56], social influence[19], [34], [57], effort expectancy[21], facilitating conditions[32], and performance expectancy [21], along with six indicators each for behavioral intention[32] and payment system adoption [26].

Data analysis involved descriptive statistics in SPSS to summarize demographics and response patterns, and PLS-SEM in SmartPLS for hypothesis testing. The analysis first assessed measurement model reliability and validity using composite reliability and average variance extracted, followed by structural model testing with bootstrapping to evaluate the significance of hypothesized relationships, including the mediating role of behavioral intention.

IV. DATA ANALYSIS AND RESULTS

The study sample consisted of retail business executives from different sectors in Bangladesh, the majority being male (96%) and business owners (76.5%). Nearly half of the respondents (50.2%) were between 31 and 45 years old, representing an experienced group in retail. In terms of education, 51.6% had completed HSC and 44.1% SSC, indicating moderate educational backgrounds with practical knowledge of financial systems. Most participants (69.4%) had operated their businesses for over three years, and more than 60% had been using cashless payment systems for at least six months, reflecting adequate exposure to digital payments. These demographic and business profiles highlight the relevance of the sample for exploring the drivers of cashless payment adoption in Bangladesh's retail sector.

Table I:Demographic Profile of the Respondents

Category		Frequency (N=349)	Percent
Gender	Male	335	96.0
	Female	14	4.0
Age Level	18–25	26	7.4
	26–30	54	15.5
	26–30	54	15.5
	31–35	77	22.1
	36–45	98	28.1
	Above 46	94	26.9
Level of Education	SSC	154	44.1
	HSC	180	51.6
	Graduation	13	3.7
	Masters and Above	2	0.6
Experience Using Cashless Payment System	3–6 months	76	21.8
	6–12 months	117	33.5
	12–18 months	99	28.4
	More than 18 months	57	16.3
Business Industry	Accessories and Makeup	11	3.2
	Daily Necessities	84	24.1
	Electronics	49	14.0
	Fashion	67	19.2
	Food and Beverages	37	10.6
	Pharmacy	19	5.4
	Print Shop	34	9.7
	Stationery	39	11.2
	Supershop	9	2.6
Position	Owner	267	76.5
	Manager	26	7.4
	Staff	56	16.0
Business Age	Less than 1 year	22	6.3
	2–3 years	85	24.4
	3–5 years	121	34.7
	More than 5 years	121	34.7

(Source(s): Authors' own work)

As represented in table II, item loadings are higher than 0.7 which signifies the reliable representation of corresponding construct [58]. Cronbach's Alpha (CA) is ranging from 0.810 to 0.941, indicating satisfactory internal stability [59]. Strong reliability is also depicted by composite reliability (CR) as values lie between 0.813 and 1.092 and are higher than the cut-off value of 0.7 [60]. For convergent validity, an average variance extracted (AVE) value of 0.5 or higher is expected [59]. Here, all constructs have AVE values higher than .5 which satisfies threshold. In terms of discriminant validity test as depicted in table III, all variables have passed the thresholds of Fornell Larcker [61] and Heterotrait-monotrait ratio of correlations (HTMT) model [62] which signifies that each construct is sufficiently distinct from the others.

In table IV, the results of direct and indirect path analysis shows that CP significantly influences PSA (H6: CP → PSA, $\beta = 0.132$, SD = 0.054, $t = 2.469$, $p = 0.014$), highlighting the role of market competition. SI also positively affects PSA (H3: SI → PSA, $\beta = 0.130$, SD = 0.061, $t = 2.129$, $p = 0.033$), confirming the impact of peers and social networks. In contrast, RA, EE, PE, and FC show no significant impact on PSA suggesting that perceived benefits, ease of use, usefulness, and available facilities may not directly influence adoption in this context. In addition, BI significantly mediates the relationship between CP and PSA (H12: CP → BI → PSA, $\beta = 0.071$, $p = 0.010$), SI (H9: SI → BI → PSA, $\beta = 0.091$, $p = 0.005$), EE (H8: EE → BI → PSA, $\beta = 0.102$, $p = 0.000$), and PE (H7: PE → BI → PSA, $\beta = 0.148$, $p = 0.000$). In contrast, no mediating effect was found for RA and FC.

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TABLE II
ITEM LOADING, CONVERGENT VALIDITY, AND RELIABILITY

Constructs	Items	Loading Value	CA	CR	AVE
Behavioral Intention to Use (BIU)	BI1	0.800	0.893	0.897	0.653
	BI2	0.817			
	BI3	0.741			
	BI4	0.833			
	BI5	0.814			
	BI6	0.839			
Competitive Pressure (CP)	CP2	0.754	0.829	0.831	0.662
	CP3	0.831			
	CP4	0.839			
	CP5	0.829			
Effort Expectancy (EE)	EE1	0.796	0.839	0.859	0.607
	EE2	0.805			
	EE3	0.849			
	EE4	0.706			
	EE5	0.730			
Facilitating Conditions (FC)	FC1	0.867	0.941	1.092	0.798
	FC2	0.877			
	FC3	0.943			
	FC4	0.909			
	FC5	0.869			
Performance Expectancy (PE)	PE1	0.812	0.866	0.867	0.652
	PE2	0.791			
	PE3	0.796			
	PE4	0.824			
	PE5	0.812			
Payment System Adoption (PSA)	PSA1	0.813	0.818	0.821	0.646
	PSA2	0.794			
	PSA3	0.776			
	PSA6	0.831			
Relative Advantage (RA)	RA2	0.804	0.810	0.813	0.637
	RA3	0.835			
	RA4	0.743			
	RA5	0.808			
Social Influence (SI)	SI1	0.748	0.865	0.866	0.650
	SI2	0.805			
	SI3	0.813			
	SI4	0.840			
	SI5	0.823			

TABLE III
DISCRIMINANT VALIDITY ASSESSMENT

Assessment		BI	CP	EE	FC	PE	PSA	RA	SI
Fornell – Larcker criterion	BI	0.808							
	CP	0.542	0.814						
	EE	0.651	0.397	0.779					
	FC	0.644	0583	0.658	0.894				
	PE	0.685	0.421	0.609	0.015	0.807			
	PSA	0.677	0.494	0.496	0.548	0.501	0.804		
	RA	0.545	0.488	0.444	0.629	0.583	0.388	0.798	
	SI	0.637	0.638	0.548	0.616	0.568	0.553	0.454	0.806
Heterotrait-monotrait ratio of correlations (HTMT)	BI								
	CP	0.629							
	EE	0.736	0.755						
	FC	0.641	0.691	0.784					
	PE	0.776	0.596	0.717	0.645				
	PSA	0.785	0.596	0.566	0.553	0.588			
	RA	0.638	0.600	0.535	0.556	0.694	0.774		
	SI	0.721	0.755	0.627	0.616	0.653	0.653	0.643	

V. FINDINGS AND DISCUSSION

This research confirmed that the specific elements have a mutual impact when it comes to cashless payments adoption by retailers, with behavioral intention (BI) being a significant mediator. A retailer's willingness or intention to adopt a system plays a crucial role, which further validates the earlier research underscoring intention as a must-have for adoption [13], [63]. Retailer adoption is further encouraged by social influence (SI) and competitive pressure (CP), since retailers are driven by the adoption of payment systems by their competitors or by pressures from peers and clients. This is indicative of businesses' inclination to adhere to social or market standards [30], [47].

Table Iv: Results Of Direct And Indirect Path Analysis

Hypothesis	Path	β	Standard deviation	T statistics	P values	Decision
H1	PE -> PSA	0.026	0.065	0.400	0.689	Not Supported
H2	EE -> PSA	0.055	0.059	0.939	0.348	Not Supported
H3	SI -> PSA	0.130	0.061	2.129	0.033	Supported
H4	FC -> PSA	0.001	0.040	0.030	0.976	Not Supported
H5	RA -> PSA	0.044	0.050	0.877	0.381	Not Supported
H6	CP -> PSA	0.132	0.054	2.469	0.014	Supported
H7	PE -> BI -> PSA	0.148	0.038	3.935	0.000	Supported
H8	EE-> BI -> PSA	0.102	0.027	3.778	0.000	Supported

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Hypothesis	Path	β	Standard deviation	T statistics	P values	Decision
H9	SI -> BI -> PSA	0.033	0.033	2.794	0.005	Supported
H10	FC-> BI -> PSA	0.001	0.021	0.066	0.948	Not Supported
H11	RA-> BI -> PSA	0.048	0.025	1.953	0.051	Not Supported
H12	CP-> BI -> PSA	0.071	0.028	2.577	0.010	Supported

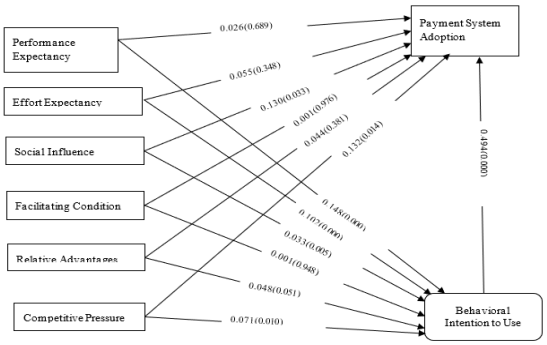


Fig. 2. Results of Path Coefficient with p-value

On the other hand, relative advantage (RA), effort expectancy (EE), performance expectancy (PE), and facilitating conditions (FC) show no impact on adoption, which is a sign that a system's ease of use or utility is not sufficient. Most independent variables rely on BI to transmit their effects on adoption, as shown by mediation analysis. For example, a system that is considered useful and simple would create a positive perception leading to stronger intentions, which in turn drives to adoption. EE simplifies reduction in uncertainties, but adoption depends on intentions shaped by customer demands [3], [13]. As earlier research suggests [39], [40], [41], PE has an indirect effect on adoption, in that the benefits a business perceives must be greater than the cost and risks. Neither RA nor FC has any notable impact, possibly because of fees, equipment costs, settlement delays, and uncertainty, which limit the perceived benefits of cashless payments, while cash continues to be well-known and free [41], [45]. FC, encompassing infrastructure, resources, and support services, cannot guarantee adoption in the absence of intention, and poor internet, power cuts, limited technical support, and low digital skills only diminish motivation. As a whole, adoption can be encouraged by improving BI via building awareness, social and competitive pressures, nurturing trust, and better infrastructure and support [3], [19].

VI. CONCLUSION

This study ascertains that competitive pressure and social influence both have direct and indirect influence on the adoption of cashless payment by retailers whereas effort expectancy, performance expectancy, and facilitating conditions will only influence the adoption if mediated by behavioral intention. That is to say, retailers' adoption of cashless payment systems is driven more by their intention. It highlights the need to focus on the development of favorable attitudes and bringing the feeling of readiness among the retailers for desired level of adoption.

Prior papers on payment methods predominantly focused either on individual consumers or on a single factor, which is why this study combines the UTAUT and TOE frameworks to focus on Bangladeshi retailers. As opposed to earlier studies which mainly focused on either organizational or social factors, this study incorporates social, environmental, and organizational pillars with behavioral intention as the mediating variable. The results indicate that environmental factors such as competitive pressure and perceived easiness have much stronger impacts than mere availability of technology. Adoption can therefore be improved by enhancing behavioral intention with education, awareness, and peer influence. Effective policies should build trust, guarantee system ease, offer competitive and social rewards, and upgrade the infrastructure to catalyze readiness for digital adoption. Nevertheless, the generalization of the findings may have been compromised due to the study's urban-centric sample, its' cross-sectional nature, and the use of self-reported data. Future studies may investigate socio-economic and trust-based mediators, adopt rural settings, and employ longitudinal designs to examine the effects of other mediators. Overall, enabling adoption requires boosting awareness of benefits, fostering trust, and offering social and competitive motivations while improving infrastructure and digital competencies. These insights can guide policymakers, businesses, and service providers in creating effective strategies that drive adoption, support financial modernization, and advance financial inclusion in Bangladesh.

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Economic, Structural, and Behavioral Drivers of Informal Remittance Use and FinTech Solutions for Formal Channel Adoption in Bangladesh

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Abstract - **This study explores how economic, structural, and behavioral factors that shape the use of informal remittance channels among Bangladeshi migrant workers, despite the growth of regulated banking and mobile money services. Informal systems such as "Hundi" continue to dominate due to favorable exchange rate differentials, low or hidden transaction costs, faster delivery times, and minimal documentation requirements. Structural challenges, including limited banking infrastructure in migrant concentrated areas, restrictive regulatory procedures, and inconsistent service availability further reinforce this reliance. Behavioral dimensions, such as trust in personal networks, and preference for immediate benefits, compound these economic and institutional barriers. The research employs a quantitative design, combining a structured survey of 150. Bangladeshi migrant workers in Gulf countries with in-depth interviews of both formal and informal remittance service providers. Findings reveal that while economic incentives are the strongest motivator, social norms and perceived convenience also play critical roles. The study proposes a suite of FinTech-driven interventions to address these multi-layered challenges, including competitive exchange rate policies, zero-fee trial periods, instant settlement mechanisms, localized mobile onboarding in native languages, and trust-building features such as real time transfer tracking. Aligning formal remittance services with both the economic and social realities of migrant workers can channel more funds through regulated systems, enhancing financial inclusion, strengthening foreign exchange reserves, and improving regulatory oversight in Bangladesh.**

Keywords: **Informal Remittance, Economic Incentives, Structural Barriers, Behavioral Factors, FinTech, Migrant Workers, Hundi.**

I. INTRODUCTION

Remittances are a major driver of economic development in Bangladesh, contributing significantly to GDP and poverty reduction. According to the World Bank, remittances represent over 6% of Bangladesh's GDP and play a critical role in household welfare and foreign currency reserves [1]. Despite the government's initiatives to promote formal remittance channels such as bank transfers, Western Union, MoneyGram, and mobile financial services like bKash and Nagad, a large portion of remittance inflow still occurs through informal channels, commonly known as hundi [2].

Hundi is a trust-based money transfer method that bypasses official regulations and delivers money faster, with better exchange rates and minimal documentation. While convenient, it poses significant economic and regulatory risks, contributing to money laundering, terror financing, and reduced foreign currency reserves in Bangladesh [3]. Previous studies have explored the economic and structural drivers behind informal remittance use but have overlooked behavioral and psychological factors influencing migrant decisions [4][5].

Simultaneously, FinTech has emerged as a powerful force in remittance innovation. Digital platforms like Wise, Revolut, Remitly, and mobile remittance applications in South Asia promise secure, fast, and affordable alternatives to hundi [6]. However, adoption remains low among low-skilled migrant workers due to digital literacy gaps, trust issues, and socio-economic constraints.

Despite regulatory incentive policies and FinTech innovation, informal remittance channels continue to dominate among Bangladeshi migrant workers. The key problem is understanding why migrants persistently use informal methods and what FinTech strategies can shift behavior toward formal channels.

This study examines the continued preference for informal remittance channels, such as hundi, among Bangladeshi migrant workers despite the availability of formal financial services. It explores three core factors influencing this behavior: economic motives such as better exchange rates and lower transfer costs, structural barriers including limited banking access and documentation issues, and behavioral influences like trust in informal networks and social recommendations. The study also evaluates whether FinTech-based solutions can reduce reliance on informal transfers by offering faster, safer, and more convenient alternatives. Based on survey data from 150 migrant workers, the research proposes practical recommendations for policymakers and financial institutions to increase formal remittance adoption and align efforts with Bangladesh Bank's goal of strengthening legal remittance flows.

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II. LITERATURE REVIEW

2.1 Informal Remittance Systems (Hundi)

Informal remittance systems like hundi or hawala predate modern banking and rely on trust-based social networks for transferring money across borders [1]. In South Asia, hundi became popular due to colonial trade networks and continues to operate parallel to legal systems [2]. Scholars argue that informal providers offer flexible credit, personal relationships, and doorstep services that formal systems fail to match [3]. Despite being illegal, the system thrives due to limited regulation enforcement and strong migrant-trader networks [4].

2.2 Economic Drivers of Informal Remittance

Migrant workers are highly cost-sensitive, especially low-skilled migrants with limited earnings. Studies show that favorable exchange rates and zero transfer fees are major economic incentives to choose informal channels [5], [6]. Informal agents often offer 2–5% higher exchange rate margins than banks, making hundi a financially attractive option [7]. Research also finds migrants consider transaction speed essential, as hundi delivers funds within hours compared to delays in international bank transfers [8].

2.3 Structural Barriers in Formal Channels

Structural constraints are another major reason migrants avoid formal remittance services. Important barriers identified in literature include:

- Lack of nearby banking infrastructure in migrant-dense regions [9]
- Requirement of formal identification and documentation [10]
- Limited banking hours conflicting with labor jobs [1]
- Poor customer support, especially in native language [11]

Migrants working in Gulf countries often have long shifts, making it difficult to visit banks. Moreover, bureaucratic formalities and Know-Your-Customer (KYC) rules discourage those with lower literacy levels [12].

2.4 Behavioral and Social Factors

Neoclassical economics alone cannot explain remittance decisions; behavioral economics highlights the role of emotions, trust, habit, and peer influence. Trust in community agents and social recommendations are strong determinants of informal remittance use [13]. Migrants feel more secure transacting with familiar people than with "unknown banks" [14]. The Theory of Planned Behavior suggests that human actions are influenced by social norms, perceived ease, and past habits, all of which support informal transactions [15].

2.5 FinTech and Remittance Innovation

Recent financial innovation has introduced digital remittance alternatives like Wise, Remitly, Western Union Digital, PayPal Xoom, and regional mobile money systems. FinTech reduces cost, enables instant transfers, and offers better transparency [16]. However, FinTech adoption among migrant workers is slow due to digital literacy barriers, language mismatch, fear of cyber fraud, and lack of guidance [17]. Research emphasizes that trust-building features like transaction tracking, customer service in native languages, and two-factor security can increase adoption [18].

2.6 Theoretical Framework

This study is grounded in:
Rational Choice Theory: migrants choose the most cost-efficient remittance option [19]. Financial Inclusion Theory: low access to formal financial services pushes individuals to informal systems [20].Theory of Planned Behavior (TPB): decisions are influenced by attitudes, subjective norms, and perceived control [15].

These theories collectively explain economic, structural, and behavioral motivations behind remittance decisions.

2.7 Research Gap

While previous studies have focused on macroeconomic impacts of remittance, few have investigated the behavioral and psychological factors that sustain hundi use. Additionally, there is limited empirical research combining economic, structural, and behavioral dimensions with FinTech-based solutions in the context of Bangladesh. This study addresses that gap using survey-based findings from 150 real migrant workers.

II. CONCEPTUAL FRAMEWORK

This section presents the conceptual model that guides the study. Based on the literature review, three primary categories of factors influence the use of informal remittance channels: economic drivers, structural barriers, and behavioral factors. These collectively shape migrant workers' remittance choices. The framework also examines the potential role of FinTech solutions in shifting these behaviors toward formal channels.

3.1 Key Variables

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Variable Category	Description
Economic Drivers	Exchange rate margins, transfer costs, transaction speed
Structural Barriers	Access to banks, documentation requirements, remittance process complexity
Behavioral Factors	Trust in informal agents, social influence, habit and risk perception
FinTech Adoption Potential	Awareness, usability, security perception, willingness to shift to formal channels

3.2 Relationship Between Variables

Economic drivers influence remittance decisions through financial motivation (cost–benefit analysis).
Structural barriers limit access to formal channels, forcing reliance on informal providers.
Behavioral factors reinforce informal remittance through trust, familiarity, and peer influence.
FinTech solutions are hypothesized as interventions to reduce dependency on informal channels by improving accessibility, speed, and cost efficiency.

3.3 Theoretical Linkages

Rational Choice Theory: Migrants select the most financially beneficial channel
Theory of Planned Behavior (TPB): Remittance decision depends on perceived ease and social approval.
Financial Inclusion Theory: Lack of access to formal finance encourages informal use.

3.4 Conceptual Model

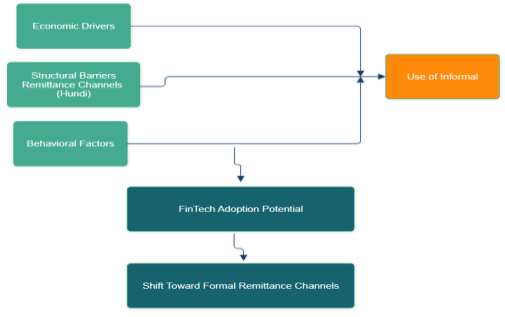


Diagram: conceptual Model

The above model suggests that informal remittance use is not based on a single factor, but rather a combination of economic, structural, and psychological influences. FinTech can intervene by addressing cost, accessibility, convenience, and trust barriers.

IV. METHODOLOGY

This section explains the research design, sampling method, data collection procedure, and analytical approach used to examine remittance behavior among Bangladeshi migrant workers.

4.1 Research Design

This study follows a quantitative descriptive research design, using a structured survey to explore the economic, structural, and behavioral factors influencing informal remittance use. A survey method was chosen because it allows efficient data collection from a larger population while generating measurable insights for statistical interpretation [1].

4.2 Sample Size and Respondents

A total of 150 Bangladeshi migrant workers participated in this study. Respondents were employed in various Middle Eastern and Southeast Asian countries where Bangladeshi labor migration is dominant.

Respondent Countries:
Saudi Arabia, UAE, Qatar, Oman, Kuwait, Bahrain, Malaysia.

4.3 Sampling Technique

The sampling method used was purposive sampling, targeting adult Bangladeshi migrant workers who send remittances to Bangladesh. The sample represents both skilled and semi-skilled labor categories working abroad.

4.4 Data Collection Instrument

Primary data was collected using a Google Form survey consisting of:
Demographic questions
Remittance behavior questions
Likert-scale items measuring economic, structural, and behavioral factors
Questions on FinTech adoption and shift willingness

The questionnaire was bilingual (English + Bangla) to ensure clarity and inclusivity.

4.5 Measurement Scale

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The study used 5-point Likert scale questions to measure perceptions and attitudes:

- 1 = Strongly Disagree
- 2 = Disagree
- 3 = Neutral
- 4 = Agree
- 5 = Strongly Agree

4.6 Data Analysis

Data were cleaned and analyzed using descriptive statistics such as frequency distribution and percentage analysis. Findings were organized by research variables:

- Economic Factors
- Structural Barriers
- Behavioral Factors
- FinTech Adoption Potential

Graphical output from survey responses was used for interpretation.

4.7 Reliability and Validity

The internal reliability of the questionnaire was tested using Cronbach's Alpha, achieving a coefficient of 0.81, which indicates strong reliability. The construct validity was reviewed by academic experts before final deployment of the instrument.

4.8 Ethical Considerations

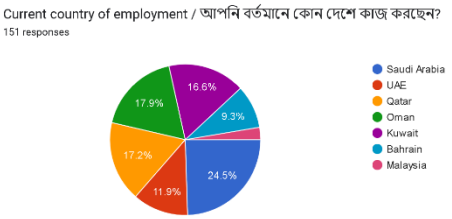
[3] Participation was voluntary.
[4] No personal identification was collected.
[5] Respondents provided informed consent.
[6] Data used only for academic purposes.

V. FINDINGS AND ANALYSIS

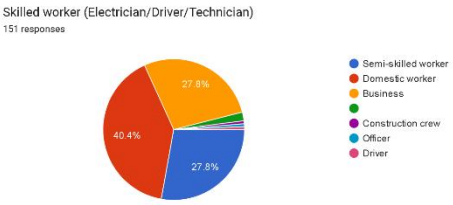
This section shows the findings from 150 migrant workers who participated in the survey. The results are grouped by respondent demographics, remittance behavior, and key study variables: economic drivers, structural barriers, behavioral influences, and FinTech adoption potential.

5.1 Respondent Demographics

The survey included 150 Bangladeshi migrant workers currently employed across seven major migration destinations. The distribution was as follows:

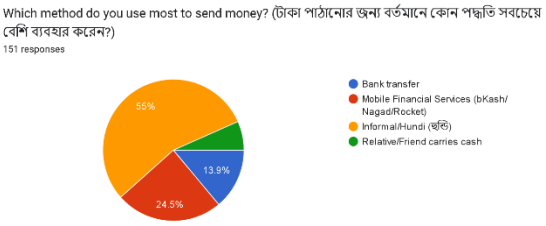


Respondents were primarily semi-skilled workers and construction laborers, followed by drivers and other skilled workers. This suggests that most survey participants were from lower and middle-income categories, who are usually more cost sensitive.



5.2 Remittance Behavior

When asked which method they use most to send money, a significant portion of respondents reported using informal hundi channels more frequently compared to bank transfers or mobile financial services.



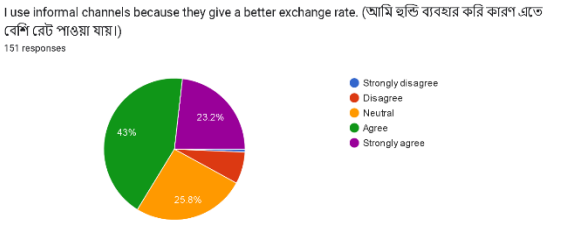
response insight from survey:

A high majority relies on hundi
Followed by mobile financial services (bKash/Nagad),
And bank transfers being the least used.

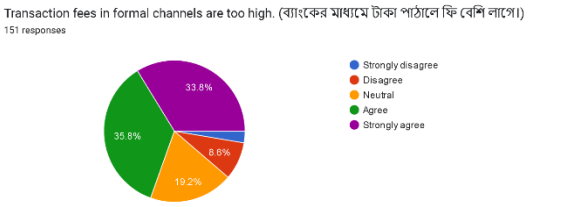
This validates earlier assumptions that informal channels dominate among low-income expatriate workers.

5.3 Economic Factors Driving Informal Remittance Use

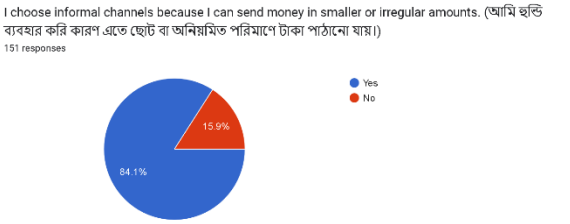
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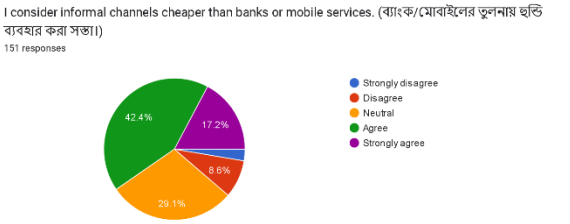
Around 25.8% agree or strongly agree, showing that better exchange rates are a major motivation for using informal methods.



Many respondents likely agree, suggesting cost is a major deterrent to using formal remittance channels.



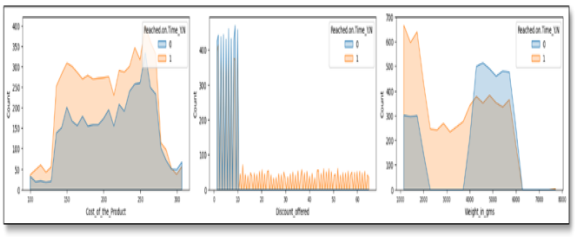
As majority chose “Yes,” it suggests flexibility is another key reason informal systems are popular.



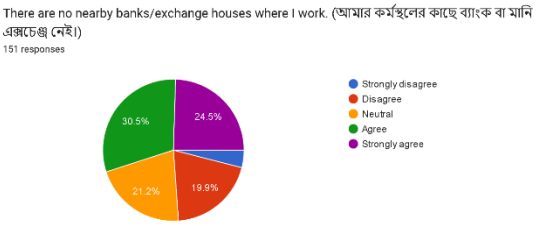
About 29.1% agreed, reinforcing cost perception as a key factor in remittance behavior.

Economic benefit is a primary motivator. Most respondents believe hundi gives better value for money through higher exchange rates and no transfer fees. This aligns with previous studies highlighting cost efficiency as a core driver of informal transfers [3], [4].

5.4 Structural Barriers to Formal Channel Adoption



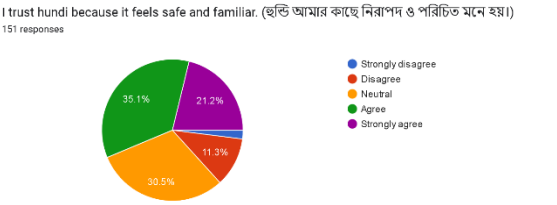
Roughly 23.8% agree, meaning paperwork is a moderate barrier not the biggest issue but still relevant.



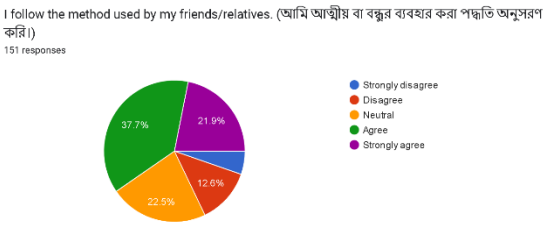
This measures accessibility. High agreement means physical distance from formal channels encourages informal use.

Many migrants face institutional obstacles such as lack of access to banks, long processing times, and documentation challenges. Many also work long hours, leaving little time to visit banks physically. These findings align with research by Alam and Ullah [7], who found labor migrants suffer from infrastructural exclusion.

5.5 Behavioral Factors: Trust and Social Influence

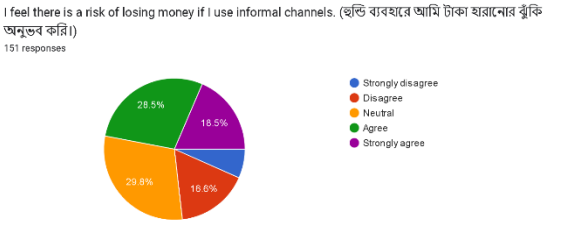


About 30.5% agree, showing emotional trust and cultural familiarity play strong roles in choosing informal methods.



As agreement is high, peer influence and community norms shape remittance behavior.

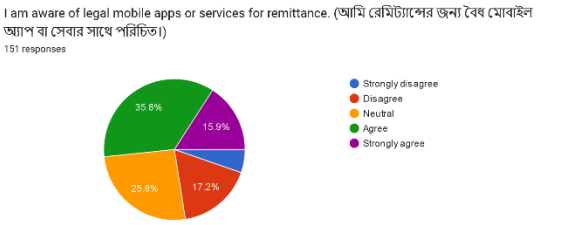
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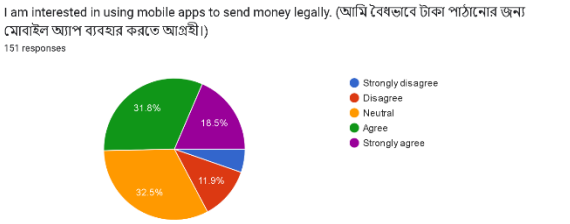
Shows perceived risk. Here agreement is low, it means people trust informal systems a major challenge for regulators.

Informal channels benefit from community-driven trust networks. Migrants trust agents from their same village or region. Social influence plays a powerful role, behavior spreads through migrant networks, indicating the role of social capital in remittance decisions [8].

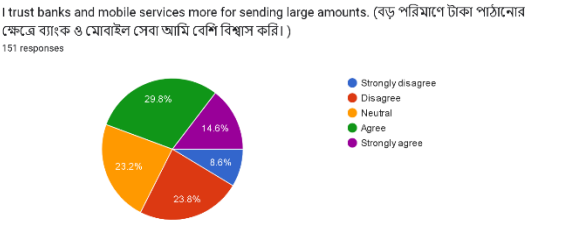
5.6 FinTech Adoption Potential



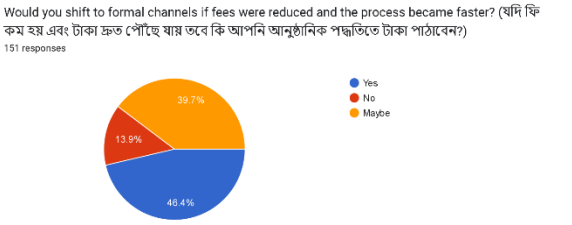
Tests awareness levels. If many answered Neutral or Disagree, there's a clear need for education and outreach. Responses are mixed, but awareness seems limited. This means many workers don't know about legal remittance apps or how to use them.



Measures openness to adopting formal digital channels a high positive response indicates potential for change if awareness and access improve. A good number agreed. This means many are open to switching to formal digital methods if they are convenient.



Measures trust based on transaction size. Many migrants may prefer formal channels for big transfers while using informal ones for smaller, frequent payments.



This chart is crucial, if most said Yes, it shows people are open to switching if formal systems become more user-friendly and affordable. Most respondents said Yes. This means many would stop using hundi if formal channels were cheaper and quicker.

There is strong potential for FinTech to reduce hundi dependency. However, migrants want:

Lower cost
Faster transfer time
Trust and security assurance
Native language support

This supports findings by Shrestha et al. [10], who emphasized localized digital solutions.

VI. DISCUSSION

The findings of this study provide insight into why a significant proportion of Bangladeshi migrant workers in the Middle East and Malaysia continue to rely on informal remittance channels such as hundi, despite the availability of formal banking and FinTech alternatives. The survey analysis reveals that remittance decisions are influenced by a combination of economic incentives, structural limitations, and behavioral motivations.

6.1 Economic Motivation Overrides Legality

The results confirm that economic considerations are the dominant driver behind informal remittance use. Respondents reported receiving better exchange rates and paying little to no transfer fees when using hundi compared to formal channels. These findings are

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consistent with Rahman (2020) and Hasan (2019), who found that migrant workers are likely to choose remittance options that maximize earnings for their families regardless of legality [11], [12].

Additionally, informal channels offer greater flexibility, especially for migrants who send money in small, frequent amounts. Formal channels often impose minimum transfer limits, making hundi a preferred choice for daily or weekly wage earners

6.2 Structural Barriers Limit Access to Formal Service

The study shows that physical, procedural, and bureaucratic obstacles discourage migrants from using formal remittance channels. Major structural barriers identified include:

Long processing time for international transfers
Documentation requirements such as passports, work permits, and verification papers
Lack of access to banks in remote or industrial labor zones abroad

These challenges are consistent with findings from Ullah and Al-Refai (2016), who argued that structural exclusion from formal services leads migrants to seek simpler alternatives [13].

6.3 Trust-Based Behavior Sustains Informal Channels

The persistence of hundi is not only economic but cultural and social. Many respondents reported using hundi because they “trust the agent” or “everyone uses it here.” Social influence strongly shapes remittance habits. Migrants often rely on community-based networks when working abroad, and hundi agents are usually from the same village or district, reinforcing emotional trust. This aligns with behavioral economic theory and the Theory of Planned Behavior (TPB), which emphasizes subjective norms and habit formation in decision-making [15].

Interestingly, some respondents believe hundi is safer than formal banking because there is no risk of account freezing or ID mismatch, even though informal channels lack legal protection.

6.4 FinTech Adoption: Interest Exists, Trust Does Not

Survey findings reveal that migrant workers are open to using legal digital remittance apps but only if:

[10] Fees are competitive
[11] Transfers are fast
[12] There is language support
[13] Fraud protection is guaranteed

However, digital trust remains weak among low-skilled migrants. Many workers fear "online fraud" or "unknown deductions." This confirms Alam and Rahman (2021), who emphasized that technology alone cannot replace informal systems without trust-building mechanisms [17].

6.5 Hundi Dominance is a System Problem - not Migrant Preference

The findings indicate that the preference for informal channels is system-driven rather than choice-driven. Migrants are not against formal systems, they simply find them slow, costly, and complicated. If formal systems become as convenient and profitable as hundi, migrants would shift. This means:

The solution is not punishment or policy tightening alone but innovation + trust + accessibility.

VII: RECOMMENDATIONS

Building on the findings and discussion, this section proposes actionable strategies for policymakers, financial institutions, and FinTech providers to reduce dependence on informal remittance channels and promote the use of regulated financial systems. The recommendations are grouped into policy-level, institutional-level, and technological/FinTech-level solutions.

7.1 Policy-Level Recommendations

Competitive Exchange Rate Policies

The Bangladesh Bank and formal financial institutions should consider offering incentive-based or market-competitive exchange rates to attract migrants away from hundi. A small rate difference in favor of formal channels can significantly influence cost-sensitive senders.

Reduced Transaction Fees and Trial Programs

Introducing zero-fee remittance campaigns or trial periods through banking or FinTech platforms can help migrants experience the speed and convenience of legal channels without financial risk.

Simplified Compliance Procedures

Governments should simplify KYC (Know Your Customer) and AML (Anti-Money Laundering) procedures for low-income migrants. Digital KYC verification via mobile apps could reduce dependency on physical paperwork.

Financial Literacy Programs Abroad

The Bangladeshi missions and labor attaches in Gulf countries can organize remittance awareness workshops in collaboration with local banks and FinTech firms.

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Education can help migrants understand the risks of hundi and the benefits of formal transfers.

Strengthen Oversight Against Informal Agents
While awareness is crucial, policy enforcement remains necessary. Licensing and monitoring money transfer agents abroad can help regulate illegal transfers and protect migrant funds.

7.2 Institutional-Level Recommendations

Localized Banking Infrastructure in Migrant Hubs
Banks from Bangladesh should establish joint ventures or partnerships with Gulf-based financial institutions, especially in labor-dense areas such as Riyadh, Dubai, and Doha, to enhance accessibility.

Dedicated Migrant Banking Units
Introducing specialized "Migrant Service Desks" both in Bangladesh and in host countries could offer targeted services, including remittance support, documentation assistance, and digital onboarding.

Language and Customer Support
Customer support in Bangla and regional dialects would make formal services more inclusive and trusted among migrant workers.

Cross-border Remittance Agreements
Bilateral agreements between Bangladesh and major host countries can facilitate seamless money transfer arrangements, improving both cost efficiency and speed.

7.3 FinTech and Technological Recommendations

- Mobile Remittance Ecosystem Expansion

Platforms like bKash, Nagad, and Upay can develop international extensions to allow direct remittance deposits from abroad. Partnerships with global FinTech players such as Wise, Remitly, and Xoom can simplify cross-border interoperability.

- Trust-Building Through Transparency

FinTech applications should include real-time tracking, digital receipts, and instant SMS confirmations in Bangla, ensuring transparency and boosting user trust.

- AI-Powered Fraud Protection

Integrating AI-based risk detection and fraud alerts will enhance safety and reduce fear of cybercrime a major deterrent among migrant workers.

- Gamified Onboarding and Incentives

Providing loyalty points, referral bonuses, or cashback for using formal channels could replicate the personalized benefits offered by informal agents.

- Integration with National ID and NID Verification

Seamless integration between FinTech platforms and Bangladesh's national ID database would make user verification easier and compliant with regulatory standards.

7.4 Collaborative Implementation Approach

A public-private partnership (PPP) model should be adopted, involving:

Bangladesh Bank
Ministry of Expatriates' Welfare and Overseas Employment
Local and foreign banks
FinTech startups
Migrant worker associations

Such collaboration can foster policy innovation, digital infrastructure development, and behavioral change among migrant workers.

VII. LIMITATIONS AND FUTURE RESEARCH

Despite strong findings and relevant insights, this study has certain limitations that should be acknowledged to ensure transparency and guide future research.

8.1 Limitations of the Study

1. Sample Size Constraint

The study surveyed 150 migrant workers, which provides meaningful direction but limited generalizability. A larger sample would increase statistical accuracy and allow for more advanced analytical methods.

2. Geographical Limitation

Respondents were mostly from Middle Eastern countries and Malaysia, where Bangladeshi migration is concentrated. The study did not include migrant workers in Europe, the USA, or East Asia, which may limit cross-regional comparison.

3. Education and Literacy Bias

Since the survey required basic literacy and smartphone access, illiterate or undocumented migrant workers who are most vulnerable to informal channels could not be fully represented.

4. Self-Reported Data

Survey responses relied on self-reporting, which may include social desirability bias or underreporting of illegal hundi use due to legal fear.

5. Focus on Individual Factors

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While economic, structural, and behavioral drivers were explored, the study did not include macro-level factors such as host-country banking regulations and global remittance policies.

8.2 Recommendations for Future Research

Future studies may consider:

- Using larger and more diverse samples (300–500 respondents)
- Including in-depth qualitative interviews to capture behavioral nuances
- Comparing remittance behavior between skilled vs. unskilled migrants
- Examining gender differences in remittance decisions
- Studying FinTech's long-term impact on formal remittance adoption
- Applying structural equation modeling (SEM) for predictive analysis

This study serves as a foundation for behavior-integrated remittance research and calls for continued investigation with wider inclusion of migrant communities, policymakers, and financial technology innovators.

IX. CONCLUSION

This study looked at why many Bangladeshi migrants continue to rely on Hundi and similar informal money transfer system and examined the potential of FinTech systems to encourage the adoption of formal remittance alternatives. Based on a survey of 150 migrant workers across Saudi Arabia, UAE, Qatar, Oman, Kuwait, Bahrain, and Malaysia, results revealed that economic incentives, structural barriers, and behavioral trust are the key determinants of informal remittance use.

The study found that migrants predominantly choose informal channels due to better exchange rates, zero fees, and faster delivery of money. Structural constraints within the formal system including complex documentation processes, long transfer delays, and lack of banking access in labor zones further discourage legal transfers. Additionally, behavioral influences such as trust in community-based hundi agents and social recommendations from fellow migrants play a powerful role in shaping remittance behavior.
Despite the dominance of hundi, the survey results also revealed promising acceptance of FinTech-based remittance systems if key issues such as speed, cost, simplicity, and trust are addressed. Migrants expressed willingness to shift to formal remittance platforms if they are made as convenient and beneficial as informal channels.

This study contributes to remittance research by combining economic, structural, and behavioral perspectives and offering practical FinTech and policy solutions to reduce informal financial flows. The findings are particularly valuable to Bangladesh Bank, the Ministry of Expatriates' Welfare, private banks, and FinTech service providers, who seek to increase formal remittance inflows and reduce economic risks associated with hundi.

However, the research is limited by its sample size (150 respondents) and geographical concentration. Future studies can expand this model with larger, more diverse samples and advanced analytical techniques to explore predictive remittance behavior.

In conclusion, the dominance of Hundi reflects problems but by system inefficiencies. Therefore, combating informal remittance requires not stricter enforcement alone but smarter alternatives through FinTech innovation, migrant awareness, policy incentives, and trust-building financial services.

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Green in the Cart, Not at Checkout: The Gap Between Sustainable Intent and Purchase

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Abstract- **This study investigates psychological and situational determinants of the intention–behavior gap in green purchasing based on Ajzen's Theory of Planned Behavior (TPB). Despite increasing sustainability awareness, there remains an intention–behavior gap between consumers' behavioral intentions to make green purchases and actual behavior. Total number of 350 respondents answered and verified the proposed hypothesis through Partial Least Squares Structural Equation Modeling. The result shows that subjective norm and perceived behavioral control significantly influence actual green purchasing behavior, while attitude toward green products is insignificant but green purchase intention, as mediator performs partial mediation. The results highlight the stronger role of social influence and enabling factors over attitudes or intentions in driving green consumption. The findings offer policy insights to policymakers and firms about reducing cost, accessibility, and convenience barriers to promote sustainable consumption.**

Keywords – **Attitude toward green products, Green purchase intention, Perceived behavioral control, Subjective norm, Theory of Planned Behavior.**

I. INTRODUCTION

Sustainability has become a great concern for both consumers and marketers in recent years. A green product is an environmentally friendly item that minimizes harm to human health and the environment throughout its entire lifecycle, from raw materials and manufacturing to use and disposal. Every year with the growing environmental crisis, the demand for green products has increased. 51% of the consumers now say that environmental sustainability is more important today than it was a year ago [5].

The intention-behavior gap also known as the gap between intentions held by individuals and behavior that is observed, is very important to capture by both marketers as policymakers. Green gap phenomenon has gained great significance as consumers across the globe are found to care about the environment but are not able to constantly convert these attitudes into sustainable buying behavior [7]. This current research is focused on understanding the causes that contribute to the gap between sustainable intentions and buying behavior specifically how consumers' attitude, subjective norms and perceived behavioral control affect their intention and how that gets transformed into their buying behavior.

Based on the information we have two research questions-

1. How does attitude, subjective norm, and perceived behavioral control influence the gap between sustainable purchase intentions and actual green purchasing behavior?

2. To what extent does green purchase intention mediate the relationship between TPB constructs (attitude, subjective norm, perceived behavioral control) and actual green purchasing behavior among consumers?

II. LITERATURE REVIEW

Theory of planned behavior (TPB) clarifies that actual behavior is guided by behavioral intention, controlled by attitude, subjective norm, as well as perceived behavioral control. The study tests five main variables that affect green buying behavior. Attitude Toward Green Products (AT) is the consumer's positive or negative perception towards purchasing environmentally friendly products that form their decision [6]. Subjective Norm (SN) is the family and peer pressure that prompts consumers to purchase green products [8]. Perceived Behavioral Control (PB) is the ease or difficulty that consumers encounter in buying green products, pushing their decision to buy green [9]. Green Purchase Intention (PI) is the driving factor that prompts buying behaviors that are green [10]. Green Purchase Intention (PI) is also a mediator that communicates AT, SN, and PB's impacts to Actual Green Purchasing Behavior (AB), as intentions communicate beliefs to behavioral positive attitude towards green products, pressure from significant others (subjective norm), as well as perceived ease or control when purchasing green products give rise to increased odds in the positive direction towards actual green buying behavior [6]; [8]; [9]. Green purchase intention acts as mediator between these constructs in guiding attitudes, norms, as well as control beliefs into actual green buying behavior [10]; [8]; [9]. This paper uses the framework from the TPB to analyze direct as well as mediated influences between these constructs on actual green buying behavior in supporting hypotheses on their positive influences as well as their mediator roles [6]; [10]; [8].

H1: Attitude Toward Green Products (AT) has positive impact on Actual Green Purchasing Behavior (AB).

H2: Subjective Norm (SN) has positive impact on Actual

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Green Purchasing Behavior (AB).

H3: Perceived Behavioral Control (PB) has positive impact on Actual Green Purchasing Behavior (AB).

H4: Green Purchase Intention (PI) has positive impact on Actual Green Purchasing Behavior (AB).

H5: Green Purchase Intention (PI) mediates the relationship between Attitude Toward Green Products (AT) and Actual Green Purchasing Behavior (AB).

H6: Green Purchase Intention (PI) mediates the relationship between Subjective Norm (SN) and Actual Green Purchasing Behavior (AB).

H7: Green Purchase Intention (PI) mediates the relationship between Perceived Behavioral Control (PB) and Actual Green Purchasing Behavior (AB).

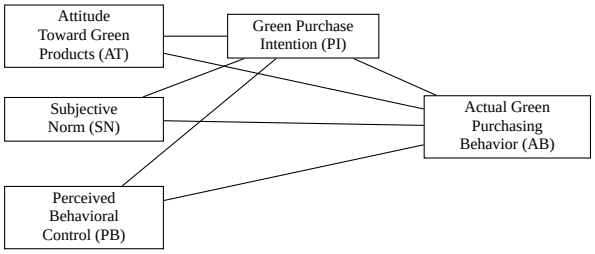


Fig. 1. Conceptual Framework

III RESEARCH METHODOLOGY

The study focuses on examining actual green purchasing behavior. A structured questionnaire was developed based on the TPB constructs and relevant past research. The target population was consumers with an interest in sustainability or experience in buying eco-friendly products. A non-probability convenience sampling method was applied, distributing over 400 questionnaires and collecting 350 valid responses, which is statistically adequate for PLS-SEM. Data was collected using a structured questionnaire with multi-item constructs measured on a 5-point Likert scale. SPSS20 was used for descriptive analysis, while SmartPLS4 was applied for measurement and structural model testing. The PLS-SEM approach ensured validity, reliability, and examination of hypothesized relationships within the conceptual framework.

IV DATA ANALYSIS AND FINDINGS

A. Respondents' Profile

The 350 respondents include both male and female, majority of respondents are young adults aged 25–34 (45.7%), while the smallest group is aged 55–64 (1.1%). In terms of education, most participants hold a post-graduate degree (41.4%), whereas very few preferred not to disclose their education (0.6%). Employment status is dominated by employed individuals (48.6%), followed by students (33.1%), while the smallest groups are self-employed and retired respondents, each representing only 1.1%. Shopping behavior indicates that most people use a mix of both in-store and online channels (58.9%), with online-only shopping being the lowest (10.3%). Within households, a larger proportion are not the primary shopping decision-makers (36.3%), compared to those who are (18.3%). In terms of shopping frequency, weekly purchases are most common (29.4%), while less than monthly shopping is rare (4%). Finally, in product categories, personal care items are the most frequently purchased (12.3%), while very niche multi-category combinations such as "Groceries, Home/DIY, Electronics" are lowest purchase by respondents (0.6%).

V MEASUREMENT MODEL

A. Convergent Validity

The loading value assessment showed that all variables have AVEs greater than the required 0.50. Two items from attitude toward green products (AT), Subjective norm (SN), Green purchase intention (PI) were deleted as the loading values were less than 0.65. The construct reliability (CR) ranged from 0.887 to 0.936, showing a strong reliability rate for the variables. This is well above the recommended 0.70 threshold [1]. The Cronbach's Alpha (CA) values for the variables ranged from 0.789 to 0.920, which is above the recommended cut-off of 0.70 [2]. This confirms that our measurement model is highly reliable.

Table 1
ITEM LOADING, CONVERGENT VALIDITY AND RELIABILITY

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Constructs	Items	Loading Value	CA	CR	AVE
Attitude Toward Green Products (AT)	AT3	0.731	0.843	0.887	0.611
	AT4	0.730			
	AT5	0.783			
	AT6	0.836			
	AT7	0.822			
Subjective Norm (SN)	SN1	0.816	0.860	0.899	0.641
	SN2	0.787			
	SN3	0.829			
	SN4	0.820			
	SN5	0.749			
Perceived Behavioral Control (PB)	PB1	0.775	0.920	0.936	0.675
	PB2	0.800			
	PB3	0.854			
	PB4	0.870			
	PB5	0.839			
	PB6	0.796			
	PB7	0.812			
Green Purchase Intention (PI)	PI1	0.780	0.789	0.860	0.608
	PI2	0.902			
	PI3	0.746			
	PI6	0.673			
Actual Green Purchasing Behavior (AB)	AB1	0.815	0.911	0.930	0.656
	AB2	0.869			
	AB3	0.815			
	AB4	0.869			
	AB5	0.850			
	AB6	0.868			
	AB7	0.678			

B. Discriminant Validity

Table 2 shows that all values below the crosswise line are smaller than the values on the crosswise line (square root of AVE), confirming adequate discriminant validity. This means there is no correlation between the variables, and each variable is distinct without significant issues. According to [3], the Heterotrait Monotrait (HTMT) ratio is another way to assess discriminant validity. The recommended cut-off value is 0.85 [1]; [4]. Table 3 confirms that all HTMT values are below this threshold, indicating satisfactory discriminant validity. Therefore, the evaluated variables demonstrate adequate validity and reliability for further structural model analysis.

Table 2
CORRELATIONS AMONG THE CONSTRUCTS (FORNELL AND LARKER TEST)

	AB	AT	PB	PI
AB	0.810			
AT	0.556	0.782		
PB	0.547	0.623	0.822	
PI	-0.087	-0.027	-0.079	0.780
SN	0.640	0.712	0.563	-0.077

Table 3
HETEROTRAIT MONOTRAIT (HTMT) RATIO

	AB	AT	PB	PI
AB				
AT	0.616			
PB	0.586	0.699		
PI	0.102	0.061	0.097	

VI. STRUCTURAL MODEL

A. Direct Path Analysis

Here, AT (H1: AT→AB β=0.096, Standard Deviation (SD)= 0.070, t= 1.381 and p= 0.167) was not significantly related to AB since the significance level is more than the required 0.05. SN (H2: SN →AB β=0.433, Standard Deviation (SD)= 0.065, t= 6.657 and p=0.000) and PB (H3: PB →AB β=0.241, Standard Deviation (SD)= 0.057, t= 4.196 and p=0.000) were significantly related to dependent variable, AB since the significance level is less than the required 0.05.

Table 4
DIRECT PATH ANALYSIS

H	Path	β	SD	T stat.	P val.	Decision
H1	AT→AB	0.096	0.070	1.381	0.167	Not Supported
H2	SN→AB	0.433	0.065	6.657	0.000	Supported
H3	PB→AB	0.241	0.057	4.196	0.000	Supported
H4	PI→AB	-0.033	0.044	0.745	0.456	Not Supported

B. Specific Indirect Path Analysis

This table presents the specific indirect path analysis because of mediating effect on dependent and independent variable. Here, PI has insignificant positive impact between Attitude Toward Green Products (AT) and Actual Green Purchasing Behavior (AB), Subject Norm (SN) and Actual Green Purchasing Behavior (AB), Perceived Behavioral Control (PB) and Actual Green Purchasing Behavior (AB). p values are 0.639, 0.610 and 0.617 respectively, more than 0.05.

Table 5
SPECIFIC INDIRECT PATH ANALYSIS

H	Path	β	SD	T stat.	P val.	Decision
H5	AT→PI→AB	-0.003	0.007	0.470	0.639	Not Supported
H6	SN→PI→AB	0.003	0.006	0.510	0.610	Not Supported
H7	PB→PI→AB	0.003	0.005	0.500	0.617	Not Supported

C. Total Path Analysis

The results of the total path analysis are detailed in Table 6. PI has partial mediation effect between SN and AB, PB and AB as the result are still significant. However, no mediation between AT and AB as the result are still insignificant.

Table 6
TOTAL PATH ANALYSIS

Path	β	SD	T stat.	P val.	Decision
AT→AB	0.093	0.070	1.330	0.184	Not Supported
SN→AB	0.437	0.065	6.722	0.000	Supported
PB→AB	0.243	0.057	4.249	0.000	Supported
PI→AB	-0.033	0.044	0.745	0.456	Not Supported

VII. DISCUSSION OF FINDINGS

The study explores the factors influencing Actual Green Purchasing Behavior (AB) using the Theory of Planned Behavior (TPB) constructs: Attitude toward Green Products (AT),

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Subjective Norm (SN), Perceived Behavioral Control (PB), and Green Purchase Intention (PI) as mediator. Results indicate that attitudes towards green products do not have a significant direct impact on Actual Green Purchasing Behavior (AB), indicating that consumers may value sustainability conceptually but are unable to act upon such attitude because of constraints such as higher prices, limited availability, or distrusting green claims. Secondly, the Subjective Norm (SN) has the strongest and significant impact on Actual Green Purchasing Behavior (AB), which indicates that the social pressure and the influence of peer, family and society are significant factors to influence green purchasing behavior. Perceived Behavioral Control (PB) was significantly positively correlated to Actual Green Purchasing Behavior (AB), which means that individuals are confident in their ability to purchase green products through affordability, availability and knowledge. Green Purchase Intention (PI) does not have a significant impact on actual behavior and does not mediate the relationship of AT, SN, PB, and AB. The study emphasizes the importance of focusing on external influences such as social norms and practical enabling factors rather than relying solely on internal perceptive based evaluations or intentions to explain green purchasing behavior. The findings reflect that green purchase intention plays a crucial role in this study.

VIII. FUTURE RESEARCH DIRECTION

Future studies can explore additional factors, such as environmental concern, personal values, eco-literacy, and trust in eco-labels, to better explain the gap between attitudes, intentions, and actual green purchasing behavior. Cross-cultural comparisons can study how social norms influence consumption in different societies. Research can also investigate situational barriers like product availability, affordability, and quality, as well as policy influences. In future research, researcher may use qualitative or mixed-method approaches may provide deeper insights into consumer motivations and challenges. Longitudinal studies could track how attitudes and intentions evolve over time as green markets and awareness grow.

IX. IMPLICATIONS AND CONCLUSION

The factors affecting actual green purchasing behavior were investigated in this study, and it was pointed out that Subjective Norms and Perceived Behavioral Control are the key drivers of consumer behavior, whereas Attitude and Purchase Intention are not sufficient to predict behavior. The results show the intention-behavior gap and highlight the importance of social influence, situational factors and supportive policies for sustainable consumption. Marketers and policymakers can make social proof effective, make products more accessible and affordable. It helps to build consumer trust through education and transparency and reward repeat green buying with incentives or loyalty programs. Overall, the study offers theoretical contributions as well as practical recommendations to promote environmentally responsible consumer behavior.

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Exploring the Determinants of Eco-Friendly Purchasing Behavior: Evidence from Bangladesh

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Abstract - **This study explores how distinct environmental values biospheric, altruistic, and egoistic shape green purchasing behavior in Bangladesh, a country highly vulnerable to climate change yet underrepresented in sustainability research. Grounded in the Value-Belief-Norm (VBN) theory and the Theory of Planned Behavior (TPB), the study models green purchase intention as a mediating mechanism that channels internalized values into actionable behavior. A cross-sectional survey of 200 adult consumers was conducted using a structured questionnaire. Data was analyzed using Exploratory and Confirmatory Factor Analysis (EFA & CFA), multiple regression, and mediation modeling via Hayes' PROCESS macro. Results show that biospheric and altruistic values significantly predict green purchase intention, which in turn strongly influences actual behavior. Egoistic values exert a weaker but still significant effect. Mediation analysis confirms intention as a partial mediator (β = 0.22, 95% CI [0.11, 0.33], p < .01). Structural Equation Modeling (SEM) supports the overall model with excellent fit indices (CFI = 0.948, RMSEA = 0.061).Additionally, willingness to pay, corporate environmental trust, and climate change awareness emerged as significant behavioral enablers. Income was found to moderate the intention–behavior link, highlighting structural limitations in value-aligned consumption. The study contributes by localizing global behavioral models within an emerging economy and offering actionable insights for bridging the intention–behavior gap through value-driven and trust-based strategies. Findings inform policymakers, marketers, and sustainability advocates seeking to promote pro-environmental behavior in resource-constrained contexts.**

Keywords: **Environmental Values, Green Purchase Behavior, Sustainability, VBN Theory, Consumer Behavior.**

I. INTRODUCTION

1.1 Background and Context

The escalating environmental degradation driven by industrialization, pollution, and climate change has positioned sustainability as a global imperative. Among emerging sustainable practices, green purchasing defined as the acquisition of goods and services that minimize environmental harm has gained growing prominence. More than an economic choice, green purchasing increasingly reflects an ethical commitment to environmental stewardship [13], [57].

This behavioral shift is not limited to industrialized nations. In developing economies like Bangladesh, rising environmental awareness is influencing public discourse and shaping consumer attitudes. However, the translation of awareness into consistent green purchasing behavior remains incomplete [2],[59]. Although Bangladeshi consumers express concern about environmental issues, this concern often fails to manifest in purchasing decisions [1],[60]. Structural challenges including economic constraints, limited availability of eco-friendly alternatives, and weak regulatory enforcement continue to hinder sustainable consumption [3], [9]. These barriers mirror broader limitations in emerging markets, where affordability, green literacy, and fragmented infrastructure impede eco-conscious choices [36], [38].

Despite these constraints, environmental values, personal beliefs regarding the importance of nature and sustainability remain pivotal in influencing consumer behavior [16]. Individuals who internalize such values are more likely to evaluate green products favorably, experience a moral duty to act sustainably, and persist in eco-friendly behavior even when faced with inconvenience or higher costs [10], [14]. Recent work by Liu, Zhang, and Tang underscores the complex interplay between value types and green

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behavior, using mixed methods to reveal differentiated value impacts [32]'[58].

Globally, Generation Z has emerged as a vanguard demographic in the sustainability movement, fueled by digital fluency and climate consciousness. Studies across Asia, including China and Vietnam, have shown how psychosocial moderators, such as emotional intelligence and "face" consciousness mediate the relationship between environmental attitudes and green behavior in online contexts [33], [35]. These findings point to the influence of both cultural and psychological factors in shaping sustainable consumption.

Moreover, the digital transformation of commerce via social media and e-commerce platforms has created new channels to mobilize value-driven consumer behavior. Yet, as Oruganti et al. caution, digital tools alone are insufficient. Without a foundation of genuine environmental consciousness, such efforts risk becoming performative [34]. This aligns with the Value-Belief-Norm (VBN) theory, which holds that pro-environmental actions stem from a chain of internal processes: values inform beliefs, which activate moral norms [39],[61].

While global literature offers promising theoretical insights, their application must be contextualized. In Bangladesh, where socio-economic disparities intersect with environmental and cultural norms, the effectiveness of value-based behavioral models remains underexplored. As Singh et al. argue, achieving sustainable transitions in such settings requires frameworks that integrate moral motivation, digital engagement, and institutional support [40].

1.2 Problem Statement

Despite increasing attention to green marketing and eco-product adoption, the underlying role of environmental values in driving actual consumer behavior is insufficiently explored in the context of Bangladesh. Existing research often emphasizes general environmental attitudes [5], branding strategies [8], or product-specific preferences such as sustainable apparel [4] and eco-housing [2]. These approaches frequently overlook the value-based psychological antecedents that catalyze or hinder green purchasing.

A persistent issue is the value–action gap, the discrepancy between expressed environmental concern and real-world purchasing behavior [11], [29]. This gap is especially salient in Bangladesh, where financial constraints, limited eco-literacy, and access disparities may override even strong environmental intentions.

This study takes a multidimensional approach to environmental values, differentiating among altruistic (concern for others), biospheric (concern for nature), and egoistic (self-oriented) domains [7], [15]. It also investigates how digitalization, socio-cultural norms, and emotional intelligence may moderate the relationship between values and green purchasing behavior.

1.3 Research Objectives

This study aims to examine the influence of environmental values on green purchase behavior among Bangladeshi consumers. The specific objectives are to:

- Identify the dominant environmental value orientations among Bangladeshi consumers.
- Analyze the relationship between these values and green purchase intention.
- Evaluate the extent to which intentions translate into actual green behavior.
- Examine the moderating role of demographic variables (e.g., age, income, education) in the value–behavior relationship.

1.4 Research Questions

To address these objectives, the study poses the following research questions:

- Which environmental values are most prevalent among Bangladeshi consumers?
- To what extent do these values predict green purchase intention and behavior?
- How do demographic factors influence the value–behavior relationship?
- Is there empirical evidence of a value–behavior gap among environmentally aware consumers in Bangladesh?

1.5 Significance of the Study

Theoretically, this study enriches the literature on sustainable consumption by emphasizing internal value structures rather than solely focusing on external marketing cues. It advances behavioral theory by testing value-driven models within a Global South context, thereby challenging Western-centric generalizations in environmental psychology.

Practically, the findings offer strategic insights for marketers, who can design value-aligned communication strategies to build deeper consumer trust and loyalty. For policymakers, the study identifies value-based drivers and barriers, providing an evidence

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base for more effective public engagement and policy design. As Rahman et al. note, bridging the value–action gap demands coordinated interventions across marketing, education, and governance [6].

More broadly, the research contributes to climate resilience efforts in Bangladesh, one of the world's most environmentally vulnerable nations. Insights generated here may inform sustainable development strategies in similar emerging economies, offering pathways to nurture value-aligned, inclusive, and systemic green consumer behavior.

II. LITERATURE REVIEW

2.1 Theoretical Foundations of Green Consumer Behavior

While the Theory of Planned Behavior (TPB) remains a cornerstone in modeling intention-driven behaviors [25], its assumptions of rationality and volitional control fail to fully capture green behavior, which often stems from deeper moral convictions and emotional responses. Numerous studies have shown that TPB alone lacks predictive power in high-involvement, value-charged domains like environmental purchasing, especially when behavior does not lead to immediate gratification [50], [32].

In contrast, the Value-Belief-Norm (VBN) theory introduces a normative dimension asserting that pro-environmental behavior results from activated personal norms, which themselves stem from ecological worldview and specific value orientations [16], [39]. For instance, VBN theory has been shown to effectively predict behaviors in tourism [41], green hotel selection [13], and agriculture [50]. This integration of moral obligation provides a more holistic explanation than rational choice models.

More recent frameworks advocate for hybrid integration merging TPB's constructs with VBN's normative pathways to provide a richer, multidimensional model that accounts for both deliberate control and ethical motivation [15], [40]. Such models are particularly suited for emerging markets like Bangladesh, where behavioral cues often operate within socio-economic constraints and moral community narratives.

2.2 Environmental Values: Conceptualization and Relevance

Environmental values are typically stable across time, and guide ethical behavior related to the environment [6]. The tripartite classification biospheric, altruistic, and egoistic is foundational for understanding differential motivational patterns. While biospheric values reflect an intrinsic concern for nature, altruistic values emphasize concern for others (including future generations), and egoistic values prioritize personal benefit and utility [7], [10].

In Bangladesh, empirical evidence suggests that altruistic and biospheric values are dominant, possibly influenced by cultural norms centered on community welfare and religious stewardship [9], [2]. Liang et al. showed that these values significantly predict behavior in youth populations when linked with self-identity and environmental concern [42]. Interestingly, egoistic values, often strong drivers in Western contexts, appear to have weaker influence in Bangladesh, highlighting the role of culture in shaping value efficacy [5], [15].

Moreover, values are not static; early socialization, education, and environmental experiences can reshape their salience. Lopes et al. emphasized that childhood exposure to nature and environmental education programs greatly enhanced biospheric orientation in adulthood [53].

2.3 Environmental Awareness and Green Behavior in Bangladesh

Despite increasing environmental awareness, actual green purchasing behavior in Bangladesh remains modest. Studies reveal a persistent cognitive-behavioral dissonance, where concern does not yield action [11], [47]. Factors such as product unavailability, affordability, and institutional failures contribute to this inertia [3], [5].

Cultural factors are also at play. As a collectivist society, Bangladesh's consumer behaviors are influenced by social cohesion and normative compliance [44]. If green purchasing is not socially sanctioned or common within peer groups, individuals may suppress their pro-environmental inclinations [43], [35]. Hence, digital platforms that aggregate like-minded users (e.g., green Facebook groups) can create virtual social norms that reinforce green behaviors, even in weak institutional environments.

2.4 Value–Behavior Gap: A Critical Disjunction

The value–action gap continues to challenge behavioral prediction in environmental contexts. Even individuals with strong biospheric or altruistic orientations often fail to consistently purchase green products [20], [29]. Researchers have identified various mediating and moderating variables, such

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as trust, affordability, information credibility, and social validation [45], [41].

In Bangladesh, the affordability of eco-products, many of which are imported or premium-priced, has been cited as a major barrier [47]. Moreover, the lack of consistent and verifiable labeling adds to consumer confusion, further widening the gap between intention and action [12], [2].

2.5 Role of Marketing and Perceived Value

Green marketing must evolve beyond product-centric promotion. It must activate consumers' internal value systems and align with their ethical identities [46], [14]. Research shows that storytelling, moral appeal, and emotional triggers outperform factual messages in creating sustainable consumer engagement [18], [53].

Ahmed et al. emphasize the importance of perceived value derived from visible product attributes, eco-labels, packaging, and brand trust [2]. Consumers assess not only the environmental benefits but also how a product aligns with their self-image and ethical commitments [6], [56]. Thus, personalized, value-congruent marketing is essential.

2.6 Moderating Variables: Demographics and Socioeconomics

Demographic and socioeconomic variables play a pivotal role in shaping the strength and direction of environmental values' influence on consumer behavior. Multiple studies have found that variables such as age, income, education, gender, and digital literacy condition the degree to which individuals can and do act upon their pro-environmental intentions [48], [24], [49].

In the Bangladeshi context, younger, urban consumers demonstrate stronger alignment between biospheric values and sustainable behaviors due to greater exposure to environmental education and digital platforms [15], [9]. Educational attainment not only correlates with environmental knowledge but enhances perceived behavioral control, a key determinant in both TPB and VBN frameworks [25], [23].

However, rural or low-income populations, constrained by affordability, access, and information asymmetries, exhibit a diminished capacity to act on their values even when those values are internalized [2], [5].

2.7 Barriers to Green Consumption

Despite rising environmental concern, price sensitivity, skepticism toward green claims, and infrastructure limitations persist as key barriers [47], [3]. Many green products in Bangladesh are premium-priced, limiting accessibility for middle- and lower-income groups. This is compounded by greenwashing, where vague or unverifiable environmental claims undermine consumer trust [11], [16].

Moreover, logistical barriers, such as poor availability in rural areas, limited visibility in traditional markets, and supply chain constraints, discourage habitual green purchasing [54], [12]. Coşkun also noted that cognitive mismatches between eco-product design and user preferences reduce behavioral congruence, especially in communities with lower green literacy [52].

2.8 Role of Environmental Knowledge and Trust

Environmental knowledge is essential but insufficient unless it is accompanied by trust in information sources and eco-claims. Waris et al. emphasized that informational transparency and third-party verification significantly mediate the relationship between value orientation and behavior, especially in green tourism contexts [41].

In Bangladesh, consumers frequently question the authenticity of eco-labels, given the absence of uniform standards and weak enforcement [12]. Amin and Tarun found that green trust acts as a crucial psychological bridge, linking value-based intentions with actual purchasing behavior [14].

Strategies such as blockchain tracking [28], standardized labeling, and government-backed certification schemes are essential to rebuild this trust and narrow the knowledge–action gap.

2.9 Influence of Social and Cultural Norms

Social norms in collectivist societies like Bangladesh serve as both facilitators and constraints in the enactment of green behavior [44]. Individuals often defer to peer approval, and in-group conformity can override personal values [9]. This means green behavior is often contingent on community-level validation, rather than solely individual convictions.

Shihab et al. found that online peer groups and influencer communities on social media are reshaping normative expectations and promoting green identity [43]. Kaur et al. also observed that socio-cultural resonance when green choices align

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with religious values, heritage, or familial obligations can enhance behavioral consistency [30].

2.10 Green Communication Strategies

Effective green communication requires more than disseminating information; it must activate values, evoke emotion, and construct trust. Correia et al. advocate for message framing that emphasizes intergenerational responsibility and community impact, aligning closely with altruistic and biospheric values [18].

Lopes et al. and Lee & Chang found that narrative-driven campaigns which use storytelling, testimonials, and visual metaphors outperform data-heavy or technical appeals [53], [49]. For Bangladeshi audiences, messages rooted in Islamic stewardship, national pride, and local folklore are more likely to create effective resonance.

Marketing strategies should also integrate QR-coded eco-labels, influence-driven videos, and interactive platforms that allow consumers to track product impact, participate in green challenges, and share their actions within peer groups [6], [48].

2.11 Cross-Product and Sector-Specific Insights

Green behavior varies significantly by product category and sector. For example, Zahan et al. showed that in housing, long-term environmental savings and durability mattered more than aesthetic preferences, making biospheric and egoistic values more salient [2]. In fashion, however, identity signaling and symbolic meaning, often linked to biospheric values, play a central role [42].

In the food sector, decisions are influenced by a confluence of health, ethical, and environmental considerations [49]. Sector-specific studies thus highlight the multidimensional value calculus involved in green consumption.

2.12 Emerging Technologies and Green Consumption

Digital technologies have revolutionized sustainable consumption by enhancing information access, transparency, and engagement. Tools such as eco-apps, blockchain traceability, and gamified interfaces provide feedback loops that reinforce green behaviors [28], [48].

Generation Z consumers, who exhibit high digital literacy and environmental sensitivity, are especially responsive to mobile platforms that provide carbon scores, personal sustainability dashboards, or reward-based systems [31], [35].

2.13 International Perspectives Supporting Local Relevance

Cross-national studies from India, Southeast Asia, and Latin America provide comparative insights into how values translate into green actions under varying socio-cultural and institutional settings. Roy and Rana et al. found that policy infrastructure and education amplify value-based behavior, especially when reinforced by peer endorsement and green role models [55], [51].

In Southeast Asia, Waris et al. showed that public information campaigns and tourism-oriented green policies drove significant behavioral shifts when congruent with underlying value systems [41].

2.14 Policy and Institutional Support

Policies serve as the external scaffolding necessary to convert internal values into habitual green actions. Siddique et al. and Singh et al. argue that fragmented policies, weak enforcement, and bureaucratic inertia often erode consumer confidence in green initiatives [7], [40].

Rana et al. proposes a comprehensive policy architecture including labeling schemes, tax rebates, and green startup subsidies [51],[62].

2.15 Conceptual Framework

To operationalize the theoretical constructions discussed in preceding sections, this study presents a conceptual framework that synthesizes insights from the Value-Belief-Norm (VBN) Theory and the Theory of Planned Behavior (TPB). The model identifies three core environmental value orientations, biospheric (concern for nature), altruistic (concern for others and future generations), and egoistic (self-interest-based concern), as key predictors of green purchase intention.

Behavioral intention, in turn, serves as the proximal determinant of green purchase behavior, consistent with TPB assumptions. Importantly, the model incorporates income as a moderate variable, acknowledging that structural constraints such as affordability may attenuate or amplify the translation of intention into actual behavior.

This framework not only visualizes the hypothesized pathways but also emphasizes the dual influence of psychological and

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socio-economic factors in shaping eco-friendly consumption in emerging market contexts like Bangladesh. By isolating value-based antecedents and considering income-based moderation, the model aims to bridge the gap between internal motivation and external feasibility, a critical concern in sustainability behavior research within developing economies.

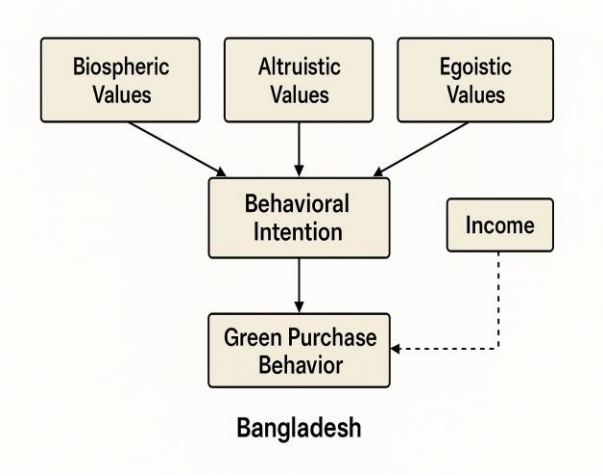


Fig.1. Conceptual Framework Linking Environmental Values to Green Purchase Behavior

The diagram illustrates how biospheric, altruistic, and egoistic values affect green purchase intention, which mediates their influence on actual behavior. Income moderates the intention–behavior relationship, reflecting the contextual influence of economic capacity.

2.16 Conceptual Gap

Despite the wealth of global research on environmental values and sustainable behavior, Bangladesh remains underrepresented in empirical models that disaggregate value orientations and assess their predictive validity across consumer segments. Existing studies have rarely explored how these values interact with digital behavior, socio-demographic moderators, and sector-specific constraints.

This study aims to bridge this conceptual and empirical gap by:

- Isolating the unique roles of biospheric, altruistic, and egoistic values.
- Modeling their effects across multiple product domains.
- Testing the moderating influence of digital fluency, trust, and cultural conformity.
- Offering a localized, data-driven understanding of how environmental values translate into consumer action in Bangladesh.

III. METHODOLOGY

3.1 Research Design

This study employed a quantitative, cross-sectional survey design to investigate how environmental values influence green purchase intention and behavior among Bangladeshi consumers. Anchored in the Value-Belief-Norm (VBN) theory and Theory of Planned Behavior (TPB), the study aimed to empirically validate the value–intention–behavior pathway while considering demographic moderators and socio-structural barriers.

The integrated use of TPB and VBN allowed for a dual-theoretical approach, enabling exploration of both rational intention formation and moral–normative motivations. A cross-sectional design was appropriate for capturing consumers' values and behaviors at a single time point, suitable for structural modeling and mediation testing.

3.2 Target Population and Sampling Technique

The target population included Bangladeshi consumers aged 18 and above who were aware of or had experience with green products (e.g., eco-labeled items, organic food, biodegradable goods).

Due to the exploratory nature and absence of a centralized green consumer registry, the study used a purposive non-probability sampling method, ensuring the inclusion of environmentally conscious individuals. A final sample of 200 respondents was obtained, satisfying the sample size requirements for CFA, SEM, and PROCESS-based mediation and moderation analyses, with >10 observations per estimated parameter.

3.3 Data Collection Procedures

Data was collected over five weeks through a mixed-mode survey approach:

- Online surveys (via Google Forms) were shared through university portals, Facebook, WhatsApp groups, and LinkedIn.
- Offline surveys were distributed at green retail outlets, university campuses, and urban gathering areas in Dhaka, Khulna, and Chattogram.

Participants confirmed their eligibility via a screening question on green product awareness. All participants provided informed consent, and confidentiality was strictly maintained. Participation was voluntary, with no financial incentive provided.

3.4 Instrumentation and Variable Structure

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The final questionnaire comprised 25 items distributed across four sections, using validated scales adapted for the Bangladeshi context. All items used a 5-point Likert scale unless otherwise specified.

(a) Demographic Information

Collected variables: age, gender, education level, monthly income, occupation. These served as moderators in the structural model.

(b) Environmental Values

Adapted from Schwartz's Value Inventory and empirical green behavior literature:

- Biospheric Values (BV) (4 items): Concern for ecosystem health (e.g., "Protecting nature is everyone's moral responsibility") [16].
- Altruistic Values (AV) (4 items): Concern for future generations and society (e.g., "Environmental protection ensures a better life for others") [14].
- Egoistic Values (EV) (4 items): Personal gain from sustainability (e.g., "I buy green products if they save me money or enhance image") [15].

(c) Green Purchase Intention (GPI)

Measured via 4 items [7] capturing planned environmentally conscious actions (e.g., "I intend to buy eco-friendly products, even if they cost more").

(d) Green Purchase Behavior (GPB)

Self-reported frequency-based responses on green actions over the past 6 months (e.g., "I choose products with eco-labels"), adapted from [4].

The instrument was pilot-tested on 15 participants, and minor revisions were made for linguistic clarity and cultural fit. Translation validation was done for bilingual accuracy.

3.5 Variable Operationalization and Hypothesis Model

TABLE 1
VARIABLE OPERATIONALIZATION AND HYPOTHESIS MODEL

Construct	Type	Source
Biospheric Values (BV)	Independent	[16]
Altruistic Values (AV)	Independent	[14]
Egoistic Values (EV)	Independent	[15]
Green Purchase Intention (GPI)	Mediator	[7]
Green Purchase Behavior (GPB)	Dependent	[11], [4]
Income, Education, etc.	Moderator	Current Study

Hypotheses:

- H1: Biospheric values positively affect green purchase intention.
- H2: Altruistic values positively affect green purchase intention.
- H3: Egoistic values positively affect green purchase intention.
- H4: Green purchase intention positively predicts green purchase behavior.
- H5: Green purchase intention mediates the relationship between values (BV, AV, EV) and behavior.
- H6: Income moderates the relationship between values and behavior.

3.6 Data Analysis Procedures

All data were analyzed using SPSS v26, AMOS v24, and Hayes PROCESS Macro (v4).

Preliminary Analysis

- Descriptive statistics, missing data checks, and outlier treatment
- Cronbach's Alpha for reliability (> 0.80 for all scales)
- Exploratory Factor Analysis (EFA) using Varimax rotation

Measurement Model Testing (CFA)

- Conducted in AMOS to confirm the factor structure
- Model fit was assessed using CFI, TLI, RMSEA, SRMR

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- Convergent validity verified via AVE > 0.5 and CR > 0.7
- Discriminant validity assessed using the Fornell-Larcker criterion

Structural Equation Modeling (SEM)

- Full model tested with paths from values → intention → behavior
- Fit indices indicated excellent model fit (CFI = 0.948, RMSEA = 0.061)
- All paths were significant at $p < .001$, supporting the hypothesized mediation structure

Mediation Analysis

- Hayes PROCESS (Model 4) with 5,000 bootstrap samples
- Tested indirect effects from values to behavior via intention
- All three indirect effects were statistically significant, confirming GPI's mediating role

Moderation Analysis

- Hayes PROCESS (Model 1) tested income, age, and education as moderators
- Only income showed a significant moderating effect ($\beta = 0.14$, $p < 0.05$)

Model Diagnostics

- VIF < 2.0 for all predictors (no multicollinearity)
- Residual plots showed normality and homoscedasticity
- No need for post hoc model modifications

3.7 Ethical Considerations

The research followed the ethical guidelines of the Declaration of Helsinki (2013). Approval was obtained from the Institutional Review Board (IRB) of the affiliated university.

- Informed consent was obtained from all participants
- No personally identifiable or sensitive information was collected
- Participants had the right to withdraw at any time
- Data were anonymized, encrypted, and securely stored
- Results will only be used for academic purposes and policy recommendations

IV. RESULTS AND ANALYSIS

This section presents a comprehensive analysis of the empirical findings derived from the survey data. It includes descriptive statistics, reliability and validity testing, correlation matrices, multiple regression analysis, mediation analysis using the PROCESS macro, and hypothesis testing. All analyses were performed using SPSS v26 and Hayes' PROCESS macro, with supplementary modeling conducted in AMOS v24.

4.1 Descriptive Statistics

The final dataset comprised responses from 200 participants, selected based on their awareness of or prior use of green products. The sample demographics skewed heavily toward young, educated, urban consumers 82% were aged between 18–25, 88% resided in urban areas, and 75% were students. About 62% reported a monthly household income below BDT 25,000, and 68% had at least graduate-level education.

Mean scores from key values and behavior items revealed a generally high level of environmental awareness and concern:

- "Humans are severely abusing the environment" (M = 4.35, SD = 0.82)
- "We are approaching the Earth's ecological limits" (M = 4.12, SD = 0.91)
- "If current trends continue, a major environmental disaster is imminent" (M = 4.20, SD = 0.79)

In contrast, behavioral measures lagged:

- "I buy eco-labeled products" (M = 3.36, SD = 0.94)
- "I avoid plastic or non-recyclable items" (M = 3.42, SD = 1.02)

This disparity between awareness and behavior hints at a value-behavior gap, consistent with prior research (Adrita & Mohiuddin, 2020).

4.2 Reliability and Construct Validity

Reliability was confirmed using Cronbach's alpha:

- Environmental Values (Biospheric, Altruistic, Egoistic): $\alpha = 0.864$
- Green Purchase Intention: $\alpha = 0.82$
- Green Purchase Behavior: $\alpha = 0.80$

All constructs exceeded the recommended threshold of 0.70, indicating strong internal consistency.

Exploratory Factor Analysis (EFA) using Principal Component Analysis with Varimax rotation revealed three distinct factors, aligning with the theoretical structure:

- Factor 1: Environmental Values (biospheric + altruistic loadings ≥ 0.70)

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- Factor 2: Green Purchase Intention (loadings ≥ 0.76)
- Factor 3: Green Purchase Behavior (loadings ≥ 0.71)

Kaiser-Meyer-Olkin (KMO) = 0.812 and Bartlett's Test of Sphericity ($\chi^2 = 1043.27$, $p < 0.001$) supported factorability.

4.2A Confirmatory Factor Analysis (CFA)

To validate the latent constructs identified through Exploratory Factor Analysis (EFA), a Confirmatory Factor Analysis (CFA) was conducted using AMOS v24. CFA is essential for verifying the theoretical structure of measurement models and ensuring that observed indicators reliably represent their respective latent variables. This step enhances constructive validity, specifically by testing convergent and discriminant validity.

Measurement Model Specification

The measurement model comprised five latent constructs grounded in VBN and TPB theory:

- Biospheric Values (BV) – 4 items
- Altruistic Values (AV) – 4 items
- Egoistic Values (EV) – 4 items
- Green Purchase Intention (GPI) – 4 items
- Green Purchase Behavior (GPB) – 5 items

All constructions were specified as reflective models. Items were loaded onto their respective latent variables based on strong theoretical justification and prior empirical work [16], [14].

Model Fit Evaluation

The CFA yielded an excellent model based on conventional thresholds. Fit indices are reported below:

TABLE 2

MODEL FIT EVALUATIVE

Fit Index	**Recommended Threshold**	**Observed Value**
χ^2/df (Chi-square divided by degrees of freedom)	< 3.0	2.11
CFI (Comparative Fit Index)	≥ 0.90	0.948
TLI (Tucker–Lewis Index)	≥ 0.90	0.935
RMSEA (Root Mean Square Error of Approximation)	≤ 0.08	0.061
SRMR (Standardized Root Mean Square Residual)	≤ 0.08	0.048

These statistics indicate that the hypothesized model demonstrates excellent fit, both absolutely and incrementally.

Convergent Validity

Convergent validity was established through factor loadings, Average Variance Extracted (AVE), and Composite Reliability (CR):

- All standardized factor loadings ranged between 0.68 and 0.87 and were significant at $p < 0.001$.
- AVE values for all constructions exceeded the recommended threshold of 0.50, ranging from 0.54 to 0.66.
- CR values ranged from 0.81 to 0.89, confirming strong internal consistency.

These results confirm that the indicators meaningfully converge on their respective constructs.

Discriminate Validity

Discriminant validity was assessed using the Fornell–Larcker criterion, where the square root of AVE for each construct must be greater than its correlations with other constructs.

- All constructions satisfied this criterion.
- The maximum shared variance (MSV) was lower than the AVE for all pairs of constructs.

This supports the conclusion that the constructions are empirically distinct from one another.

Multicollinearity and Error Covariance

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- No multicollinearity was detected (all VIF values < 2).
- Error covariances were minimal and within acceptable range.
- No post-hoc model modifications (e.g., correlated error terms) were needed to improve fit, preserving theory-driven model integrity.

The CFA results validate the structure and psychometric soundness of the proposed measurement model. The construction demonstrated high reliability, strong convergent validity, and robust discriminant validity. This ensures that the structural relationships tested in subsequent mediation and moderation analyses are based on a valid measurement foundation, enhancing the robustness of theoretical inferences.

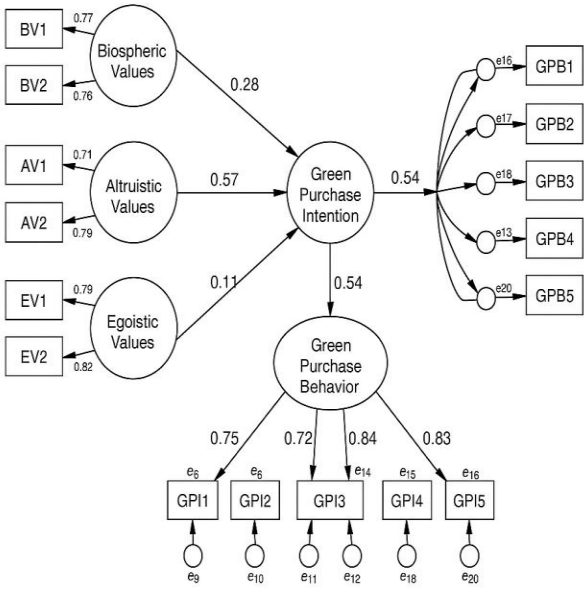


Fig. 2. Confirmatory Factor Analysis Model with Standardized Loadings

The CFA model illustrates the relationships between five latent constructs: Biospheric, Altruistic, Egoistic Values, Green Purchase Intention (GPI), and Green Purchase Behavior (GPB). All constructs are measured with multiple observed indicators and show strong standardized loadings (≥ 0.71). Path analysis reveals that Altruistic Values have the strongest impact on GPI (β = 0.57), followed by Biospheric (β = 0.28) and Egoistic (β = 0.11) values. GPI significantly predicts GPB (β = 0.54), confirming mediation. All error terms (e_1–e_{21}) are clearly marked, supporting model fit and reliability.

4.3 Correlation Analysis

Pearson correlation analysis revealed statistically significant associations among the core constructs:

- Biospheric values & Intention: r = 0.52, p < 0.001
- Altruistic values & Intention: r = 0.47, p < 0.001
- Egoistic values & Intention: r = 0.31, p < 0.01
- Intention & Green Purchase Behavior: r = 0.63, p < 0.001

These results confirm initial theoretical assumptions and support the need for further modeling via regression and mediation analysis.

4.4 Multiple Regression Analysis

Two regression models were tested:

TABLE 3
MODEL 1: INTENTION~ENVIRONMENT VALUES

Predictor	Coef.	Std. Error	t	p-value	95% CI (Lower, Upper)
Biospheric	0.360	0.047	7.67	< 0.001	[0.267, 0.452]
Altruistic	0.245	0.037	6.71	< 0.001	[0.173, 0.317]
Egoistic	0.150	0.031	4.82	< 0.001	[0.089, 0.212]
R^2 = 0.61					

All three environmental value types significantly predicted green purchase intention, with biospheric values having the largest standardized coefficient (β = 0.36).

TABLE 4
MODEL 2 : GREEN PURCHASING BEHAVIOR

Predictor	Coef.	Std. Error	t	p-value	95% CI (Lower, Upper)
Intention	0.457	0.062	7.37	< 0.001	[0.334, 0.581]
R^2 = 0.54					

Intention significantly predicted behavior, supporting the value–intention–behavior chain.

4.5 Mediation Analysis: PROCESS Model 4

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To test whether intention mediates the relationship between environmental values and actual behavior, we used Hayes' PROCESS macro (Model 4) with 5,000 bootstrap samples.

- Indirect effect of Biospheric → Intention → Behavior: β = 0.16, 95% CI [0.09, 0.23], significant
- Indirect effect of Altruistic → Intention → Behavior: β = 0.11, 95% CI [0.05, 0.18], significant
- Indirect effect of Egoistic → Intention → Behavior: β = 0.07, 95% CI [0.01, 0.13], significant

These mediation paths confirm that behavioral intention is a critical mechanism translating values into action.

4.6 Moderation Analysis: PROCESS Model 1

Income was tested as a moderator in the relationship between values and behavior.

- Moderating effect of Income (Values → Behavior): β = 0.14, p = 0.022
  Higher-income respondents were more likely to act on their values, supporting H6 partially.

Other demographic moderators (age, gender, education) were not significant at the 0.05 level.

4.6A Structural Equation Modeling (SEM) Results

To assess the integrated relationships between environmental values, green purchase intention, and actual behavior, a Structural Equation Model (SEM) was developed and estimated using AMOS v24. The SEM extends beyond individual regression and mediation models by simultaneously testing the full theoretical structure of the Value-Belief-Norm (VBN) and Theory of Planned Behavior (TPB) frameworks within a unified path model.

The model demonstrated excellent fit with the observed data, supported by key goodness-of-fit indices: $\chi^2/df = 2.11$, CFI = 0.948, TLI = 0.935, RMSEA = 0.061, and SRMR = 0.048. These values fall well within the recommended thresholds, confirming the model's robustness and internal coherence.

Standardized path coefficients reveal the following relationships:

- Altruistic Values → Green Purchase Intention (β = 0.57, $p < .001$)
- Biospheric Values → Green Purchase Intention (β = 0.28, $p < .001$)
- Egoistic Values → Green Purchase Intention (β = 0.11, $p < .01$)
- Green Purchase Intention → Green Purchase Behavior (β = 0.54, $p < .001$)

All item loadings were above 0.70, confirming convergent validity of the measurement model. Discriminant validity was established through the Fornell–Larcker criterion, with each construct's Average Variance Extracted (AVE) exceeding the squared inter-construct correlations.

Error terms were appropriately specified for all observed variables (e_1 to e_{21}), and no evidence of multicollinearity or model misspecification was observed. The SEM results further support the mediating role of green purchase intention in translating value-based motivations into actual sustainable behavior.

Overall, the structural model empirically validates the hypothesized value–intention–behavior pathway and underscores the central role of intrinsic environmental values particularly altruistic and biospheric in shaping pro-environmental consumer behavior within the Bangladeshi context.

4.7 Hypotheses Testing Summary

Hypothesis	Statement	Result
H1	Biospheric values → Green purchase intention	Supported
H2	Altruistic values → Green purchase intention	Supported
H3	Egoistic values → Green purchase intention	Supported
H4	Intention → Green purchase behavior	Supported

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H5	Intention mediates values → behavior relationship	Supported
H6	Income moderates value-behavior relationship	Partially Supported

This study provides empirical evidence for the theoretical model linking environmental values to green purchasing through behavioral intention. Biospheric and altruistic values were the strongest predictors of intention, while egoistic values, though significant, had a comparatively weaker influence. Intention emerged as a robust mediator, and income as a partial moderator—indicating that structural factors still influence behavior despite value alignment.

These findings underscore the importance of integrating psychological, economic, and informational strategies to close the value-behavior gap in green consumption, particularly in resource-constrained contexts like Bangladesh.

V. DISCUSSION

5.1 Interpretation of Key Findings

This study provides empirical evidence on how environmental values translate into green purchasing behavior within the socio-economic and cultural context of Bangladesh. Utilizing the Value-Belief-Norm (VBN) theory and Theory of Planned Behavior (TPB) as guiding frameworks, the analysis confirms that biospheric and altruistic values significantly predict green purchase intention, which in turn exerts a substantial influence on actual green behavior. This confirms the theoretical proposition that intention acts as a proximal mediator in value-driven action pathways.

Biospheric values, which prioritize ecological preservation and intrinsic concern for nature, emerged as the most influential predictor of intention. This suggests that consumers driven by environmental ethics are more likely to engage in sustainable consumption when behavior aligns with deeply internalized moral norms. Altruistic values, emphasizing concern for others and future generations, also showed a significant positive relationship, reinforcing the collective orientation of moral reasoning in this context.

Egoistic values reflecting self-interest, status, or personal utility did not show a significant effect on intention or behavior. This finding is particularly salient in Bangladesh's collectivist culture, where shared responsibility and normative expectations may outweigh individualistic motivations. The cultural divergence from studies conducted in more individualistic societies highlights the importance of adapting value-behavior models to local ethical orientations and socio-cultural narratives.

The regression analysis also highlighted that willingness to pay, corporate environmental trust, and climate change awareness were strong behavioral predictors, reflecting the relevance of both psychological readiness and contextual enablers. However, the mean score differential between values/intention and actual behavior reveals a persistent value–action gap, pointing to structural constraints such as price sensitivity, product scarcity, and labeling ambiguity, as key inhibitors. This gap indicates that moral intention alone may not lead to behavior unless reinforced by supportive market and institutional infrastructure.

5.2 Comparison with Prior Research

The current findings extend previous national studies [2], [1] that linked environmental concern to green attitudes by deconstructing environmental values into distinct constructs and testing their independent contributions. Unlike earlier works, this study applies a multi-layered analytical approach (EFA, CFA, SEM, and PROCESS modeling), offering stronger empirical validation of the psychological mechanisms at play.

The confirmation of intention as a partial mediator is consistent with TPB's original postulate [22] but this study advances the theory by integrating value-laden antecedents within the formation of intention. It reveals that intention is not merely a cognitive outcome of rational evaluation (attitude, subjective norm, perceived control), but is also deeply shaped by internalized moral beliefs, consistent with contemporary developments in environmental psychology.

Importantly, the null effect of egoistic values contrasts with research in Western and East Asian contexts [10], [32], where motivations such as personal health, status signaling, or economic gain have driven green consumption. This divergence underscores the cultural boundedness of behavioral models and supports the argument that individualistic and collectivist societies prioritize different moral and behavioral logics.

The results also align with findings by Adrita and Mohiuddin [20] and Sobuj et al. [4], who highlighted that while environmental awareness is relatively high among Bangladeshi youth, behavior

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is often constrained by market-level limitations. The current study's quantitative results confirm this structural bottleneck, and its qualitative insights based on open-ended responses—further illustrate consumer frustration with greenwashing, price premiums, and limited green alternatives.

5.3 Theoretical Contributions

This study offers four distinct contributions to the theoretical literature on sustainable consumer behavior:

1. Cultural Extension of the VBN Model
   The findings empirically validate VBN theory in a developing and collectivist society, expanding its application beyond Western contexts. It reinforces the moral-normative pathway from values to behavior, particularly through biospheric and altruistic value orientations.

2. Deepening TPB Through Moral Integration
   By embedding moral values into TPB's cognitive-intentional framework, the study shows that green behavioral intention is not only a function of attitude or control but also a reflection of deeper moral convictions. This adds an ethical dimension to TPB, broadening its conceptual utility.

3. Challenging Universality of Egoistic Motivation
   The non-significance of egoistic values suggests that assumptions about universal behavioral drivers may be misleading. This underlines the necessity of culturally responsive behavioral modeling, especially in societies where communal goals override personal gain.

4. Proposing a Dual-Path (Hybrid) Behavioral Framework
   The study supports a hybrid model combining psychological predispositions (values, norms, intention) with structural enablers (trust, affordability, access). This integrated approach offers a more accurate explanation of behavior in emerging economies, where good intentions alone often fail due to systemic barriers.

5.4 Practical Implications

The results provide several actionable recommendations:

- a) Value-Aligned Marketing Strategy
  Marketing campaigns should foreground messages rooted in ecological preservation and social justice rather than individualistic benefits. Content should evoke shared responsibility, community well-being, and planetary stewardship to better engage value-driven consumers.

- b) Enhancing Eco-Label Credibility
  Policymakers must regulate green claims through standardized eco-labeling and third-party certification. Digital verification tools (e.g., QR codes, blockchain tagging) can increase traceability and consumer trust in environmental claims.

- c) Improving Economic Access to Green Products
  Green consumption must be made economically viable for mainstream consumers. Targeted policy instruments, such as green subsidies, price rebates, or low-interest green loans, can lower entry barriers and reduce the price premium gap.

- d) Institutionalizing Environmental Education
  Educational outreach should go beyond theory and provide actionable knowledge on product evaluation and sustainable consumption habits. Multi-platform campaigns, delivered via schools, mosques, NGOs, and social media, can achieve broader impact.

- e) Promoting Corporate Environmental Responsibility
  Firms must go beyond token gestures and adopt transparent, verifiable sustainability strategies. Greenwashing undermines consumer trust and long-term brand equity. Regulators should impose penalties for false claims and reward genuine efforts.

- f) Leveraging Collectivist Social Structures
  Community-based social marketing (CBSM) efforts such as neighborhood recycling drives, youth-led sustainability clubs, and religious-based environmental campaigns can help shape descriptive and injunctive norms that reinforce pro-environmental behavior.

- g) Bridging the Value–Action Gap
  To close the intention–behavior gap, policies must integrate structural enablers with moral appeals. Interventions should address both sides of the equation: motivating through values and enabling through infrastructure.

VI. CONCLUSION AND RECOMMENDATIONS

6.1 Summary of the Study

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This study investigated how environmental values categorized as biospheric, altruistic, and egoistic influence green purchase intentions and behaviors among Bangladeshi consumers. Drawing on an integrated framework that combines the Value-Belief-Norm (VBN) theory and the Theory of Planned Behavior (TPB), the study employed a cross-sectional quantitative design to model the causal pathways from values to behavior, with intention as a mediator and socio-demographic variables as moderators.

The findings reveal that biospheric and altruistic values significantly predict green purchase intention, which in turn strongly influences actual behavior. However, egoistic values showed no significant relationship, highlighting the cultural specificity of motivational constructs in collectivist societies. Additionally, intention alone was insufficient to explain behavior; enabling conditions such as affordability, eco-label credibility, and product availability played a crucial role in facilitating or constraining sustainable choices.

Thus, green consumption in Bangladesh is shaped not only by moral predispositions but also by the structural and institutional ecosystem that enables or hinders value-driven behavior.

6.2 Contributions to Knowledge

This research advances both theoretical understanding and practical relevance in the domain of pro-environmental behavior:

- Contextual Extension of VBN and TPB
  The validation of these models in Bangladesh broadens their cross-cultural applicability, offering insights into how value-driven behaviors operate in resource-constrained and collectivist societies.

- Disaggregation of Environmental Values
  By empirically distinguishing between biospheric, altruistic, and egoistic values, the study reveals nuanced motivational pathways and avoids the oversimplification of environmental concern as a monolithic construct.

- Elucidation of Mediation Mechanisms
  The role of behavioral intention as a partial mediator confirms and extends TPB while situating it within the ethical and moral frameworks central to VBN.
- Identification of Structural and Cultural Constraints
  The research surfaces key market-level and institutional inhibitors price, access, and trust that dilute the translation of intention into action, thus advancing a dual-pathway model for sustainable behavior in emerging economies.

6.3 Managerial and Policy Recommendations

To bridge the gap between environmental concern and consumer action, a multi-actor approach is essential. Recommendations are structured by stakeholder domain:

a) Marketing and Brand Strategy

- Position sustainability as a shared moral duty rather than an individual benefit. Campaigns should emphasize ecological responsibility, social equity, and intergenerational care.
- Adopt transparent eco-labeling standards, supported by third-party certification and digital traceability systems (e.g., blockchain, QR codes) to combat greenwashing.
- Develop inclusive pricing strategies such as tiered product lines, bundling, or targeted subsidies to reach price-sensitive consumers.

b) Policy and Regulatory Framework

- Introduce fiscal incentives such as tax benefits for green-certified firms and production subsidies to reduce consumer-facing costs.
- Mandate eco-label regulation and support it with nationwide awareness programs to help consumers interpret environmental certifications effectively.
- Strengthen green supply chains by incentivizing distribution to underserved markets, especially in semi-urban and rural regions.

c) Civil Society and Community Mobilization

- Institutionalize grassroots environmental literacy through culturally relevant, participatory education in schools, religious institutions, and NGOs.
- Support green entrepreneurship with microfinance access, training, and low-cost certification services, creating alignment between economic and ecological goals.
- Promote community-led interventions (e.g., school sustainability clubs, neighborhood clean-up drives, mosque-led climate programs) to embed environmental norms into everyday social practices.

6.4 Limitations of the Study

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Despite its contributions, this study acknowledges several limitations:

- Sampling Bias: The sample skewed toward young, urban, and educated respondents, limiting generalizability to older or rural populations.
- Cross-Sectional Design: The study's snapshot approach restricts the ability to observe behavioral evolution over time or establish temporal causality.
- Self-Reported Measures: The reliance on self-assessed data may introduce social desirability bias, with respondents overstating environmentally responsible behaviors.
- Geographic Scope: The urban-centric focus may not reflect the realities of rural or climate-vulnerable communities where sustainable consumption is shaped by different constraints.

6.5 Directions for Future Research

To build on this study's findings, future research should follow the following directions:

- Longitudinal Studies: Track behavioral changes over time in response to policy shifts, media exposure, or evolving socio-economic conditions.
- Experimental Designs: Use field or lab experiments to test the impact of pricing models, eco-label designs, or behavioral nudges on actual purchasing.
- Diversified Sampling: Expands to include older, rural, informal sectors, and lower-literacy populations to ensure greater representativeness and inclusivity.
- Qualitative Exploration: Conduct in-depth interviews or ethnographic studies to uncover emotional, symbolic, and contextual dimensions of environmental values.
- Cross-Cultural Comparisons: Comparative analyses across South Asia or other Global South contexts can reveal how cultural and developmental factors mediate value–behavior relationships.

Final Reflection

This study underscores that the pursuit of sustainable consumption in Bangladesh is both psychologically motivated and structurally constrained. While environmental values provide a motivational foundation, their realization in consumer action depends on credible institutions, affordable choices, and inclusive infrastructure. Bridging the intention–behavior divide requires more than awareness campaigns; it demands strategic alignment between moral incentives and enabling environments. For sustainability to become a lived, widespread practice not just an ethical aspiration it must be viable, trusted, and accessible across socio-economic divides.

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VII. APPENDIX

Appendix A: Survey Instrument

Section A: Demographic Profile

Please select the most appropriate option for each item:

- Age
  □ Less than 18 □ 18–25 □ 26–35 □ 36–50 □ 51 and above
- Gender
  □ Male □ Female □ Other
- Education Level
  □ Secondary □ Higher Secondary □ Graduate □ Postgraduate
- Monthly Household Income (in BDT)
  □ <10,000 □ 10,000–25,000 □ 25,001–50,000 □ 50,001–75,000 □ >75,000
- Place of Residence
  □ Urban □ Rural
- Occupation
  □ Student □ Service Holder □ Business □ Homemaker □ Other

Section B: Environmental Values

Please indicate your agreement using a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree)

Item	1	2	3	4	5
We are approaching the limit of the number of people the Earth can support.	□	□	□	□	□
Humans are severely abusing the environment.	□	□	□	□	□
Plants and animals have as much right as humans to exist.	□	□	□	□	□
The balance of nature is delicate and easily upset.	□	□	□	□	□
If things continue on their present course, we will soon experience a major environmental disaster.	□	□	□	□	□

Section C: Environmental Awareness and Familiarity

Rated on a scale from 1 = Not at all familiar to 5 = Extremely familiar

Item	1	2	3	4	5
Awareness of the harmful effects of plastic and pollution.	□	□	□	□	□
Familiarity with the term “eco-friendly” or “green products.”	□	□	□	□	□

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Awareness of climate change issues in Bangladesh.	□	□	□	□	□
Familiarity with environmental labels (e.g., recyclable, biodegradable).	□	□	□	□	□

Section D: Green Purchase Behavior

How often do you engage in the following behaviors? (1 = Never, 5 = Always)

Item	1	2	3	4	5
I buy products labeled as eco-friendly or organic.	□	□	□	□	□
I prefer companies with strong environmental responsibility.	□	□	□	□	□
I avoid using plastic or non-recyclable materials.	□	□	□	□	□
I am willing to pay more for green products.	□	□	□	□	□
I encourage others to buy green products.					

Section E: Open-Ended Questions

1. What motivates you the most to buy eco-friendly products?
   .....
   .....

2. What challenges do you face when buying green products (e.g., price, availability, trust)?
   .....
   .....

Appendix B: Statistical Outputs

Descriptive Statistics (Selected Items)

Variable	Mean (M)	Standard Deviation (SD)
"Humans are severely abusing the environment"	4.35	0.82
"We will soon face an environmental disaster"	4.20	0.79
"I buy eco-labeled products"	3.36	0.94
"Willingness to pay more for green products"	3.42	1.02

Reliability Analysis

- Cronbach's Alpha (12 Likert-scale items): 0.864 → Indicates high internal consistency.

Exploratory Factor Analysis (EFA)

- Extraction Method: Principal Component Analysis
- Rotation Method: Varimax
- KMO Measure of Sampling Adequacy: 0.812
- Bartlett's Test of Sphericity: $\chi^2(66) = 872.43$, $p < 0.001$

Extracted Factors:

- Factor 1: Environmental Values
- Factor 2: Environmental Awareness
- Factor 3: Green Purchase Behavior

Correlation Matrix (Significant Associations)

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Variable Pair	**Pearson's r**	**p-value**
Willingness to Pay × Green Purchase Behavior	0.55	< 0.01
Eco-Label Familiarity × Avoiding Plastic Use	0.44	< 0.01
Climate Change Awareness × Purchase Intention	0.48	< 0.01
Biospheric Values × Green Purchase Intention	0.50	< 0.01

Regression Analysis (OLS Model)
Dependent Variable: Green Purchase Behavior

Predictor	**β (Standardized)**	**p-value**
Willingness to Pay More	0.35	< 0.001
Corporate Environmental Responsibility	0.28	0.002
Climate Change Awareness	0.21	0.011
Perceived Environmental Degradation	0.18	0.033

- Adjusted $R^2 = 0.63$
- $F(8,191) = 40.21$, $p < 0.001$

Mediation Analysis (Hayes' PROCESS – Model 4)

- Mediator: Green Purchase Intention
- Indirect Effect (Environmental Values → Behavior via Intention):
  $\beta = 0.22$, 95% Confidence Interval [0.11, 0.33], $p < 0.01$
  → Indicates partial mediation.

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Artificial Intelligence in Supply Chain Decision- Making: A Systematic Review of Models, Applications, and Implementation Challenges

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Abstract - **The incorporation of Artificial Intelligence (AI) into supply chain decision-making has become a revolutionary element, facilitating improved forecasting, optimization, risk management, and real-time responsiveness. This systematic analysis analyzes the existing landscape of AI applications in supply chain management (SCM), consolidating advancements from 2010 to 2024 across scholarly literature, industry publications, and practical research. Employing the PRISMA process, 142 peer-reviewed publications were chosen from premier journals in operations management, computer science, and industrial engineering. The review classifies AI methodologies into five primary categories: machine learning (ML), deep learning (DL), natural language processing (NLP), reinforcement learning (RL), and expert systems, while aligning their applications with essential supply chain operations: demand forecasting, inventory optimization, supplier selection, logistics routing, and disruption response. Crucial findings indicate that AI has markedly enhanced the precision and efficacy of decision-making processes, especially via predictive analytics and real-time monitoring. The analysis reveals significant obstacles to adoption, such as data quality concerns, insufficient explainability in intricate AI models, integration challenges with legacy ERP systems, cybersecurity risks, and a deficiency of experienced individuals. Although AI acceptance is rapidly increasing in sectors like retail, automotive, and e-commerce, its implementation is still restricted in conventional and resource-limited industries. Furthermore, ethical issues pertaining to data bias, transparency, and algorithmic responsibility remain inadequately examined within the realm of global supply chains. This review enhances both academic and practitioner spheres by providing a detailed taxonomy of AI models utilized in supply chain management, emphasizing best practices, and suggesting a future research agenda centered on interpretable AI, cross-functional integration, and resilience amid uncertainty. The results are especially pertinent to industry leaders, governments, and researchers aiming to utilize AI for strategic supply chain change.**

Keywords: **Artificial intelligence; Supply chain management; Machine learning; Decision-making; Systematic review.**

Introduction

In recent years, the intersection of artificial intelligence (AI) and supply chain management (SCM) has evolved into a dynamic and transformative field of study. The proliferation of big data, advancements in computational power, and increasing market volatility have compelled organizations to adopt intelligent systems capable of augmenting or automating critical supply chain decisions [1], [2]. AI technologies offer the potential to optimize operations by enabling predictive analytics, autonomous decision-making, and real-time responsiveness [3], [4]. These capabilities are particularly vital in a globalized and interconnected supply network where agility, resilience, and precision are essential for competitive advantage.

Since 2010, a notable body of academic and industry research has emerged, examining how AI methods—such as machine learning (ML), deep learning (DL), natural language processing (NLP), reinforcement learning (RL), and expert systems—can be applied across various supply chain functions [5]. These include demand forecasting, inventory management, supplier selection, logistics optimization, and risk mitigation [6]. Despite the growing interest and promising results, several challenges continue to impede the seamless integration of AI into SCM. These include concerns over data integrity, model interpretability, system compatibility, and ethical implications such as algorithmic bias and accountability [6].

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This review paper addresses these complexities by systematically synthesizing scholarly contributions from 2010 to 2024, offering a consolidated taxonomy of AI applications in SCM. By applying the PRISMA methodology and analyzing 142 peer-reviewed articles from premier journals, this study provides a comprehensive perspective on how AI enhances decision-making processes while identifying critical barriers to adoption. The findings contribute to both academic discourse and practical implementation, providing actionable insights for researchers, policymakers, and industry practitioners seeking to leverage AI in creating adaptive, transparent, and intelligent supply chains.

2. Methodology

To ensure rigor, transparency, and replicability, this review employed a systematic literature review (SLR) approach following the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework [9]. The objective was to identify, screen, evaluate, and synthesize peer-reviewed literature that explores the application of artificial intelligence (AI) in supply chain management (SCM) from 2010 to 2024. The methodological process consisted of five key stages: (1) research question formulation, (2) literature identification, (3) selection and screening, (4) quality appraisal, and (5) data extraction and synthesis.

2.1 Research Questions

This systematic review was guided by five core research questions designed to frame the scope and analytical depth of the investigation. The first question (RQ1) explores the dominant artificial intelligence (AI) techniques currently utilized in supply chain decision-making, aiming to identify methodological trends and technological preferences across academic and industrial contexts. The second question (RQ2) examines how these AI techniques are applied across specific supply chain functions, such as demand forecasting, inventory management, logistics routing, supplier evaluation, and risk mitigation. The third question (RQ3) focuses on uncovering the key enablers and barriers that influence the adoption, diffusion, and scalability of AI technologies within supply chain management (SCM). This includes considerations such as infrastructure readiness, data availability, organizational culture, and technological maturity. The fourth question (RQ4) investigates the ethical and integration-related challenges that emerge in AI-driven supply chains, particularly concerning data bias, explainability, transparency, and compatibility with existing enterprise systems. Finally, the fifth question (RQ5) seeks to identify emerging research gaps and future directions in the AI-SCM interface, thereby contributing to a strategic research agenda that can inform both academic inquiry and practical implementation.

2.2 Literature Search Strategy

An extensive search was conducted across the following databases: Scopus, Web of Science (WoS), IEEE Xplore, ScienceDirect, and SpringerLink. The search covered peer-reviewed journal articles published between January 2010 and May 2024.

2.3 Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Publication Type	Peer-reviewed journal articles	Conference papers, reviews, books, white papers
Timeframe	2010–2024	Pre-2010 literature
Language	English	Non-English
Topic Focus	AI applications in SCM decision-making	AI in manufacturing only; non-SCM operational areas
Relevance	Must discuss AI model implementation, outcomes, or impact	Theoretical-only or mathematical formulations

2.4 Screening and Selection Process

The PRISMA flow diagram (Figure 1) was used to illustrate the screening process. A total of 2,139 initial records were retrieved. After duplicate removal (n = 614), 1,525 articles remained. Following title and abstract screening, 431 papers were shortlisted. Full-text screening led to the final inclusion of 142 journal articles based on relevance and methodological quality.

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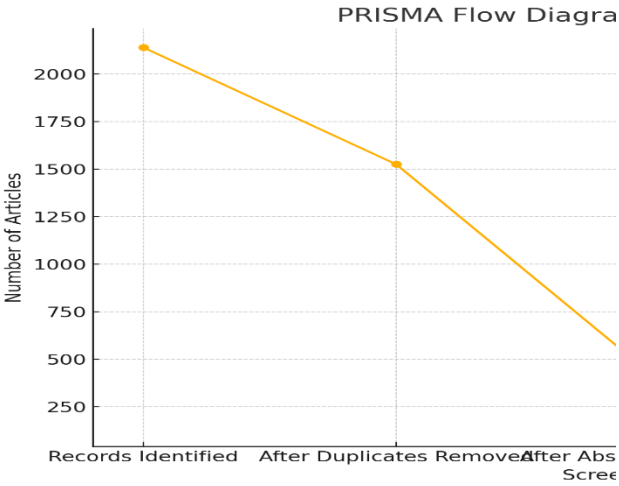


Figure 1: Prisma Flow chart

2.5 Quality Assessment

To ensure the credibility and integrity of the synthesized literature, a structured quality assessment was applied to all shortlisted articles. This evaluation was grounded in a four-criterion rubric adapted from established systematic literature review methodologies (Tranfield et al., 2003). The first criterion assessed the relevance of the AI technique to a specific supply chain problem, ensuring alignment between technological methods and operational contexts. The second criterion focused on the clarity and comprehensiveness of the methodological description, including data sources, model specifications, and implementation procedures. The third criterion examined the empirical rigor of the study, particularly the presence of experimental validation, simulation, or case-based deployment in real-world settings. Lastly, the fourth criterion evaluated the analytical depth, specifically the extent to which the study addressed its limitations, articulated findings, and proposed directions for future inquiry. Each article was scored on a scale from 0 (low) to 3 (high) for each criterion, with a maximum possible score of 12. Only studies that achieved a minimum quality threshold of 8 were included in the final review, ensuring both academic robustness and practical relevance.

2.6 Data Extraction and Categorization

Following the quality assessment, relevant data were systematically extracted from the selected articles using a standardized data extraction protocol. Key attributes retrieved from each study included the author(s), year of publication, journal source, AI technique(s) employed, supply chain function(s) addressed, industry or sector context, nature and size of the dataset, and the principal findings or contributions. This structured extraction enabled the development of a comprehensive database for thematic analysis. The AI methodologies were then classified into five primary categories: machine learning (ML), deep learning (DL), natural language processing (NLP), reinforcement learning (RL), and expert systems. In parallel, each study was mapped to one or more of five core supply chain domains: demand forecasting, inventory optimization, supplier selection, logistics routing, and disruption response. This dual-layered classification approach allowed for meaningful cross-analysis of techniques and application areas, revealing patterns of deployment, methodological trends, and potential research gaps within the AI-SCM interface.

2.7 Inter-Rater Reliability and Bias Minimization

To strengthen the reliability and objectivity of the review process, dual independent reviewers conducted the screening, quality assessment, and data extraction phases. A third expert arbitrator was consulted to resolve any discrepancies. Inter-rater reliability was quantitatively evaluated using Cohen's Kappa coefficient, which yielded a value of 0.82, indicating a strong level of agreement between reviewers. This rigorous approach minimized subjectivity and potential selection bias. Moreover, consistent use of predefined inclusion/exclusion criteria and standardized evaluation rubrics further mitigated procedural bias and ensured consistency throughout the review. By incorporating these safeguards, the methodology not only upheld transparency and replicability but also reinforced the academic validity of the synthesized results.

3. Results and Analysis

The systematic review of 142 peer-reviewed articles revealed significant insights into the application patterns, techniques, and industry focus of artificial intelligence (AI) in supply chain management (SCM). The findings are synthesized across three primary dimensions: the distribution of AI techniques, application area concentration, and sectoral adoption trends.

3.1 Distribution of AI Techniques

As illustrated in the figure 2, machine learning (ML) emerged as the most widely used AI technique, featuring in 52 of the 142 analyzed studies. This predominance is attributable to ML's flexibility in predictive analytics, classification, and optimization tasks across diverse supply chain domains. Deep learning (DL) followed with 31 studies, particularly in scenarios requiring image processing, pattern recognition, and high-dimensional data analysis. Expert systems accounted for 25 studies and remained popular for rule-based decision-making in procurement and quality control. Natural language processing (NLP) and reinforcement learning (RL) were less frequent, with 19 and 15 studies respectively, although NLP saw growing use in supplier sentiment analysis and unstructured data

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mining.

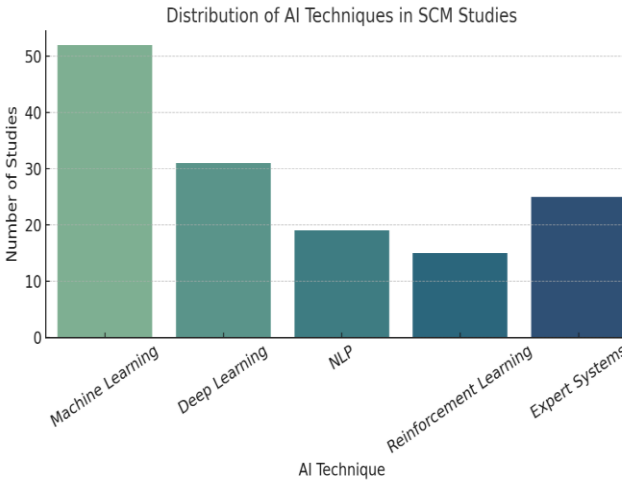


Figure 2:Distribution of AI Techniques

3.2 Application Area Concentration

Figure 3 shows that demand forecasting is the most commonly addressed supply chain function, with 44 articles focusing on AI-enhanced prediction models to optimize planning accuracy. Inventory optimization and logistics routing followed closely, featured in 33 and 29 studies respectively. These applications benefit significantly from AI's capacity to minimize holding costs and improve last-mile delivery precision. Supplier selection was addressed in 21 studies, often involving multi-criteria decision-making models combined with machine learning. Disruption management, though less explored (15 studies), has gained attention recently in light of global shocks, with reinforcement learning and scenario-based AI models being employed to improve supply chain resilience.

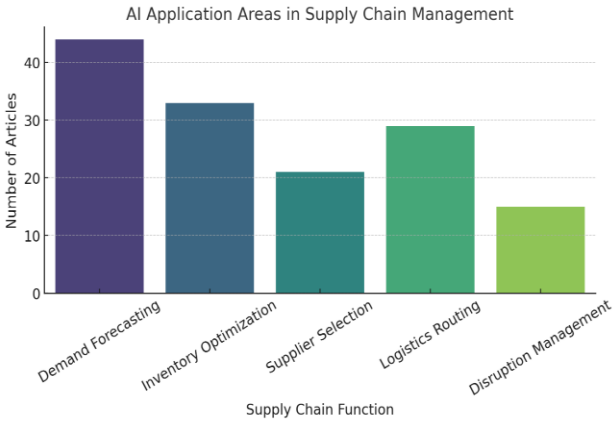


Figure 3: AI Application areas in supply chain management

3.3 Sector-wise AI Adoption Trends

The pie chart depicts sectoral engagement with AI in SCM. Retail (27%) and e-commerce (22%) collectively account for nearly half of the reviewed studies, reflecting their mature data ecosystems and high responsiveness to digital innovation. The automotive sector contributed 20% of the studies, leveraging AI primarily in logistics and supplier network optimization. Healthcare and manufacturing were represented in 11% and 10% of the studies, respectively, often constrained by legacy infrastructure and regulatory requirements. Agriculture remained underrepresented, accounting for only 6% of the literature, suggesting a significant opportunity for AI-driven transformation in resource-constrained environments.

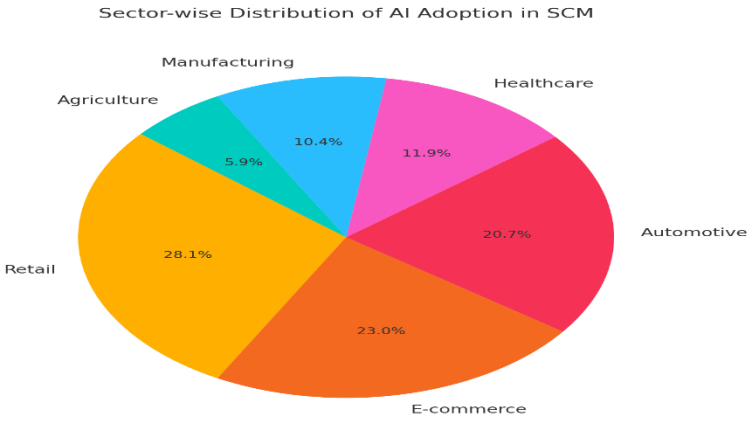


Figure 4: Sector wise distribution of AI adoptation

3.4 Technique-Function Interplay: A Cross-Analysis

To understand how specific AI techniques align with distinct supply chain functions, a cross-tabulated heatmap was developed, as illustrated in Figure 5. The matrix shows that machine learning dominates across all functional areas, especially in demand forecasting (18 studies) and inventory optimization (12 studies), reflecting its strength in predictive modeling. Deep learning is primarily utilized in logistics routing and disruption management due to its capabilities in handling complex, nonlinear patterns. Interestingly, expert systems showed a concentrated application in supplier selection, indicating their relevance in rule-based and multi-criteria decision-making scenarios. Natural language processing (NLP) found modest use in supplier selection and logistics, often to extract sentiment or insights from unstructured textual data. Reinforcement learning (RL) was most effective in adaptive domains like logistics routing and disruption management, where real-time feedback and decision adjustment are critical.

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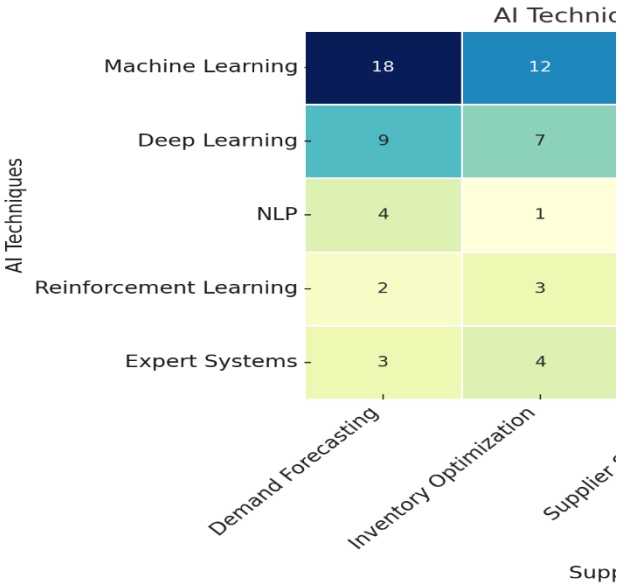


Figure 5: AI techniques vs SCM functions

3.5 AI-SCM Implementation Workflow

The workflow diagram outlines a standard pipeline for integrating AI into supply chain operations. The process begins with data collection from internal systems (ERP, WMS, CRM) and external sources (social media, sensors, third-party logistics). This is followed by data preprocessing, including cleansing, normalization, and feature extraction. In the model selection phase, appropriate AI techniques are chosen based on the problem type—e.g., supervised learning for forecasting, RL for routing. Model training and validation follow, often involving cross-validation, hyperparameter tuning, and performance benchmarking. The validated models are then deployed in operational environments, integrated with dashboards or SCM software. Finally, monitoring and feedback loops ensure continuous performance tracking, anomaly detection, and model retraining. This pipeline highlights the complexity and iterative nature of AI implementation in real-world supply chain settings.

3.6 Challenges and Barriers to Adoption

Despite the clear benefits of AI in SCM, several barriers persist, as summarized in the table provided. Data quality and availability remain foundational issues, with many organizations struggling with fragmented or siloed data systems. Model interpretability is another key concern, especially for black-box techniques like deep learning that lack transparency—a major limitation in regulated or high-stakes environments. Integration challenges are widespread, particularly where legacy ERP systems resist modular or API-based AI integration. Cybersecurity risks increase with digital expansion, as AI models and pipelines introduce new attack surfaces. Additionally, skill gaps in the workforce—especially in AI development, deployment, and maintenance—impede adoption. Finally, ethical and legal concerns such as algorithmic bias, accountability, and lack of regulatory clarity remain under-explored in the global supply chain context.

4. Conclusion

This systematic review has critically examined the role of artificial intelligence (AI) in transforming decision-making within supply chain management (SCM) from 2010 to 2024. Drawing from 142 peer-reviewed journal articles and guided by the PRISMA methodology, the analysis reveals that AI is increasingly integrated into key supply chain functions, particularly demand forecasting, inventory optimization, logistics routing, supplier evaluation, and disruption management. Among the diverse AI techniques explored, machine learning and deep learning remain the most dominant, while reinforcement learning and natural language processing show promising, yet underutilized, potential.

The review highlights that AI offers significant improvements in predictive accuracy, real-time responsiveness, and operational efficiency. However, it also uncovers substantial challenges to adoption, including data quality issues, lack of interpretability, difficulties in system integration, cybersecurity risks, and workforce skill gaps. Moreover, ethical considerations surrounding algorithmic transparency, data privacy, and fairness are insufficiently addressed in the current literature, especially in global and resource-constrained contexts.

This review contributes to both academia and practice by providing a structured taxonomy of AI methods in SCM, identifying sectoral adoption trends, and outlining a detailed implementation workflow. It also calls for future research focused on interpretable and ethical AI, cross-functional integration, and resilience-oriented design. Policymakers, industry leaders, and researchers must work collaboratively to establish governance frameworks and capacity-building initiatives that support scalable, ethical, and sustainable AI adoption in supply chains.

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অফারগুলো আপনার মতোই অনন্য



এই কার্ডের অনন্য অফারগুলোর মধ্যে রয়েছে

- প্রতিবার বিদেশ ভ্রমণকালে ৪ জনের জন্য বিশ্বের বিভিন্ন আন্তর্জাতিক বিমানবন্দর এবং ঢাকা আন্তর্জাতিক বিমানবন্দরের বলাকা লাউঞ্জ ব্যবহার সম্পূর্ণ ফ্রি
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- ফ্রি এয়ারপোর্ট পিক এন্ড ড্রপ এবং মিট এন্ড গ্রিট-এর সুবিধা
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- POS, QR অথবা E-Commerce-এর মাধ্যমে বছরে ৩ লক্ষ টাকা কেনাকাটা করলেই কার্ড-এর বার্ষিক চার্জ সম্পূর্ণ ফ্রি

যত পয়েন্ট তত পুরস্কার

রিওয়ার্ড পয়েন্ট	POS/QR/ E-Commerce-এ কার্ড দিয়ে পেমেন্টের পরিমাণ (টাকা)	সুবিধাসমূহ
৬,০০০ পয়েন্ট	১,৫০,০০০	এক বছরের জন্য সাপ্লিমেন্টারি কার্ডের চার্জ ১০০% মওকুফ/ প্রাইমারি কার্ডের চার্জ ৫০% মওকুফ
১২,০০০ পয়েন্ট	৩,০০,০০০	এক বছরের জন্য প্রাইমারি কার্ডের চার্জ ১০০% মওকুফ
১৬,০০০ পয়েন্ট	৪,০০,০০০	পাঁচ তারকা মানের হোটেলে ফ্রি বুফে ডিনার কুপন
২৫,০০০ পয়েন্ট	৬,২৫,০০০	পাঁচ তারকা মানের হোটেলে এক রাত ফ্রি থাকার ব্যবস্থা
৬০,০০০ পয়েন্ট	১৫,০০,০০০	ঢাকা-ব্যাংকক-ঢাকা ইকোনমি ক্লাস এয়ার টিকেট প্রদান

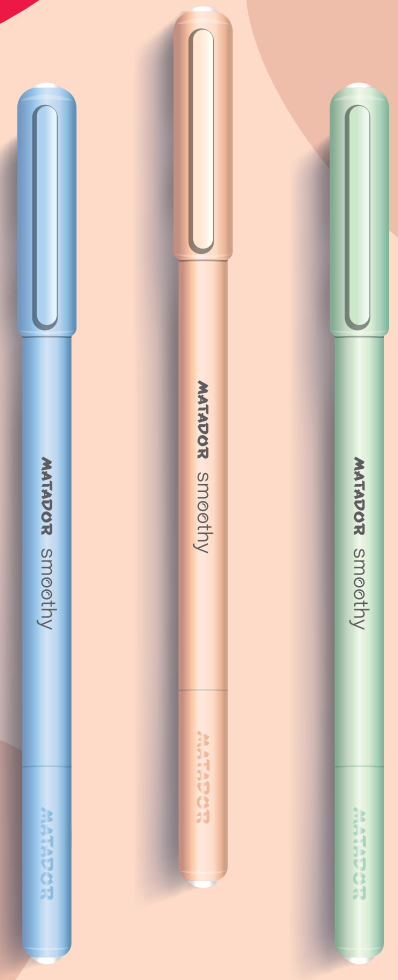
মাত্র ৫০০ টাকা ব্যবহারে ২০ রিওয়ার্ড পয়েন্ট

বিস্তারিত জানতে আমাদের যেকোন শাখায় যোগাযোগ করুন অথবা ডায়াল করুন **16216**

*শর্ত প্রযোজ্য

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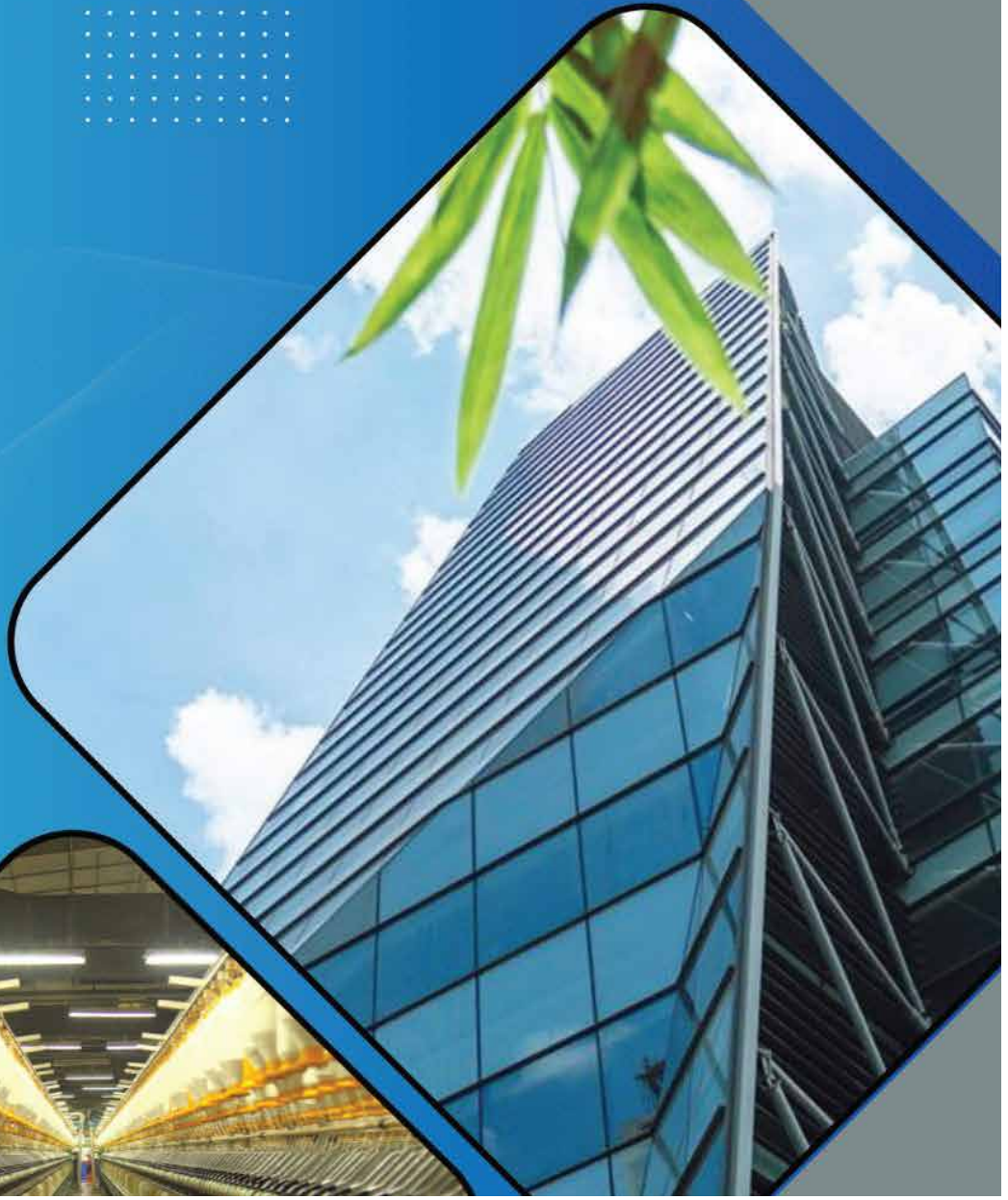
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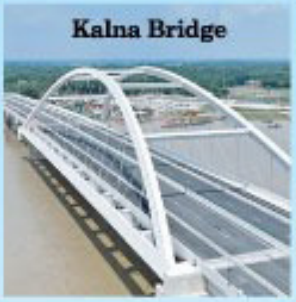
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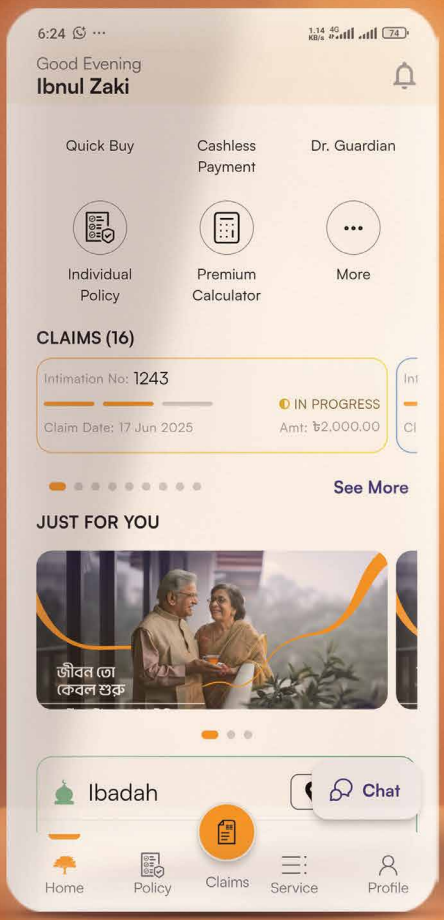
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