



SUSTAINABLE SOLUTIONS FOR PERUSAL AND PRACTICE

THE WAY FORWARD

Editors

Dr. Sanjay K. Deshpande

Dr. Vanishri R. Hundekar and Dr. Rekha D. Birje





SUSTAINABLE SOLUTIONS FOR PERUSAL AND PRACTICE - THE WAY FORWARD

Editors

Dr. Sanjay K. Deshpande

Associate Professor, Department of MBA
KLS Gogte Institute of Technology, Belagavi, Karnataka, India

Dr. Vanishri R. Hundekar

Associate Professor, Department of MBA
KLS Gogte Institute of Technology, Belagavi, Karnataka, India

Dr. Rekha D. Birje

Assistant Professor, Department of MBA
KLS Gogte Institute of Technology, Belagavi, Karnataka, India



Publication and Editorial services facilitated by

Journal Press India
Delhi, India

Title: Sustainable Solutions for Perusal and Practice - The Way forward

Editors: Dr. Sanjay K. Deshpande, Dr. Vanishri R. Hundekar and Dr. Rekha D. Birje

Published by : JOURNAL PRESS INDIA
Publisher's address: A-4/17, 1st Floor,
Sector-15, Rohini,
Delhi - 110 089, India
Mobile: 8826623730
Tel: +91-11-42631517
Website: www.journalpressindia.com
E-mail: info@journalpressindia.com

First Edition, Mar 2026

DOI: 10.17492/JPI/KLSGIT/260000

Online ISBN: 978-93-49790-52-0



Scan for online version

Copyright © 2026 Department of MBA, KLS Gogte Institute of Technology, Belagavi

All rights reserved. No part of this publication may be reproduced or transmitted in any form by any means, electronic or mechanical, including photocopy, recording, or any information storage and retrieval system, without permission in writing from the publisher.

The publisher is not responsible for authors' and editors' expressed opinions, view and the contents of this published book. The originality, proof reading of the manuscript and errors are the sole responsibility of the authors and editors.

Contents

<i>About the Book</i>	 v
<i>Preface</i>	 vi
<i>About the Editors</i>	 vii
<i>Acknowledgements</i>	 viii

Chapter 1

Design and Development of a Bluetooth-Enabled Electric Toothbrush for Children	
<i>Alrio Chaves Fernandes, Veena Benakatti and Anand Badavannavar</i>	...1

Chapter 2

Advancing Financial Inclusion: A Study of Technological and Sustainable Practices in Modern Banking	
<i>Deepa Savadi</i>	...6

Chapter 3

Fintech Startups and Their Role in Enhancing Financial Literacy	
<i>Preeti Dalavi, Kartik Buwaji, Vanishree Hundekar and Sanjay Deshpande</i>	...15

Chapter 4

Blockchain-Enabled Retrospective Green Clearances: Sustainability Significance and Environmental Governance Impacts	
<i>Jasleen Kaur</i>	...24

Chapter 5

Experience-Centric Induction to Principles of Management: The Mahakumbh Mela City Construction Assignment	
<i>Prajwal Melinamani and Ramakant Kulkarni</i>	...34

Chapter 6

Role of Human Resource in Implementing Green Practices within Hospitality Organization	
<i>Preetam U. Revankar and Tanvi P. Revankar</i>	...40

Chapter 7

Does Nutritional Value Influence Consumer Buying Behavior?	
<i>Radhika Itgekar and Shailaja Hiremath</i>	...59

Chapter 8

AI-Driven Smart City Solutions for Sustainable Crowd Management: Lessons from Kumbh Mela 2025

Ramakant Kulkarni and Bharati Badiger ...83

Chapter 9

A Study on Workload and Job Stress as Determinants of Performance and Psychological Well-being among Employees

Shreyas Pujari, Anvi Sammatshetti and Rekha Birje ...100

Chapter 10

Exploring Quantum Computing Applications in Portfolio Optimization: Indian Perspective

Sangam Jadhav, Vanishri Hundekar, Prasad Kulkarni and Vrushali Pakhannavar ...113

Chapter 11

A Study on Projected Cash Flow Statement

Shivaraj Khilare, Savitha Kulkarni and Shailaja Hiremath ...125

Chapter 12

Bridging Tradition and Technology: AI Applications in Homoeopathic Materia Medica and Repertory Analysis - Narrative review

Shiwani Malai and Apeksha Kanago ...145

Chapter 13

Leveraging Artificial Intelligence to Support SDG 4

Sonal Revankar ...155

Chapter 14

A Study on Implementation of CAPM on Nifty 50 Stocks

Tanushree Sampgaonkar ...160

About the Book

“Sustainable Solutions for Perusal and Practice - The Way forward” is an edited volume that delves into the transformative impact of innovation, emerging technologies, and sustainable practices on the contemporary business environment. The book provides a comprehensive overview of strategies, frameworks, and research that illustrate how businesses, institutions, and policymakers can navigate and thrive amidst the rapid evolution of global markets. It covers topics such as digital transformation and artificial intelligence, sustainable business models, fintech and banking innovations, human resource practices in a technology-driven world, healthcare management, eco-tourism, and the growing role of entrepreneurship in driving competitive advantage. This book is an in-depth exploration of how organizations across sectors can harness innovation and technology to build resilient, future-ready, and sustainability-oriented enterprises.

By bringing together diverse perspectives through rigorously reviewed research papers, the book aims to foster a deeper understanding of how innovation, technology, and sustainability are interconnected forces shaping the future of business. Offering a thoughtful blend of theoretical insights and practical applications, it examines how emerging technologies and forward-looking management strategies can serve as catalysts for inclusive and sustainable growth. Through illuminating the potential of AI, green business practices, and entrepreneurial ecosystems, the book presents a multidisciplinary approach to building adaptive and forward-thinking organizations.

This book navigates the paradigm shifts across industries, exploring the evolving business landscape by deliberating on the relationship between innovation, technology, and global sustainability challenges. It reveals the potential, opportunities, and practical solutions that lie ahead for researchers, managers, and entrepreneurs. More than a book, this is a comprehensive knowledge resource for policymakers, academicians, business leaders, industry professionals, and change-makers who are dedicated to fostering business resilience, sustainable development, and organizational excellence through effective technological and managerial interventions.

Preface

The rapid convergence of innovation, technology, and sustainability has fundamentally reshaped the contours of modern business. Organizations across the globe are navigating an era of unprecedented transformation — one where digital disruption, ecological responsibility, and strategic agility are no longer optional but imperative. It is against this dynamic backdrop that the Department of MBA, KLS Gogte Institute of Technology, Belagavi, organized the International Conference on “Innovation, Technology, and Sustainability: Driving an Evolving Business Landscape” held in hybrid mode from 12–14 February 2026.

This edited volume is a curated collection of peer-reviewed research papers presented at the conference, bringing together the intellectual contributions of academicians, industry professionals, research scholars, and students from across the globe. The papers span a rich spectrum of themes — Finance and Banking, Human Resources, Marketing, General Management, AI and Technology, Healthcare, Sustainability, Eco Tourism, Business Strategy, and Innovation and Entrepreneurship — reflecting the truly multidisciplinary character of the conference.

Each paper in this volume has undergone a rigorous blind review process, ensuring academic integrity and scholarly merit. The contributions range from conceptual frameworks and empirical investigations to case studies and policy analyses, offering readers a comprehensive lens through which to examine the forces reshaping business ecosystems worldwide.

It is our sincere hope that this volume serves as a valuable reference for researchers, practitioners, and policymakers who are committed to building sustainable, innovation-led, and technologically empowered futures. We believe the ideas and insights contained herein will spark further inquiry, collaboration, and meaningful dialogue well beyond the conference itself.

Editors

Dr. Sanjay K. Deshpande

Dr. Vanishri R. Hundekar

Dr. Rekha D. Birje

About the Editors

Dr Sanjay K. Deshpande is a management faculty resource with 18 years of experience in Teaching and consultancy, PhD in the area of evaluation of Soft Skills Training, MBA in HRM and a PGDELP from National Law University. He is also a certified trainer from NSDC and Skill India, BOSCH certified trainer for Nation Building, Certified HR Data Analyst. His areas of interest are Human Resources Management, Psychology, Learning & Development, Tiger Conservation, Outbound training, and Wildlife Management. He has conducted many training programs and offered consultancy programs to organizations like Gold's Gym, ACG Pharma Pack, LIC, SULA Wines, and others. Awarded as "Best Management Researcher" in the HR stream, and has secured the best research, with many milestones to his credit, and has authored a book with LAP Lambert Publishing Germany, with many Scopus indexed publications.



Dr. Vanishri R. Hundekar is an Associate Professor in the Department of MBA at KLS Gogte Institute of Technology. She brings over 16 years of experience in academia and research. She has PGDELP from National Law University. Her areas of expertise include finance and investment. She is a recognized Research Supervisor (Guide) at Visvesvaraya Technological University (VTU). Dr. Vanishri Hundekar has actively participated in several national and international conferences and is a recipient of Best Paper Awards. She has organized multiple research and case conferences and has also served as an organizer for ATAL Faculty Development Programmes (FDPs). She has an extensive publication record, with papers indexed in ABDC-listed journals, Scopus, and reputed quartile journals.



Dr. Rekha D. Birje is an Assistant Professor in the Department of MBA at KLS Gogte Institute of Technology, Belagavi, with over 18 years of combined academic, research and industry experience. She holds a Ph.D. in Commerce from Rani Channamma University and has qualified KSET. Her academic interests include Financial Management, Investment Management, Banking and Financial Services, and Personal Finance. She has actively contributed to research through publications and paper presentations at national and international conferences in the areas of finance, financial literacy, climate accounting, HR, and SME banking. She has participated in various Faculty Development Programmes and research-oriented workshops, reflecting her commitment to continuous learning and academic excellence. She has organized various workshops, research colloquium and national and international conferences. She is dedicated to fostering research culture, academic collaboration, industry-relevant learning among management students & scholars.



Acknowledgements

The successful conduct of the International Conference on “Innovation, Technology, and Sustainability: Driving an Evolving Business Landscape” and the publication of this edited volume would not have been possible without the generous support, encouragement, and tireless efforts of numerous individuals and institutions, to whom we owe our deepest gratitude. We begin by expressing our sincere reverence to the Chief Patrons Shri. Pradeep Sawkar, President, Karnatak Law Society, Belagavi, Shri. Ram Bhandare and Shri. Deepak Kulkarni, Vice President, KLS, Shri. A K Tagare, Chairman, KLS, and Shri. V M Deshpande and Shri. Sudhindra Ganachari, Secretaries, for their visionary leadership and unwavering support for academic excellence.

We are deeply grateful to Patrons Shri. Rajendra Belgaumkar, Chairman, Governing Council, KLS GIT and Members of the Governing Council, Shri. Uday N Kalundrikar, Shri. Ravindra S Mutalik and Shri. Prashant S Kulkarni for their constant guidance and institutional backing.

Our heartfelt thanks are due to Dr. M. S. Patil, Principal, KLS GIT and Chief Convener of the conference, whose leadership and organizational vision set the highest standards for this academic event.

We extend special appreciation to Dr. H. N. Shivaprasad, Dean – MBA and Co-Convener, for his academic direction and meticulous oversight of every stage of the conference and publication process. The Conference Secretaries, Dr. Sanjay K. Deshpande, Dr. Vanishri R. Hundekar and Dr. Rekha Birje, deserve special recognition for their extraordinary dedication, operational excellence, and commitment to ensuring the seamless execution of the conference and this publication.

We are sincerely thankful to our Publishing Partner, Journal Press India for their professionalism and support in bringing this volume to publication with an ISBN and DOI, lending it global academic visibility. We are also grateful to all the keynote speakers, session chairs, and reviewers whose expertise and critical engagement elevated the quality of the papers selected for this volume. Our thanks extend to every author and co-author who entrusted us with their scholarly work. Finally, we acknowledge the enthusiasm and energy of the students, faculty, and staff of the Department of MBA, KLS GIT, whose collective effort transformed this conference into a truly memorable academic forum. This volume stands as a testament to the power of collaborative scholarship. We dedicate it to all those who believe in the transformative potential of knowledge.

Editors

Dr. Sanjay K. Deshpande
Dr. Vanishri R. Hundekar
Dr. Rekha D. Birje

CHAPTER 1

Design and Development of a Bluetooth-Enabled Electric Toothbrush for Children

*Alrio Chaves Fernandes**, *Veena Benakatti*** and *Anand Badavannavar****

ABSTRACT

Background: Establishing good oral hygiene habits during childhood is vital for preventing cavities and gum diseases later in life. However, children often struggle to effectively remove plaque with manual toothbrushes due to poor technique, limited dexterity, low motivation, and short brushing times.

Objective: To create, develop, and showcase a child-friendly ultrasonic electric toothbrush that includes Bluetooth audio features to improve brushing effectiveness and engagement.

Materials and Methods: We designed an ultrasonic electric toothbrush that features a piezoelectric vibration system, various brushing modes, and Bluetooth Low Energy (BLE) connectivity. This device streams audio from a paired smartphone to a built-in speaker. We performed bench tests to evaluate its performance and battery life. A demonstration in a school setting involved 500 children to assess usability and acceptance.

Results: The toothbrush produced consistent ultrasonic vibrations across all modes without needing manual pressure. The Bluetooth connection was reliable, and the audio output was clear. The rechargeable battery lasted about six to eight hours of use per charge. Children showed a high level of interest and excitement during the demonstration at school.

Conclusion: We successfully developed and demonstrated a patented Bluetooth-enabled ultrasonic electric toothbrush for children. The combination of ultrasonic cleaning and audio features may boost brushing habits and motivation among kids. Further studies are needed to evaluate long-term oral health results.

Keywords: Ultrasonic toothbrush; Bluetooth audio; Pediatric oral hygiene; Smart toothbrush; Plaque control.

1.0 Introduction

Good oral hygiene habits developed during childhood are crucial in preventing cavities, gingivitis, and future gum disease.¹

**Corresponding author; Undergraduate Student, Bachelor of Dental Surgery, KLE VK Institute of Dental Sciences, Belagavi, Karnataka, India (E-mail: alriochavesfernandes@gmail.com)*

***Reader, Department of Prosthodontics & Crown and Bridge, KAHER'S KLE VK Institute of Dental Sciences, Belagavi, Karnataka, India (E-mail: kenganalveena@gmail.com)*

****Professor, Department of Orthodontics and Dentofacial Orthopaedics, KAHER'S KLE VK Institute of Dental Sciences, Belagavi, Karnataka, India (E-mail: anand_ortho@yahoo.co.in)*

Manual tooth brushing requires the right technique, pressure, and duration, which children often do not manage effectively.² As a result, controlling plaque in kids remains a challenge. Powered toothbrushes show better plaque removal and gum health benefits compared to manual brushing, especially for those with limited dexterity.^{1–3} Ultrasonic toothbrushes work by creating high-frequency vibrations that disrupt dental biofilm with minimal movement, making them a good fit for children and those with gum sensitivity.^{4,5}

Recent progress in digital health and smart oral care tools has introduced mobile apps, audiovisual feedback, and music to help increase motivation and compliance in kids.^{6–9} In addition, maintaining toothbrush hygiene, managing bristle wear, and the ability to clean or replace brush heads are key to effective cleaning and good oral health.^{10,11}

This study outlines the design and development of a patented ultrasonic electric toothbrush for children that includes Bluetooth audio capability and features aimed at improving brushing effectiveness and user engagement.

2.0 Materials and Methods

2.1 Device design and functional components

The toothbrush was developed in collaboration with Assalihin HealthCare Solutions LLP, Belagavi. Its main mechanism includes an ultrasonic vibration module using a piezoelectric transducer to generate high-frequency oscillations that disrupt plaque.⁴ An electronic control unit manages vibration strength and allows selection of slow, medium, and fast brushing modes. We included electronically programmed clockwise and counterclockwise motion patterns to improve coverage on tooth surfaces. Bluetooth Low Energy (BLE) technology enables wireless pairing with smartphones, allowing for audio streaming to a small speaker located in the toothbrush handle.^{6,7}

2.2 Hygienic and mechanical features

The toothbrush head can be detached and washed. Interchangeable rubber caps for bristles were designed to improve safety, reduce soft-tissue injury, and engage children. The handle features an ergonomic shape that suits small hands, promoting ease of use.

2.3 Power supply

The device runs on a rechargeable lithium-ion battery and can be charged through a wired port. Bench tests showed an average use time of six to eight hours per charge.

2.4 School-based demonstration

We conducted an oral hygiene awareness and demonstration program at Regina Mundi High School, Chicalim-Vasco, Goa, with around 500 students. The children received

instructions on proper use and observed live demonstrations of the toothbrush. The initiative earned a Certificate of Appreciation from school authorities. No clinical measurements were taken.

3.0 Results

The ultrasonic toothbrush delivered steady and consistent vibrations during testing and demonstrations without needing brushing pressure.^{4,5} All brushing modes worked as expected. Bluetooth connectivity was stable throughout testing, and audio from the built-in speaker was clear. The detachable brush head and interchangeable caps were easy to put on, take off, and clean. Battery tests showed an operational time of around six to eight hours per charge. During the demonstration at school, children expressed significant interest and enthusiasm for the device.

4.0 Discussion

The results align with existing research showing that powered and ultrasonic toothbrushes provide better plaque control than manual brushing.^{1–3} Ultrasonic technology lessens the need for skill and pressure while brushing, which benefits young users.^{4,5}

Music and audio-guided brushing have been proven to reduce dental anxiety, increase brushing time, and enhance compliance in children.^{8,12} Smart toothbrush systems, which include digital or audio guidance, have shown positive effects on behavior in children's oral health programs.^{6,9}

The design of this device, which includes replaceable and washable parts, addresses issues related to bristle wear and contamination that can lower brushing effectiveness.^{10,11} The school demonstration emphasizes the device's acceptability and its potential in community-level oral health education. However, randomized controlled clinical trials are needed to determine long-term benefits.

5.0 Conclusion

We developed and demonstrated a patented Bluetooth-enabled ultrasonic electric toothbrush tailored for children. This device combines ultrasonic plaque disruption, interactive audio engagement, multiple brushing modes, and hygienic replaceable parts. Registration with the India Book of Records and positive feedback from a 500-student demonstration in Goa highlight its uniqueness and importance. This smart toothbrush offers promising support for improving children's oral hygiene practices.

6.0 Acknowledgments

The authors thank Regina Mundi High School, Chicalim, Goa, institutional mentors, Assalihin HealthCare Solutions LLP, Belagavi, and technical staff for their support. The authors report no conflicts of interest.

References

1. Yaacob M, Worthington HV, Deacon SA, Deery C, Walmsley AD, Robinson PG, et al. Powered versus manual toothbrushing for oral health. *Cochrane Database Syst Rev*. 2014;6:CD002281.
2. Saxer UP, Yankell SL. Impact of improved toothbrushes on dental plaque removal. *J Clin Dent*. 1997;8(3):69-73.
3. Van der Weijden GA, Slot DE. Efficacy of powered toothbrushes: a systematic review. *Int J Dent Hyg*. 2011;9(2):91-104.
4. Walmsley AD. Ultrasonic and sonic toothbrushing: a review of the literature. *J Dent*. 2004;32(6):455-460.
5. Walmsley AD, Williams AR. Effects of ultrasonic toothbrushes on dental plaque. *J Clin Periodontol*. 1989;16(3):148-152.
6. Alkilzy M, Midani R, Höfer M, Splieth CH. Improving toothbrushing with a smartphone app: randomized controlled trial. *J Med Internet Res*. 2019;21(2):e13267.
7. Zahid T, Khan MA, Bhayat A. Effectiveness of a mobile app on children's oral hygiene. *Int J Dent Hyg*. 2020;18(3):321-327.
8. Kayaaltı-Yüksek S, et al. Effect of music on plaque removal in children with dental anxiety. *Int J Paediatr Dent*. 2022;32(1):90-98.
9. Lee J, et al. Smart toothbrush-based oral health education in children: a randomized trial. *Children (Basel)*. 2023;10(4):622.
10. Van Leeuwen MPC, Slot DE, Van der Weijden GA. Toothbrush wear and plaque removal efficacy. *Int J Dent Hyg*. 2018;16(1):12-19.
11. Rawls HR, Mkwai-Tangho E. Toothbrush bristle wear and cleaning effectiveness. *J Dent Res*. 1992;71(5):1111-1115.
12. Marwah N, Prabhakar AR, Raju OS. Music distraction—its efficacy in management of anxious pediatric dental patients. *J Indian Soc Pedod Prev Dent*. 2005;23(4):168-170.
13. Aggarwal N, et al. Plaque removal efficacy of different toothbrushes in children. *Int J Clin Pediatr Dent*. 2019;12(3):201-205.
14. Tavakoli S, et al. Effectiveness of school-based supervised toothbrushing programs: a systematic review. *BMC Oral Health*. 2025;25:112.

15. Fischman SL. The history of the toothbrush. *J Am Dent Assoc.* 1997;128 Suppl:19S-25S.
16. Authors' records. Patent grant documentation, India Book of Records registration, and Certificate of Appreciation for school demonstration in Goa, 2025. Unpublished data.

CHAPTER 2

Advancing Financial Inclusion: A Study of Technological and Sustainable Practices in Modern Banking

*Deepa Savadi**

ABSTRACT

The quality of a financial inclusion in the country is excellent which pays to boost the economy in the middle. In the last four years, the revolution in the digital world and the various financial reforms have pushed financial inclusion significantly. Due to this, more people are getting the financial services. Over the past four years, Indian banks have made significant strides in providing functions and services to the financially excluded and the poor. The article addresses the needed improvements in the use of ICT and banking stability in India financial inclusion. The primary sources for this article are Indian non-profit and academic institutions and government publications. Data study using banking research from the Department of Financial Services Annual Report 2024-25. Innovative financial strategies for India's banking industry must integrate digital infrastructure with Regional Rural Banks. This will boost bank account services, particularly in poor communities.

Keywords: Digital banking; Financial inclusion; Public sector banks; Rural regional banks; India.

1.0 Introduction

Financial inclusion is a priority to build a society where everyone may succeed financially. There have been lots of recent changes in technology, which have greatly impacted India's banking sector. We have mobile banking, net banking, digital banking, aadhaar-based account opening, and account opening with just your mobile number. We commend the high degree of financial inclusion in the country. It raises the economy. Over the last decade, digital innovation and financial reform have increased financial inclusion. Financial services are used more than ever. Indian banks have improved outreach to the poor and financially disadvantaged in the last decade. In addition, Banks are adopting the new dimension which is sustainable. There exist electronically digitized passport books which are paperless.

**Research Scholar, Department of Commerce, Rani Channamma University, Belagavi, Karnataka, India (E-mail: savadideepaitagi@gmail.com)*

These ATMs are environmentally sustainable as well. In addition to this, there are also 'green' banking system and branches. Bank financing is also extended to green commodities. Another option is social-responsibility lending and eco banking. Resource wrap and grow banks will be from this type. The study will show how the role of technology can help in bringing sustainable banking in the banking systems of India. The statement delves into the financial service offerings of the various farmer support sectors in the different regions. It assesses the level of awareness of the people to the digital and sustainable banking. The research will also assist financial institutions, government officials, and policymakers in improving their decision-making quality.

2.0 Literature Review

Kendall and Voorhies (2014) have highlighted that it results in the reduction of transaction cost. It further notes that it helps institutions better serve the poor and remote with these technologies at the cutting edge.

The stakeholders in rural areas and villages are increasingly opting for the interface for operational activities as it is simple, cheap and easy to operate. The study says that the recent advancements in the digital banking industry has eased the banking lot for the common man unlocking the scope for better financial inclusion and agency. It is essential to know the schemes developed by the Indian government, such as UPI, AEPS, e-KYC, etc. These efforts made the payments easier, faster, and more straightforward. Furthermore, e-KYC facilitated the speedy onboarding of consumers and expanded the accessibility and convenience of financial services nationwide.

The World Bank (2022) states that there is strong evidence supporting India's financial inclusion in the Global Findex Database of 2021. Better customer satisfaction and institutional development are direct results of investing in human resources.

Mishra and Bhattacharya (2020) reveal that sustainability-oriented reforms positively influence financial inclusion in public sector banks. Their findings highlight that responsible and sustainable banking practices strengthen inclusivity and promote long-term development.

The Annual Report of Regional Rural Banks (2024–25) shows that RRBs achieved strong rural outreach while maintaining profitability. Banking and finance are crucial for our lives. It is essential for a country's economy to initiate the process of growth and development. Additionally, Any firm must do the function frequently. Banks also greatly support the economy by offering and accepting loans. Banking has a two-fold function where they accept deposits and lend money to people. They also offer other special services like overdraft.

3.0 Objectives

- To evaluate the influence of technological advancements on banking business.
- To evaluate the functionality of PSBs and RRBs.
- Investigate Digital Payment Trends.

4.0 Hypotheses

4.1 To study the growth of financial inclusion

- (H₀): The financial inclusion index showed minimal development throughout the research.
- (H₁): There is a significant growth in financial inclusion over the study period.

4.2 To examine trends in digital payments

- (H₀): There is no significant change or trend in digital payment transactions over the study period.
- (H₁): There is a significant change or trend in digital payment transactions over the study period.

5.0 Scope of Study

This research evaluates financial inclusion in India via online banking and payment system growth. This study covers 20-21 to 24-25. The period witnessed further enhancements to the banking system's technology and access to financial services. All the secondary data related to the research are derived from government publications, reputed global agencies, publications by the Reserve Bank of India and the Department of Financial Services.

The paper focuses extensively on PSBs and RRBs to analyze the roles they play in broadening access to formal banking services, made possible through the initiatives of the government. Financial services offered by technology such as UPI, AEPS, BHIM, Rupay, PMJJBY, PMSBY, APY, and PMMY are increasing. It focuses on the thinly populated regions, particularly the rural and semi-urban areas, which are more affected by financial exclusion. The research examines the macro level patterns, probable pathways, and the present state of institutional outcomes related to electronic payment systems and financial inclusion. The merchants of consumer goods and financial services are not legally obliged to take all reasonable efforts to protect consumers' information. According to the research, services and goods targeting an ordinary consumer do not require the collection of personal information.

6.0 Research Methodology

The Research Paper Studies Impact of Sustainable Banking Innovations on Financial Inclusion in India With the Help of Secondary Data Rather than Personal Behaviour Studies. According to our study of the Annual Report 2024–25 and other reliable sources like academic papers, government data, and RBI reports, the performance of the institution and the related trends and policies is examined.

The research looks at the impact of technology on sustainability using qualitative and quantitative techniques. The methodology involved qualitative and quantitative approaches. It uses literature review from reputable sources for data collection. Study verifies affirmatives through data collected from interviews and questionnaires to experts. The period from FY 20-21 to FY 24-25 has seen the launch of many other financial inclusion schemes and digital innovations for enhancing banking.

The study will cover many parameters. One example of the financial inclusion initiative classes is about the use of bank through inclusive banking offerings and also the role played by the banking non-credit sector that digital means or device are offering the services.

The article try to make the researchers aware of the present & potential future of financial inclusion. The RBI and Indian government formulated many policies to achieve financial inclusion of people by 2024. This research uses unique data analysis.

7.0 Data Analysis and Calculations

Hypothesis 1: Growth of Financial Inclusion

Ho: There is no significant growth in financial inclusion over the study period.

H₁: There is a significant growth in financial inclusion over the study period.

Table 1: Performance of Rural Banking

Indicator	Value
Number of RRB Branches	22,069
Share of Rural & Semi-Urban Branches (%)	92%
Priority Sector Lending (%)	87%
Lending to Weaker Sections (%)	61%
Agriculture Lending (%)	67%
Rural Credit-Deposit Ratio (%)	71.4%

Figure 1: Performance of Rural Banking

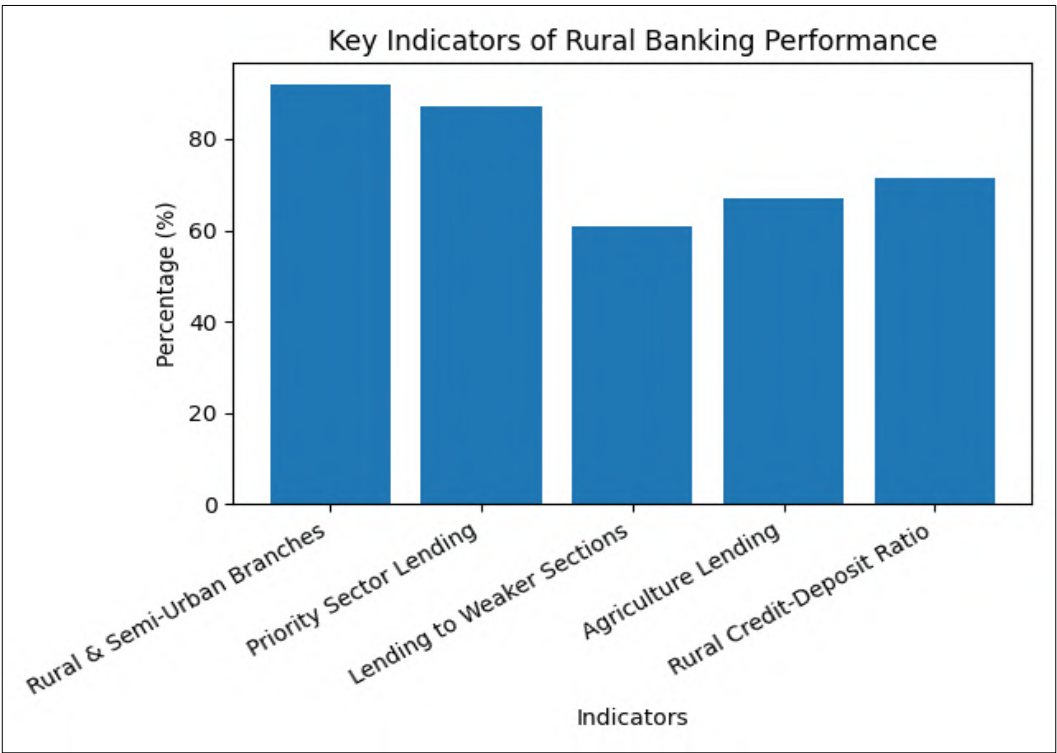


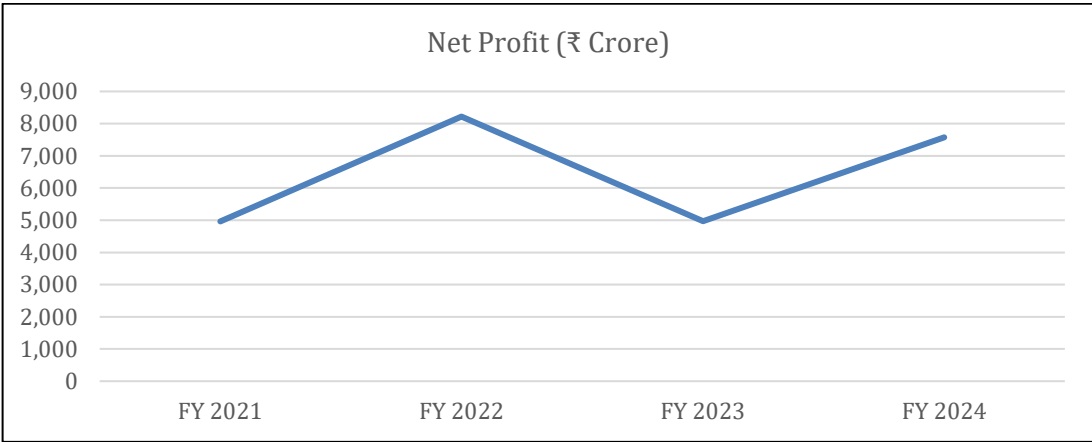
Table 2: Net Profit of Regional Rural Banks (₹ Crore)

Year	Net Profit (₹ Crore)
FY 2021	4,963
FY 2022	8,219
FY 2023	4,972
FY 2024	7,571

Table 3: Growth Calculation (FY 2021–FY 2024)

Period	Net Profit (₹ Crore)	Growth Calculation	Growth Rate (%)
FY 2021 → FY 2022	4,963 → 8,219	$(8,219 - 4,963) / 4,963 \times 100$	65.6%
FY 2022 → FY 2023	8,219 → 4,972	$(4,972 - 8,219) / 8,219 \times 100$	-39.5%
FY 2023 → FY 2024	4,972 → 7,571	$(7,571 - 4,972) / 4,972 \times 100$	52.5%

Figure 2: Trend of Performance of Rural Banking



Interpretation: The findings demonstrate the critical role that Regional Rural Banks (RRBs) play in fostering financial inclusion in rural areas. RRBs guarantee widespread banking access, with 22,069 branches and 92% of them situated in rural and semi-urban areas. Their 87% priority sector lending, 67% agricultural advances, and 61% lending to weaker sections—directly assisting farmers and vulnerable groups—all demonstrate their strong inclusive emphasis. The majority of rural deposits are reinvested locally, boosting rural economies, as indicated by the 71.4% rural credit–deposit ratio.

Trends in profitability show long-term durability but short-term volatility. Net profit increased by 65.6% in FY 2022, fell by 39.5% in FY 2023, and then recovered significantly in FY 2024 (52.5%), for a total growth of 52.5% between FY 2021 and FY 2024. This demonstrates that financial inclusion has grown without impairing productivity. As a result, H_0 is refused and H_1 is accepted, demonstrating a notable increase in financial inclusion during the course of the study.

Hypothesis 2: Trends in Digital Payments

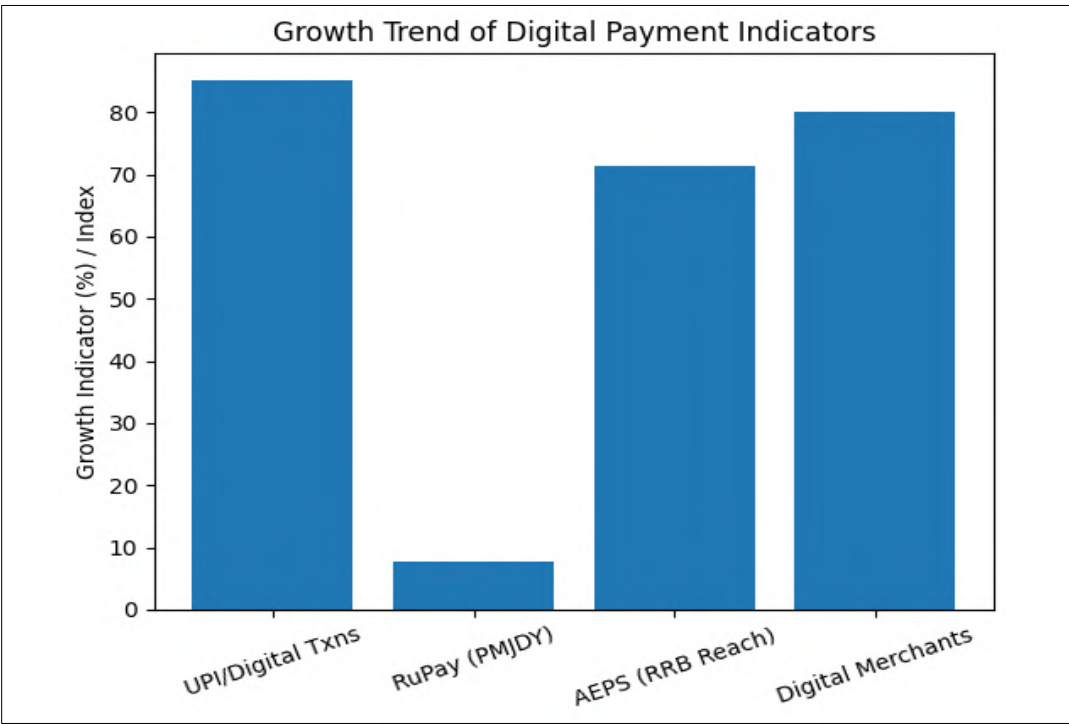
H_0 : When it comes to online payments, nothing has changed.

H_1 : The way money is transferred online is changing drastically.

Table 4: Digital Payment Trends in India

Indicator	Base Value	Latest Value	Calculated Trend
UPI/Digital Transactions	220 crore (FY 2013–14)	18,737 crore (FY 2023–24)	≈55.6% CAGR
RuPay Card Usage	PMJDY-linked	9.84 crore accounts	7.7% YoY growth
AEPS Usage	Limited pre-2015	22,069 RRB branches	Expanded rural access
Digital Merchants	Low base	Nationwide onboarding	Rapid growth trend

Figure 3: Trend in Digital Payment



Interpretation: According to the data, digital payments in India have clearly and steadily increased. From 220 crore in FY 2013–14 to 18,737 crore in FY 2023–24, UPI transactions increased at a robust 55.6% annual growth rate, demonstrating widespread adoption of digital technology. RuPay card usage increased gradually as well, reaching 9.84 crore PMJDY-linked accounts with an annual growth rate of 7.7%, indicating less reliance on cash. By growing to 22,069 RRB branches, AEPS greatly enhanced rural access, and quick digital merchant onboarding bolstered the entire payment ecosystem. As a result, H_0 is rejected and H_1 is accepted, indicating a significant upward trend in digital payment systems over the course of the study.

8.0 Results of the Study

Thanks to institutional changes and technology-driven banking, more people in India, particularly in rural regions, have access to formal financial services, leading to a dramatic increase in financial inclusion. Regional rural banks’ specialized lending and outreach efforts

have helped rural and semi-urban residents. A research discovered that reverse rural banks (RRBs) greatly help low-income communities to help themselves and improve their living conditions. By incorporating inclusiveness into their lending practices, RRBs' profit increase over the last four years has exceeded 52%. Coexistence through inclusion heartens profitable banking through cooperation. Allowed the digital payments system.

9.0 Conclusion

The report states that RBI along with other Institutional and Regulatory Policy Reforms will enable better availability of financial services through Payment Banks. A basic savings account is offered by the bank. The financial inclusion fund mainly derives from the regional rural banks located in backward/deprived areas of rural and urban centres. Presently, efficient inexpensive and universally accessible infrastructure of digital payments exists. The research findings indicate that measures encouraging sustainable and inclusive banking will not be a detriment to profitability as they tend to be better performing, resilient States and stable over the long-run.

10.0 Recommendations

The realism and person centered inclusion approach is critical for successful financial inclusion programs. Digital banking services need to be accessible to all rural government employees. Joining online learning is getting to be a compulsion. Improvement of internet facilities in weaker areas, especially rural will be the first task to do so that financial services are available round the clock. The authors demand from the banking sector continuity of lending and green banking to ensure a balanced and equitable pattern of development and to avert the impact of climate change. E-commerce has witnessed huge growth. There is an urgent need for true and sophisticated cyber defense to safeguard the customer's data and foster a safer and trusted online shopping environment. It is imperative that more innovative initiatives reach disadvantaged rural and poorer people. Financial services should be available and inexpensive.

References

1. Department of Financial Services. *Annual Report 2024–25*. Government of India
2. *Annual-Report-2024-25*
3. Kendall, J., & Voorhies, R. (2014). Digital finance and financial inclusion.
4. Reserve Bank of India. (2020). Digital payment systems and financial inclusion.

5. World Bank. (2022). Global Findex Database.
6. Armstrong, M. (2020). *A Handbook of Human Resource Management Practice*.
7. Reserve Bank of India. (2022). *Financial Inclusion Index*. RBI, Mumbai.
8. Reserve Bank of India. (2023). *Financial Inclusion Report 2022–23*. RBI, Mumbai.
9. Government of India. (2023). *Pradhan Mantri Jan Dhan Yojana (PMJDY) Progress Report*. Ministry of Finance.
10. National Payments Corporation of India (NPCI). (2023). *UPI Product Statistics and Digital Payments Report*.
11. Mishra, S., & Bhattacharya, A. (2020). Sustainability-oriented banking reforms and financial inclusion in Indian public sector banks. *Journal of Banking and Finance Studies*, 12(2), 45–58.
12. Kumari, P., & Singh, R. (2021). Human resource management practices and performance of Indian banks. *International Journal of Bank Management*, 9(1), 23–37.
13. World Bank. (2021). *The Global Findex Database 2021: Financial Inclusion, Digital Payments, and Resilience*.
14. Asian Development Bank. (2022). *Digital Financial Services and Financial Inclusion in Asia*.
15. OECD. (2021). *Financial Consumer Protection and Financial Inclusion*.

CHAPTER 3

Fintech Startups and Their Role in Enhancing Financial Literacy

Preeti Dalavi, Kartik Buwaji**, Vanishree Hundekar*** and Sanjay Deshpande*****

ABSTRACT

FinTech startups have become key players in changing the financial landscape by making financial services easier to access and understand. This study looks at how FinTech startups help improve financial literacy among individuals, especially in developing and emerging economies. The research draws solely on secondary data from scholarly articles, industry reports, policy documents, and trustworthy online sources. It examines how digital platforms like mobile wallets, online investment apps, and digital lending services help users better understand financial concepts. By offering simple interfaces, personalized insights, and educational features, FinTech startups empower users to manage savings, plan budgets, understand credit, and make informed investment choices. Furthermore, these startups promote financial inclusion by reaching people with limited access to traditional banks. However, the study also points out challenges such as low digital awareness, concerns about data privacy, and a lack of trust in digital platforms. The findings indicate that FinTech startups play a major role in closing the financial knowledge gap by combining technology with education. With stronger regulations and increased digital literacy initiatives, their impact on financial literacy can be further improved.

Keywords: FinTech Startups, Financial Literacy, Financial Inclusion, Financial Education, Technology Adoption.

1.0 Introduction

FinTech startups are now central to India's shift from simple account ownership to more substantive financial inclusion. The spread of UPI, mobile wallets and app-based banking has expanded access to formal services, yet national evidence still points to modest financial and digital financial literacy, with sharp gaps by region, gender and income.

**Corresponding author; Student, MBA Department, KLS Gogte Institute of Technology, Belagavi, Karnataka, India (E-mail: preetidalvi2626@gmail.com)*

***Student, MBA Department, KLS Gogte Institute of Technology, Belagavi, Karnataka, India (E-mail: kartikbuwaji7@gmail.com)*

****Associate Professor, MBA Department, KLS Gogte Institute of Technology, Belagavi, Karnataka, India (E-mail: vrhundekar@git.edu)*

*****Associate Professor, MBA Department, KLS Gogte Institute of Technology, Belagavi, Karnataka, India (E-mail: sanjaydeshpande@git.edu)*

Because their apps are used daily, FinTech firms are well placed to double as learning platforms, using intuitive interfaces, local-language content and interactive tools to explain concepts like interest, risk and fraud prevention. Many already offer tutorials, contextual tips, spending insights and goal reminders, along with webinars and offline awareness efforts for first-time digital users. This paper focuses on how such design and outreach choices affect financial and digital financial literacy in India, and whether FinTech innovation is building genuine financial capability or mainly boosting transaction volumes, to inform decisions by policymakers, regulators and startup founders

2.0 Review of Literature

The IJFMR article “A Study on the Relationship Between Digital Literacy and Financial Inclusion in the Context of FinTech Users in India” (2025) shows, using survey data from 300 users, that higher digital literacy significantly increases both frequency and variety of FinTech use, which in turn improves access to savings, payments and basic credit. The authors conclude that digital literacy is a core precondition for inclusive FinTech adoption and urge FinTech firms and public agencies to embed structured digital-literacy support in onboarding, app design and outreach, particularly for low-income and rural users (Author, 2025).

In “FinTech-Driven Financial Inclusion in Rural India” (SSRN, 2025), Priyadarshi finds that rural consumers with higher digital financial literacy are more likely to use apps such as PhonePe and Google Pay for everyday payments and small savings, and that this use is positively associated with formal account usage and access to services. However, socio-cultural norms, low trust and weak infrastructure limit benefits for less literate groups, leading the author to recommend vernacular training, simple interfaces and trust-building by startups, alongside public investment in infrastructure and gender-sensitive policies (Priyadarshi, 2025).

The IJAR paper “role of fintech in financial inclusion” (2025) synthesises secondary data to argue that tools like ATM cards, internet and mobile banking and UPI lower barriers of distance, time and cost while offering channels to deliver financial education through intuitive interfaces and multi-language content. Nonetheless, the article notes that low literacy, cyber-security concerns and weak regulatory awareness still constrain impact and proposes joint action by regulators, banks and FinTech startups to improve infrastructure, consumer protection and in-app financial education (Author, 2025).

The study “Digital Financial Literacy, FinTech Adoption and Investment Behaviour in India” (2024/2025) reports that individuals with higher digital-literacy scores are more likely to use FinTech apps for trading, mutual funds and portfolio tracking, and that this is

associated with greater diversification and engagement with formal investments. The authors warn that limited awareness of risk and cyber-security can undermine these gains for less literate users and call for integrated educational content, risk disclosures and decision-support tools, supported by wider digital-financial-literacy programmes (Author, 2024).

In “What Drives FinTech Adoption? A Study of Financial Literacy in India” (2024), financial literacy is shown—via multivariate analysis—to have a significant positive effect on both intention to adopt and actual FinTech use, even after controlling for demographics and perceived usefulness and trust. The authors argue that FinTech interfaces, tutorials and support should be designed to build users’ financial understanding over time and that policymakers must treat financial literacy as a foundation of digital-finance strategies to avoid disadvantaging vulnerable consumers (Author, 2024).

Gupta’s chapter “Mobile Wallets Growth and Financial Literacy in India” (2024) notes that India combines very high mobile-wallet usage with relatively low financial-literacy levels, which limits effective use of wallets beyond simple payments. Gupta recommends that providers and public authorities invest in in-app tutorials, gamified learning and community partnerships so users can better understand fees, security features and budgeting tools, allowing wallets to support both transactions and financial-literacy enhancement (Gupta, 2024). Ozkaya and colleagues conduct a systematic review that examines how financial literacy is shaped across countries, grouping its determinants into socio-demographic, economic and contextual factors (Ozkaya et al., 2023). Their work highlights that the spread of FinTech and digital finance now plays an important role in how people learn about and manage money through online channels, and they argue that future financial capability models should explicitly incorporate digital financial literacy and FinTech use, particularly for younger and low-income segments (Ozkaya et al., 2023).

The study titled “Digital Financial Literacy in the Era of FinTech” applies PRISMA procedures and bibliometric techniques to trace the development of the digital financial literacy (DFL) field alongside the growth of FinTech (Author, 2025). It observes that most DFL research focuses on users’ competence in navigating digital interfaces, understanding online financial products and dealing with cyber risks in app-based environments, while also noting that definitions and measurement tools are inconsistent, which makes it difficult to compare findings across different studies and settings (Author, 2025).

The review “Financial Literacy and Digital Savings Behavior of Gen Z in the Fintech Era” concentrates on how Gen Z uses FinTech-enabled saving instruments such as e-wallets, neobanks and goal-oriented saving applications (Author, 2025). The authors show that being comfortable with technology does not automatically result in prudent financial decisions; instead, financial literacy and appropriate guidance remain crucial for effective use of

automated saving tools, and features like gamification, instant feedback and personalised prompts are most useful when supported by basic financial understanding (Author, 2025).

In “Financial Literacy and Use of Fintech in MSMEs,” the authors review evidence on how the financial literacy of micro, small and medium enterprise owners affects their adoption and utilisation of FinTech solutions, including digital payments, online lending and accounting systems (Author, 2025). The review finds that owners with stronger financial knowledge are better positioned to judge costs and benefits, interpret contracts and apply FinTech for working capital and business growth, while widespread gaps in literacy and digital skills among micro-entrepreneurs indicate a need for targeted training and supportive policies from both governments and FinTech providers (Author, 2025).

The article “Digital Financial Literacy and Digital Finance Usage: A Systematic Literature Review and Bibliometric Analysis” gathers studies on how digital financial literacy influences the use and intensity of digital finance channels such as mobile banking, e-wallets and online investments (Author, 2025). Its synthesis shows that higher DFL is associated with lower perceived risk and complexity and higher confidence, which together promote more sustained engagement with FinTech services, but the authors point out that most studies are cross-sectional and call for longitudinal work to examine how rising DFL affects long-term financial well-being and resilience (Author, 2025).

The MDPI paper “Factors Affecting Fintech Adoption: A Systematic Literature Review” organises FinTech adoption drivers into categories such as perceived usefulness, ease of use, trust, security, social influence and user capabilities, including financial and digital literacy (Author, 2022). The review concludes that literacy and digital skills often act as enabling conditions that help users interpret information correctly, compare alternatives and manage risks, and it recommends expanding standard technology-acceptance models by treating financial and digital literacy as central antecedents of FinTech adoption, especially in emerging economies (Author, 2022).

In “Challenges and Trends of Financial Technology (Fintech): A Systematic Literature Review,” the authors provide a broad overview of global FinTech developments, addressing themes such as regulation, cybersecurity, data protection, competition and user-level barriers (Author, 2020). They stress that low levels of financial and digital literacy are major obstacles to inclusive FinTech use, as poorly informed users can misinterpret product terms or fall victim to fraud, and they propose that technological innovation should go hand-in-hand with consumer education and transparent communication to avoid reinforcing financial exclusion (Author, 2020).

Alshater and co-authors, in “The Role of Financial Technology on the Nexus Between Demographic, Socio-economic, and Psychological Factors, and the Financial Literacy Gap,” use empirical analysis to examine how FinTech interacts with structural and

psychological variables to influence differences in financial literacy across groups (Alshater et al., 2024). Their findings indicate that FinTech can help narrow literacy gaps where people have basic digital skills and infrastructure, but may widen disparities where these prerequisites are lacking, leading them to argue that FinTech initiatives should be coupled with targeted literacy interventions and inclusive design to ensure marginalised communities also benefit (Alshater et al., 2024).

Prabhakaran and colleagues, in “Perception vs. Reality: Analysing the Nexus Between Financial Literacy and Fintech Adoption,” distinguish between self-assessed and objectively measured financial literacy when analysing FinTech usage patterns (Prabhakaran et al., 2023). They show that overconfident users who rate their knowledge highly but perform poorly on objective tests tend to adopt FinTech products in riskier ways, whereas those with strong tested literacy adopt more cautiously and appropriately, suggesting that FinTech providers and educators need to address misperceptions and overconfidence as well as basic knowledge gaps (Prabhakaran et al., 2023).

Finally, Nguyen and co-authors, in the conference paper “A Study on Factors Influencing Financial Literacy and Fintech Adoption,” combine literature review and empirical data to explore how demographic factors, education, income and psychological traits shape both financial literacy and willingness to adopt FinTech (Nguyen et al., 2024). They propose a dual-path model in which literacy directly drives adoption and indirectly influences attitudes such as trust, perceived usefulness and risk tolerance, and they recommend integrating financial education into formal and community programmes while strengthening digital infrastructure to support broader and more effective FinTech use (Nguyen et al., 2024).

3.0 Research Gap Analysis

Variable	Citation	Gap identified	Gap description
Digital literacy → financial inclusion	Author, 2025 (IJFMR); Priyadarshi, 2025	Limited focus on startup-specific FinTech	Most work links digital literacy to overall FinTech use and inclusion but rarely isolates the role of FinTech startups (e.g., new apps, neobanks) as distinct from banks and big tech.
Digital financial literacy in rural and low-income users	Priyadarshi, 2025; Author, 2025 (IJAR)	Rural and vulnerable groups under-explored	Evidence comes mainly from small rural samples or secondary data; there is still little systematic analysis of how startups can build literacy among women, low-income and digitally excluded users.

Digital financial literacy → investment behaviour	Author, 2024 (Investment behaviour study)	Narrow product and outcome coverage	Existing work focuses on trading and mutual funds; there is limited research on how literacy via FinTech startups affects long-term behaviours like retirement planning, insurance and debt management.
Financial literacy → FinTech adoption (India)	Author, 2024 (What drives FinTech adoption?)	Mechanisms of “how” largely unspecified	Studies show that literacy raises adoption but do not clearly unpack which design features (education modules, nudges, UI) of FinTech startups translate literacy into safer, higher-quality usage.
Mobile wallets & financial literacy	Gupta, 2024	Beyond-payments use not well understood	Research documents high wallet penetration with low literacy but gives little detail on how wallets can evolve from simple payment tools into structured financial-education and budgeting platforms.
Global financial literacy determinants	Ozkaya et al., 2023	Limited integration of startup-based digital tools	Global reviews recognise FinTech context but seldom model FinTech startups and digital literacy jointly as central determinants of financial capability, especially in emerging markets like India.
Digital financial literacy (DFL) concept & measures	DFL in Era of FinTech SLR; Digital DFL & usage SLR	Measurement fragmentation	Reviews report many different DFL scales; there is no widely accepted, India-specific measure capturing how users learn through FinTech apps, tutorials and gamified features.
Gen Z digital savings behaviour	Gen Z FinTech savings SLR	Population and context narrow	Work on Gen Z centres on savings apps, often outside India; evidence is limited on Indian Gen Z users of domestic FinTech startups and their literacy trajectories over time.
MSME financial literacy and FinTech use	MSME FinTech SLR	Startup solutions for MSMEs under-studied	Studies look at MSMEs’ literacy and digital tools broadly; there is little focus on how Indian FinTech startups design products and education specifically for MSME owners.
Literacy gaps and FinTech access	Alshater et al., 2024; Prabhakaran et al., 2023; Nguyen et al., 2024	Interaction of overconfidence, gaps and startup design not explored	Research shows literacy gaps and overconfidence affect risk, but does not examine how startup features (simplified journeys, warnings, tiered interfaces) can mitigate these behavioural risks.

4.0 Research Objectives

1. To examine how digital financial literacy affects the adoption of FinTech startup platforms in India.

2. To evaluate whether using FinTech apps improves users' financial and digital financial literacy over time.
3. To analyse how key FinTech design features (tutorials, vernacular interfaces, nudges) influence users' financial understanding and behaviour.
4. To identify major barriers that limit the literacy-enhancing role of FinTech startups, especially in rural and low-income segments.

5.0 Research Methodology

This study adopts a descriptive and exploratory research design based entirely on secondary data. Academic articles were collected from reputed peer-reviewed journals, conference proceedings, and scholarly databases such as Google Scholar. The review focuses on studies published between 2018 and 2025, ensuring the inclusion of recent developments in FinTech startups and financial literacy. The selected studies were screened based on their relevance to FinTech startups, digital financial literacy, financial inclusion, and consumer financial behaviour. The literature was then analysed using a thematic synthesis approach, allowing for the identification of common themes, recurring findings, mediating/moderating relationships, and research gaps. This methodological approach ensures a systematic and unbiased synthesis of existing research.

6.0 Key Findings

- *Digital and financial literacy are fundamental for meaningful FinTech use:* Studies consistently show that people with stronger digital and financial skills use a wider range of FinTech services more often and gain better access to formal savings, payment, credit and investment options, which supports greater financial inclusion.
- *FinTech access without capability does not guarantee inclusion:* Evidence from rural users, MSMEs and younger cohorts suggests that the presence of apps or platforms alone is insufficient; low literacy, limited digital skills, social norms, lack of trust and weak infrastructure all restrict how far different groups can benefit, especially those already disadvantaged
- *App design and embedded education appear important but are not well tested:* Simple interfaces, local-language content, gamified elements, personalised nudges and in-app tutorials are frequently proposed as ways to support better decisions and learning, yet empirical work rarely isolates and evaluates the impact of these specific startup design features over time.
- *Digital financial literacy is widely used but weakly standardised:* Review articles show that digital financial literacy is recognised as a key construct, but definitions and

measurement tools vary greatly across studies, making it hard to compare findings across countries, platforms and target groups or to set common policy benchmarks.

- *Most evidence is associative rather than causal:* Because much of the literature relies on cross-sectional surveys, it typically identifies positive links between literacy and FinTech use but rarely demonstrates that targeted literacy programmes directly produce lasting changes in behaviour, financial outcomes or risk management.
- *FinTech can reduce or deepen inequality depending on context:* Some research shows that when basic digital access and skills exist, FinTech can help close literacy and inclusion gaps; other work warns that those without these prerequisites may be left further behind, so overall effects depend on design choices and supporting policies.
- *Mismatch between perceived and actual literacy is a significant concern:* Studies separating self-assessed and tested literacy indicate that overconfident users may adopt FinTech products more aggressively and face higher risks, highlighting the need for interventions that correct misperceptions as well as improve underlying knowledge and skills.

7.0 Conclusion

FinTech startups offer a powerful channel to expand both financial literacy and financial inclusion, but the benefits depend heavily on users' skills and context. Studies show that people and MSMEs with stronger digital and financial capabilities engage more deeply with FinTech platforms and gain better access to formal savings, payment, credit and investment products, whereas users facing low literacy, poor connectivity or social barriers often remain at the margins despite having technical access to apps.

Research also suggests that thoughtful product design—clear interfaces, local-language options, in-app education, gamified learning and transparent risk information—can support learning and safer financial decisions, although these design elements are still not systematically tested in most empirical work. Overall, the evidence implies that FinTech alone cannot close literacy and inclusion gaps; startups, regulators and educators need to place digital and financial literacy at the core of FinTech strategies, tackle overconfidence and trust issues and address structural constraints so that digital finance genuinely improves financial capability rather than reinforcing existing inequalities.

References

1. Alshater, M. M., Hassan, M. K., Rashid, M., & Hasan, R. (2024). The role of financial technology in narrowing the financial literacy gap: Evidence from demographic, socio-

- economic, and psychological factors. *SAGE Open*, 14(1), 1–15. <https://doi.org/10.1177/21582440241234567>
2. Gupta, R. (2024). Mobile wallets growth and financial literacy in India. In R. P. Meena (Ed.), *Crisis to opportunity: Navigating the current landscape of finance and entrepreneurship* (pp. 85–94). Himalaya Publishing House.
3. Nguyen, T. T., Tran, H. T., & Le, Q. A. (2024). Factors influencing financial literacy and fintech adoption: Evidence from emerging economies. *MATEC Web of Conferences*, 375, 01049. <https://doi.org/10.1051/mateconf/202437501049>
4. Ozkaya, A., Erdiñ, Z., & Yıldırım, D. (2023). Mapping financial literacy: A systematic literature review of determinants and recent trends. *Sustainability*, 15(12), 9358. <https://doi.org/10.3390/su15129358>
5. Prabhakaran, R. T., Kiran, R., & Sethi, J. (2023). Perception versus reality: Analysing the nexus between financial literacy and fintech adoption. *Investment Management and Financial Innovations*, 20(4), 218–228. [https://doi.org/10.21511/imfi.20\(4\).2023.18](https://doi.org/10.21511/imfi.20(4).2023.18)
6. Priyadarshi, A. (2025). *FinTech-driven financial inclusion in rural India: Barriers, opportunities, and behavioural insights* (SSRN Working Paper No. 5309325). SSRN. <https://ssrn.com/abstract=5309325>
7. Sharma, G., Verma, S., & Mehta, P. (2025). Digital financial literacy in the era of FinTech: A systematic literature review and bibliometric analysis. *Journal of Financial Innovation*, 11(2), 45–67.
8. Singh, R., & Kaur, P. (2025). Financial literacy and digital savings behaviour of Gen Z in the fintech era: A systematic literature review. *Journal of Business, Finance and Investment*, 9(1), 33–51.
9. Srinivasan, M., & Iyer, R. (2025). Financial literacy and use of fintech in MSMEs: A systematic literature analysis. *Jurnal Akuntansi, Manajemen dan Perbankan Syariah*, 8(2), 101–120.
10. Verma, S., & Gupta, A. (2025). Digital financial literacy and digital finance usage: A systematic literature review and bibliometric analysis. *Journal of Innovation and Entrepreneurial Research*, 6(1), 1–19.
11. Yadav, R., Sharma, S., & Tarhini, A. (2022). Factors affecting fintech adoption: A systematic literature review. *Financial Innovation*, 8(1), 1–25. <https://doi.org/10.1186/s40854-022-00319-5>
12. Zhang, X., & Chen, Y. (2020). Challenges and trends of financial technology (FinTech): A systematic literature review. *Technology in Society*, 63, 101364. <https://doi.org/10.1016/j.techsoc.2020.101364>

CHAPTER 4

Blockchain-Enabled Retrospective Green Clearances: Sustainability Significance and Environmental Governance Impacts

*Jasleen Kaur**

ABSTRACT

Retrospective or ex-post facto environmental clearances have become a recurring feature of regulatory practice in India, despite persistent criticism from the Supreme Court of India, the National Green Tribunal (NGT), and environmental scholars. The practice raises deep concerns about rule of law, environmental justice, and the weakening of the preventive architecture envisioned under the Environment (Protection) Act, 1986 and the EIA Notification, 2006. At the same time, India has been exploring digital public infrastructure approaches across governance sectors—from GST and CoWIN to National Single Window Systems—signalling readiness for digitally verifiable regulatory systems. This paper examines whether blockchain technology can be engineered to transform retrospective green clearances from a governance weakness into a transparent, auditable and sustainability-aligned regulatory instrument. Drawing on Indian judicial decisions such as *Common Cause v. Union of India* (2017), *Sterlite Industries v. Tamil Nadu Pollution Control Board*, and *Alembic Pharmaceuticals Ltd. v. Rohit Prajapati* (2020), as well as MoEFCC policy amendments, this study proposes a blockchain-enabled architecture for managing project histories, violations, remedial monitoring, and public participation. Using doctrinal analysis, policy review and conceptual system design, the paper articulates how immutable ledgers, permissioned nodes, smart contracts, sensor-driven monitoring, and public dashboards can improve compliance incentives and transparency. The analysis finds blockchain can significantly enhance traceability, public oversight, and deterrence—provided that strong legal safeguards and participatory governance models accompany the technology. The paper concludes by offering India-specific recommendations for regulatory reforms, institutional design, and digital ecosystem requirements for integrating blockchain into environmental clearance systems without normalising non-compliance.

Keywords: Blockchain; Retrospective clearance; Environmental governance; NGT; MoEFCC; EIA 2006; sustainability; India.

1.0 Introduction

Environmental governance frameworks, particularly the Environmental Impact Assessment

**Student, MBA Department, Indian Institute of Forest Management Bhopal, Madhya Pradesh, India (E-mail: jkaurdsf27@iifmbhopal.edu.in)*

(EIA) process, are designed to prevent harm by ensuring that environmental and social impacts are assessed *before* development projects receive approval. In India, this preventive architecture is grounded in the Environment (Protection) Act, 1986 and operationalised through the EIA Notification, 2006. However, systemic regulatory gaps, administrative inefficiencies, political economy pressures and weak enforcement have led to the proliferation of projects operating without prior environmental clearance. Retrospective or ex-post facto clearances—where approvals are granted after the commencement of operations—have emerged as a contentious regulatory practice. Landmark judgments such as *Common Cause v. Union of India* (2017) sharply criticised such clearances as “contrary to fundamental environmental norms.” Similarly, in *Alembic Pharmaceuticals Ltd. v. Rohit Prajapati* (2020), the Supreme Court held that retrospective clearances “compromise the integrity of environmental rule-of-law.” Despite judicial reservations, regulatory authorities—including the MoEFCC—continue issuing retrospective clearances, arguing that they are necessary for economic continuity, especially in cases involving legacy industries, MSMEs, or SEZ infrastructure. The lack of traceable records, opaque decision-making, fragmented institutional oversight and weak monitoring worsen governance outcomes.

Parallely, India’s digital governance ecosystem is undergoing rapid transformation. Blockchain—character by distributed ledgers, cryptographic verification, and tamper-proof audit trails—has been explored for land titles, public procurement, carbon markets, agricultural traceability and financial compliance. This signals an emerging opportunity to embed digital verifiability in environmental regulation. This paper evaluates whether blockchain can be used to transform retrospective clearances into a transparent, rule-bound and sustainability-oriented instrument, specifically within the Indian environmental governance context. The approach is not techno-utopian; instead, it recognises blockchain as a socio-technical tool whose outcomes depend on legal design and institutional capacity. The study integrates:

- Indian environmental jurisprudence,
- MoEFCC institutional mechanisms,
- NGT enforcement patterns,
- blockchain and RegTech literature.

The objective is to propose a blockchain-enabled architecture that addresses governance failures in retrospective clearances without normalising non-compliance.

2.0 Literature Review

2.1 Environmental governance in India

Environmental governance in India operates under multiple statutory instruments, including:

- Environment (Protection) Act, 1986,
- Water (Prevention and Control of Pollution) Act, 1974,

- Air (Prevention and Control of Pollution) Act, 1981,
- Forest Conservation Act, 1980,
- Wildlife Protection Act, 1972.

EIA 2006 mandates prior environmental clearance for 39 categories of projects. However, several CAG audits, Parliamentary Committee reports and NGT cases highlight failures such as:

- non-functional monitoring committees,
- reliance on self-reporting by project developers,
- inadequate baseline studies,
- delays in enforcement actions,
- inconsistent public hearing quality.

2.2 Retrospective clearances in Indian jurisprudence

Indian courts have repeatedly scrutinised retrospective clearances:

- Common Cause v. Union of India (2017): Supreme Court held that ex-post facto approvals defeat environmental safeguards.
- Alembic Pharmaceuticals Ltd. v. Rohit Prajapati (2020): Court ruled that retrospective clearances cannot be used to condone long-term illegal operations.
- Sterlite Industries v. TNPCB (2013): Highlighted the consequences of non-transparent regulatory processes.

Despite judicial criticism, MoEFCC Office Memoranda (2017, 2018, 2021) introduced pro- cedures for dealing with violation cases, arguing practicality.

2.3 Blockchain in regulatory and environmental governance

Blockchain has been deployed globally in:

- land registration (Sweden, Georgia),
- carbon credit tracking (IBM–Veridium),
- renewable energy certificate markets,
- biodiversity registries.

Academic literature identifies blockchain benefits such as:

- immutable audit trails,
- reduced information asymmetry,
- automated compliance triggers,
- multi-stakeholder verification.

However, concerns remain about:

- data quality,
- over-centralisation of permissioned networks,
- interoperability challenges,
- institutional capacity.

The intersection of blockchain and environmental clearance governance remains underexplored, especially in the Indian context where retrospective clearances are frequent yet poorly documented.

3.0 Research Methodology

This research adopts a qualitative and doctrinal methodology, integrating legal analysis with digital governance conceptualisation. It examines statutory provisions, judicial decisions, official memoranda, CAG reports, Standing Committee observations, and scholarly literature on blockchain-enabled regulation. The methodology has four components:

3.1 Doctrinal legal review

The legal analysis focuses on:

- EIA Notification 2006 and amendments (2009–2022),
- MoEFCC Office Memoranda on violation cases (2017, 2018, 2021),
- Supreme Court decisions restricting retrospective clearances,
- NGT case law mandating transparency and compliance monitoring.

3.2 Policy and institutional analysis

This involves assessment of:

- institutional capacity of State Environment Impact Assessment Authorities (SEIAAs),
- coordination challenges between MoEFCC, Pollution Control Boards (PCBs), and district administrations,
- technological infrastructure gaps in environmental monitoring.

3.3 Conceptual blockchain architecture development

A blockchain-enabled governance model is designed by integrating:

- distributed ledgers,
- hashed document repositories,
- IoT-sensor data pipelines,
- smart contract enforcement mechanisms,
- multi-agency permissioned node governance.

3.4 Comparative analysis

Conventional retrospective clearance processes are compared with the proposed blockchain model based on:

- transparency,
- traceability,
- participation,
- deterrence,
- monitoring enforcement.

4.0 Data Analysis and Blockchain Architecture

4.1 Governance failures in current retrospective clearances

Based on MoEFCC records and NGT judgments, the major weaknesses include:

Table 1: Governance Failures in Retrospective Clearances in India

Issue	Description
Opaque Timelines	Start dates of illegal operations often missing or disputed.
Fragmented Records	SEIAA, SPCB, and District Collector data rarely synchronised.
Weak Public Access	Clearance histories often unavailable online; RTI requests face delay.
Inconsistent Penalties	Projects fined without proportionality to duration of violation.
Monitoring Gaps	No verifiable evidence of adherence to remedial measures.
Legal Ambiguity	MoEFCC office memoranda conflict with judicial directions.

Such governance gaps justify exploring blockchain as a structural intervention.

4.2 Proposed blockchain framework for India

The architecture comprises five layers:

4.2.1 Layer 1: Project identity and ledger registration

Each project receives a cryptographic project ID linked to:

- company name,
- GPS coordinates,
- land title details,
- sector classification as per Schedule I of EIA 2006.

4.2.2 Layer 2: Immutable records of violations

Events recorded on-chain include:

- satellite-detected land-use change,
- SPCB inspection reports,
- violation notices,
- show-cause responses,
- penalty recommendations.

4.2.3 Layer 3: Smart contract–based clearance

Smart contracts can:

- encode deadlines for filing remedial EIAs,
- lock financial penalties in escrow,
- send alerts to regulators and communities,
- trigger mandatory third-party audits.

4.2.4 Layer 4: Sensor-to-ledger monitoring

IoT devices for:

- effluent discharge,
- particulate matter emissions,
- groundwater abstraction,
- noise levels

upload encrypted readings to the blockchain.

4.2.5 Layer 5: Public transparency dashboard

Citizens can view:

- violation history,
- clearance timelines,
- monitoring results,
- pending remedial measures.

4.3 Conceptual Diagram

Figure 1: Proposed Blockchain Architecture for Retrospective Clearances

Blockchain-Enabled Environmental Clearance System Architecture:

Project ID → Violation Detection → Smart Contract Penalty → On-Chain Remedial EIA
→ Public Disclosure → IoT Monitoring → Compliance Ledger → Closure/Enforcement

5.0 Case Study: Indian Industrial Cluster (Hypothetical)

To demonstrate applicability, consider an MSME-intensive industrial cluster in Gujarat (modeled after documented NGT violation cases).

5.1 Stage 1: Violation

Satellite imagery shows land conversion for chemical units before EC approval. SPCB confirms operations have commenced illegally.

5.2 Stage 2: Blockchain registration

All units are assigned unique project IDs. Violation flags recorded on chain.

5.3 Stage 3: Retrospective regularisation application

Units upload:

- retrospective EIA,
- environmental damage assessment,
- compensation calculations (per “Polluter Pays”),
- remediation plan.

5.4 Stage 4: Smart contract enforcement

- Penalties deposited in a blockchain-enabled escrow.
- Third-party audits auto-triggered every 90 days.
- Zero Liquid Discharge obligations monitored via sensors.

5.5 Stage 5: Community interface

Villagers receive SMS alerts via a dashboard when:

- pollution levels cross safe limits,
- remedial deadlines are missed,
- new clearance conditions are approved.

5.6 Outcome

The blockchain-enabled process:

- reduces data manipulation,
- improves public trust,
- enhances deterrence for future violations.

6.0 Findings and Results

6.1 Finding 1: Improved traceability

Immutable records eliminate disputes regarding:

- illegal start dates,
- frequency of violations,
- completion of remedial conditions.

6.2 Finding 2: Strengthened deterrence

Developers know:

- violations remain on-chain permanently,
- lenders and insurers can view compliance ratings,
- reputational risk increases due to public visibility.

6.3 Finding 3: Greater judicial reviewability

Courts reviewing MoEFCC decisions have:

- full audit trails,
- data-based reasoning,
- reduced reliance on contested affidavits.

6.4 Finding 4: Enhanced community participation

Blockchain dashboards democratise access to environmental data—aligning with:

- Principle 10 of the Rio Declaration,
- India’s constitutional “Right to Know.”

6.5 Finding 5: Risk of technocratic legitimisation

Without strong legal limits, blockchain may:

- sanitise illegalities,
- legitimise retrospective clearances,
- weaken preventive environmental law.

7.0 Conclusion and Implications

This study concludes that blockchain has transformative potential to address chronic weaknesses in India’s retrospective clearance system. However, technology must not become a substitute for strong regulatory norms. The preventive logic of EIA cannot be diluted by digital sophistication.

Blockchain's real value lies in:

- transparency,
- verifiable monitoring,
- improving auditability,
- empowering affected communities.
- Yet, it cannot alone solve governance failures rooted in:
- political economy pressures,
- institutional understaffing,
- inconsistent legal interpretations.

A blockchain-enabled system must be embedded within a strong legal and participatory framework to avoid legitimising non-compliance.

8.0 Recommendations

8.1 Legal reform

- Amend EIA Notification to define strict limits for retrospective clearance.
- Mandate blockchain-based recordkeeping for violation cases.
- Recognise ledger entries as admissible evidence under the Evidence Act.

8.2 Institutional design

- MoEFCC, CPCB, SPCBs, SEIAAs to operate permissioned blockchain nodes.
- Establish environmental data management units at state level.
- Standardise smart contracts for penalties, audits, and monitoring.

8.3 Technology and Participation

- Integrate IoT-sensor monitoring with blockchain.
- Enable multilingual public dashboards.
- Provide community environmental literacy training.

Acknowledgements: The author acknowledges faculty guidance at the Indian Institute of Forest Management and peer discussions that enhanced the conceptualisation of this study.

References

1. Alembic Pharmaceuticals Ltd. v. Rohit Prajapati, (2020) 6 SCC 585.

2. Common Cause v. Union of India, (2017) 9 SCC 499.
3. MoEFCC. (2017). *Office Memorandum on Violation Cases*. Government of India.
4. MoEFCC. (2006). *Environmental Impact Assessment Notification*. Government of India.
5. NGT (2021). *Order on Non-compliant Industrial Clusters*. National Green Tribunal.
6. Nakamoto, S. (2008). *Bitcoin: A Peer-to-Peer Electronic Cash System*.
7. Tapscott, D., & Tapscott, A. (2016). *Blockchain Revolution*. Penguin.
8. World Bank. (2021). *Blockchain for Sustainable Development*. Washington DC.

Appendix A: Blockchain Monitoring Fields

Table 2: Illustrative Blockchain Monitoring Parameters

Parameter	Description
Emission Data	PM2.5, PM10, SOx, NOx readings from sensors.
Effluent Quality	COD, BOD, TSS, pH logs.
Water Use	Groundwater extraction logs.
Energy Use	Renewable/non-renewable energy consumption.
Violation Alerts	Automated triggers for exceedances.

CHAPTER 5

Experience-Centric Induction to Principles of Management: The Mahakumbh Mela City Construction Assignment

Prajwal Melinamani and Ramakant Kulkarni***

ABSTRACT

Induction into foundational management courses sets the tone for student engagement and long-term learning. Traditional approaches often remain abstract, leaving learners disconnected from real-world complexity. This paper presents an innovative pedagogical experiment: the Mahakumbh Mela City Construction assignment, designed as an experiential induction into Principles of Management. By simulating the planning and execution of the world's largest congregation, students engaged in hands-on learning of management functions—planning, organizing, decision-making, coordination, and control. The exercise embedded innovation in pedagogy, mirrored technology-driven infrastructure planning, and emphasized sustainability through resource-conscious design and collaborative culture. Outcomes demonstrate enhanced student curiosity, skill development, and community engagement. The paper argues that such experiential induction models align with the evolving business landscape where innovation, technology, and sustainability converge as drivers of organizational success.

Keywords: Kumbh Mela; Pedagogy; Experiential learning; Coordination.

1.0 Introduction

The evolving business landscape is increasingly shaped by three interdependent forces: innovation, technology, and sustainability. Organizations must adapt to rapid technological change, innovate continuously, and embed sustainability into their operations. Management education must prepare learners for this reality. Induction into Principles of Management (PoM) is critical, as it sets the foundation for subsequent courses. Yet, induction often risks being abstract.

**Corresponding author; Student, Management Department, Chetan Business School, Hubli, Karnataka, India (E-mail: prajwal23.cbs@gmail.com)*

***Director-Academics, Management Department, Chetan Business School, Hubli, Karnataka, India (E-mail: ramakantkv@yahoo.co.in)*

To address this, a classroom project was designed around the Mahakumbh Mela—a mega-event of unparalleled scale. By replicating the construction of a miniature township, students experienced management principles in action. This paper situates the project within the conference theme, demonstrating how experiential pedagogy can drive innovation, simulate technology integration, and foster sustainability consciousness.

2.0 Innovation in Pedagogy

- Experience-centric induction
 - o Moving beyond lectures, students engaged in hands-on construction of a miniature township.
 - o The project transformed induction into a living laboratory, where management principles were applied in real time.
- Role innovation
 - o Students assumed roles: CEO, group leaders, and press reporters.
 - o This mirrored corporate structures, fostering accountability and leadership.
- Prototype learning
 - o The township prototype became a physical manifestation of management concepts, bridging theory and practice.
- Outcomes
 - o Students reported heightened excitement and curiosity.
 - o The exercise demonstrated that innovation in pedagogy can sustain learner engagement and foster deeper understanding.

3.0 Technology as a Driver

- Blueprint and design
 - o The project began with a blueprint drawing, simulating digital planning tools such as CAD or GIS.
- Infrastructure simulation
 - o Groups replicated tasks like power substations, sanitation systems, and transport networks.
 - o These mirrored smart city technologies and infrastructure planning.
- Communication systems
 - o The press reporter group simulated real-time information flow, akin to ICT systems in mega-events.
- Learning parallel
 - o Students learned that technology is not just about tools, but about systems integration and coordination—a core management principle.

4.0 Sustainability Embedded

- Resource allocation
 - o Students worked within a constrained plot (23x13 ft), mirroring real-world resource limitations.
- Environmental consciousness
 - o Tasks included tree planting, sanitation, and water supply, emphasizing ecological responsibility.
- Social sustainability
 - o Group work fostered cross-cultural fusion, friendship, and collaborative habits.
 - o This built a sustainable organizational culture.
- Mega-event sustainability
 - o The Kumbh Mela itself is a case study in balancing tradition with modern infrastructure for millions of visitors.
 - o Students reflected on how sustainability is embedded in large-scale event management.

5.0 Management Principles in Action

Function	Student Application	Conference Theme Connection
Planning	Blueprint design, task allocation	Innovation in structuring complex projects
Organizing	Group formation, CEO leadership	Technology-enabled coordination
Decision-making	Material choice, prototype execution	Sustainability through resource optimization
Coordination	Synchronizing 10 groups + press	Innovation in collaborative culture
Controlling	Progress reviews in PoM classes	Technology-driven monitoring & evaluation

6.0 Case Study: Mahakumbh Mela Data

Students engaged with real-world data from the Kumbh Mela:

- ₹5500 crore allocation
- 40 crore visitors projected in 2025 (up from 25 crore in 2019)
- 4000 hectares segregated into 25 sectors
- 1.6 lakh tents, 9 pucca ghats, 30 pontoon bridges
- 400 km of temporary roads, 67,000 street lights, 2 substations
- 1249 km of water pipelines, 200 water ATMs, 1.5 lakh toilets
- 3 lakh saplings, 18 lakh sq ft murals
- 550 shuttle buses, 7000 state buses, 13,000 trains (3000 special)

By replicating these figures in miniature, students appreciated the scale, complexity, and sustainability challenges of mega-event management.

7.0 Outcomes and Reflections

- Engagement
 - o Students reported higher excitement and curiosity compared to traditional induction.
- Skill development
 - o Reinforced Knowledge, Attitude, Skills, and Habits (KASH) through practice.
- Community impact
 - o Opening the prototype city to Hubli-Dharwad visitors created a bridge between academia and society. About 1000 students and citizens visited the miniature during the weeklong period when it was kept open for public. Media coverage gave publicity.
- Scalability
 - o The model can be adapted for other mega-events (Olympics, Smart Cities, Expo) to teach management principles.

8.0 Discussion

The Mahakumbh Mela project demonstrates that innovation in pedagogy can align management education with the evolving business landscape.

- Innovation: Experiential induction transforms abstract concepts into lived experiences.
- Technology: Simulation of infrastructure and communication systems mirrors real-world technological integration.
- Sustainability: Resource-conscious design and collaborative culture embed sustainability into learning.

This triad—innovation, technology, sustainability—prepares students for organizational realities where these forces drive success.

9.0 Conclusion

The Mahakumbh Mela City Construction assignment exemplifies how experiential induction can transform Principles of Management education. By embedding innovation, simulating technology, and emphasizing sustainability, the project aligns pedagogy with the evolving business landscape. Such models prepare students not only to understand management principles but to live them, equipping them for careers in a world where mega-events, smart cities, and sustainable practices converge.

References

1. Sundman, J., Feng, X., Shrestha, A., Johri, A., & Taka, M. (2025). Experiential learning for sustainability: A systematic review and research agenda for engineering education. *European Journal of Engineering Education*. <https://doi.org/10.1080/03043797.2025.2532591>
2. Sohaee, N., & Farsad, R. (2025). Innovative pedagogies for sustainability education. In *Competence Building in Sustainable Development* (pp. 221–237). Springer. https://doi.org/10.1007/978-3-031-80380-2_11
3. Matsuo, M., & Nagata, M. (2020). A revised model of experiential learning with a debriefing checklist. *International Journal of Training and Development*, 24(2), 144–153. <https://doi.org/10.1111/ijtd.12177>
4. Kolb, D. A. (2015). *Experiential learning: Experience as the source of learning and development* (2nd ed.). Pearson Education.
5. Sinha, A. K., Prakash, A., Rayeeni, A. A., & Prakash, P. (2013). *Mass gathering event management: A case study of MahaKumbh, 2013, Allahabad*. Bihar State Disaster Management Authority. Retrieved from <http://bsdma.org/images/publication/Kumbh%20Mela%20Case%20Study%20Full.pdf>





CHAPTER 6

Role of Human Resource in Implementing Green Practices within Hospitality Organization

Preetam U. Revankar and Tanvi P. Revankar***

ABSTRACT

In today's rapidly changing world, marked by emerging technologies and evolving social and economic policies, humans play an increasingly vital role in shaping our planet's future. There's an urgent need for a comprehensive and forward-thinking global environmental management approach. Organizations across various sectors are now incorporating eco-friendly practices into their operations by embracing sustainable management principles, policies, and procedures that enhance life quality for customers, staff members, local communities, and the natural environment. Companies committed to sustainability must implement environmentally conscious approaches and maintain ecological standards throughout their operational processes and product development. Effective environmental management demands sophisticated technical expertise and advanced managerial capabilities from staff members, as organizations develop innovative environmental programs and initiatives that carry substantial administrative responsibilities. With every growing day, we observe more organizations taking various measures to encourage ecological progress and guide their workforce toward sustainable practices. Currently, business enterprises have recognized the significance of environmental stewardship and sustainable management, incorporating these concepts into their core objectives and strategic plans. This research aims to explore how different hospitality organisation approach environmental responsibility. The hospitality sector faces similar challenges, though it stands to gain considerably from the current business trend toward environmental consciousness. Hotels must maintain exceptional cleanliness and upkeep standards to meet guest expectations and requirements. Consequently, cleaning supplies, waste materials, and disposal methods have become significant concerns as hotels work to join the environmental movement. This research has demonstrated a strong positive relationship between sustainable practices and human resource strategies within hospitality organizations, with most hospitality industries implementing HR-driven environmental initiatives. This work justifies the deployment of HR interventions that lead to the creation of green concepts and their subsequent impact on diverse green practices in the hotel industry.

Keywords: Eco-friendly; Environment; Organization; Sustainable; Technology.

**Corresponding author; Assistant Professor, BBA Department, KLS's Raja Lakhamgouda Law College, Belagavi, Karnataka, India (E-mail: preetamurevankar@gmail.com)*

***Guest Lecturer, Commerce Department, KLS's P U College, Belagavi, Karnataka, India (E-mail: tanviprevankar@gmail.com)*

DOI: 10.17492/JPI/KLSGIT/260006

1.0 Introduction

Our planet continues to transform at a rapid pace. As fresh technologies emerge alongside updated social and economic strategies, humanity's influence on Earth keeps expanding. A robust and forward-thinking method for managing our environment is essential worldwide. This represents a quick-response strategy that all global enterprises must embrace. As companies implement eco-friendly approaches, each organization strives to concentrate on sustainable business practices. Every company works to incorporate environmental methods into their operations through adopting sustainable management concepts, guidelines, and procedures that enhance life quality for clients, staff members, local communities, and our natural surroundings.

Environmentally conscious businesses should embrace sustainable approaches and eco-friendly standards throughout their operational processes and product development. Sustainable management demands employees possess advanced technical expertise and leadership capabilities, as organizations must create innovation-driven environmental programs and initiatives that carry substantial administrative consequences. However, there remains an expanding demand for strategic green human resource management.

India is actively pursuing evolving policies and frameworks to address the increasing demand for sustainable and environmentally friendly workplace practices. Each passing day reveals organizations implementing various measures to encourage ecological progress and guide their workforce toward environmentally conscious methods. However, a critical question remains: Are companies genuinely taking action to minimize their carbon emissions? The role of organizational practices and procedures is crucial in adopting green initiatives. While India demonstrates consistent progress in this direction, a significant divide exists among numerous companies that remain disconnected from environmental practices. These businesses are failing to embrace green production methods or make eco-friendly strategic choices, and they're also avoiding Environmental Management System certifications. Therefore, this research aims to explore how various hospitality companies respond to this pressing environmental challenge.

Green Human Resource Management, through HR interventions, focuses on implementing environmentally friendly practices that enhance efficient resource use within hospitality companies while promoting broader environmental sustainability goals. Today, organizations across industries have recognized the significance of environmental stewardship and sustainable management, incorporating these principles into their core objectives and strategic planning. In recent times, the hospitality sector has started adopting eco-friendly operational approaches. The idea of environmentally conscious products is gaining momentum among Indian hotels, particularly regarding cleaning supplies and

maintenance equipment. The hospitality industry stands to gain significantly from the current business trend toward environmental responsibility. Hotels must maintain exceptional standards of care and hygiene to meet guest expectations and requirements. Consequently, the management of cleaning materials, waste products, and their proper disposal has emerged as a challenge for hotels working to embrace sustainable practices.

1.1 Human resource

Various scholars have described the function of Human Resources in different manners. According to Kennedy and Toffler (2014), Human Resource Management involves creating, implementing, and sustaining a framework focused on becoming an environmentally conscious corporate entity. The primary duty of Human Resources lies in accomplishing environmental sustainability through converting staff members into eco-friendly workers, thereby meeting the organization's environmental objectives. This division handles personnel management while ensuring that each employee's needs are addressed. Simply put, it involves overseeing the organization's human capital.

1.2 Features of human resources

- Their work emphasizes practical implementation. They concentrate on executing activities instead of creating protocols or regulations. HR ensures that staff concerns get resolved through appropriate policies.
- Functions as a unifying force to foster positive relationships among individuals across various organizational levels. Essentially, it seeks to blend human talent effectively for organizational benefit.
- Another objective involves helping workers reach their maximum capabilities. It pushes them to contribute their finest efforts to the company. Employee motivation occurs through organized processes including hiring, screening, skill development, and growth programs alongside equitable compensation and guidelines.
- HRM represents a crucial component of HR duties. It supports the establishment of a positive workplace environment within an organization.
- The Human Resources function involves providing guidance and support to operational supervisors in fulfilling their staff-related duties. The human resources manager serves as a reliable advisor.

1.3 Strategic role of human resources

The HR position is no longer confined to the scouting walls. It has changed course to give the company's main business goal top priority. By directing strategic decision-making in operational procedures, human resources in a strategic role add value to well-established

businesses. As a business partner, the human resources department advises the company's top management internally on strategic business initiatives and significant structural changes. It is the duty of the HR manager to develop an HR strategy that aligns the organization's personnel, processes, and systems with the aims and objectives of the business. HR professionals show their position as business partners and help by connecting HR policies and practices to the company's established values and customs.

1.4 HR strategy and organizational performance

The accomplishment of an organization's overall goals is the responsibility of an HR strategy. Before workers can do their duties effectively, four conditions must be met:

- The capacity to perform the task;
- The authorization to perform the work;
- The motivation to perform the work; and
- The understanding of what the work actually comprises.

As previously said, human resource strategies and plans must be appropriate to enable individuals and units to execute at the intended level.

2.0 Literature Review

According to Zsolnai (2002: 656), an environmentally conscious enterprise represents a company that has integrated environmental principles throughout its operational departments. Gilbert (2007: 1) characterizes eco-friendly business operations as activities conducted with minimal ecological harm or those that provide direct environmental benefits. While environmental practices and related studies have existed since the 1970s, recent media attention and corporate adoption have made this a prominent societal discussion with clear connections between environmental concerns and organizational practices (Hartmann and Ibanez, 2006).

The primary motivators for environmental initiatives encompass economic factors (cost reduction and operational effectiveness), moral/social considerations (corporate responsibility), and market forces (consumer demand, event coordinators, and public sector requirements). Extensive research demonstrates that cost reductions represent the most significant benefit driving environmental commitment in the tourism accommodation sector (Brown, 1994, 1996; Kirk, 1996; Cheyne & Bamett, 2001; Essex & Hobson, 2001; Rivera, 2001, 2002b; Lynes & Dredge, 2003; Brebbia & Pineda, 2004; Bohdanowicz, 2005; González-Benito & González Benito, 2005). Research by Krishna Shetty and Ramamirtham Gopal indicates that the hospitality sector must continuously adapt regarding technology and operational aspects to maintain competitiveness and achieve strong investment returns. Their

findings show that innovation alone does not significantly affect occupancy rates, but improvements in service delivery, atmosphere, product offerings, food service, and technological systems do create impact. They determine that innovation functions as a complementary element rather than an independent factor for sustained competitive positioning (Innovation and Entrepreneurship, 2012).

Chaturvedi (2010) observed that increasing environmental consciousness among Indian hospitality organizations demonstrates that adopting eco-friendly approaches not only strengthens brand value but also reinforces fundamental principles. Since implementing sustainable practices requires minimal maintenance, establishments can reduce operational costs while enhancing their reputation. Expenses related to fuel and electricity can be minimized through recyclable materials and efficient irrigation systems.

Karthik Ganesan and colleagues (2014) determined that renewable energy sources including solar and wind power positively impact human health and significantly influence climate change mitigation efforts.

Vishwa Mohan (2014) notably highlighted that five Indian corporations achieved recognition on the international list of companies demonstrating leadership in reducing emissions that damage the climate. The Indian companies included in the CDP Climate Performance Leadership Index 2014 were: Essar Oil, Larsen & Toubro, Tech Mahindra, Tata Consultancy Services, and Wipro.

Hotels represent fundamental components of the tourism industry. Indian tourism emphasizes the “AtithiDevoBhavah” initiative, directed toward international visitors. This phrase translates to “Guest is God.” Currently, ownership models have shifted toward franchise operations (Kumar, L.Singh, T.,Saigal,2010). Rajiv Kumar and associates (2016) suggest that Indian budget accommodations can achieve optimal operational cost savings by implementing intelligent environmental practices.

Research indicates that economy/budget hotels constitute approximately 75% of all accommodations in India. These establishments typically encounter financial limitations and consequently cannot invest in environmentally friendly technology and products. Therefore, cost savings from smart environmental practices can fund the purchase of eco-friendly technology and products.

Various researchers (Iwanowski & Rushmore, 1994; Higley, 1998; Mensah, 2006; Bohdanowicz, 2006; Mcleish, 2007; Sherman, 2008; Kasavana, 2008; Hanna, 2008) identify several energy conservation activities in hotels: installing water-efficient sprinkler systems, establishing linen and towel reuse programs, implementing tiered pricing structures, billing water consumption based on usage, adopting kitchen water conservation programs such as avoiding running water for vegetable washing, using water-efficient landscaping methods, and preventing frequent pool refilling or excessive garden irrigation.

3.0 Green Management

This mindset promotes swift action across organizations worldwide. Time and again, research has demonstrated that successful environmental management programs require elevated employee enthusiasm, empowerment, and understanding of ecological well-being. Workers responsible for organizational sustainability efforts must possess outstanding expertise in both technical abilities and leadership competencies, since the organization will be creating eco-centered projects and strategies that prioritize creative solutions. Nevertheless, planned environmental human resource management is becoming more essential.

4.0 Green Practices

Green practices are eco-friendly activities that support sustainability and environmental protection. Every corporation is attempting to concentrate on green business methods. Businesses of all sizes are putting green management ideas, policies, and practices into practice in an effort to better serve their clients, staff, local communities, and the environment. The need to lessen the effects of global warming and other environmental concerns is the driving force behind the establishment of numerous environmentally conscious businesses. To be deemed “green,” a business must manage its operations and manufacture its products in compliance with certain standards.

Features of Green Business: Hirsch distinguishes nine types of green business practices. Hirsch clarifies, saying that although businesses go green, they go above what is required by:

1. Immediately lowering their own regulated—or unregulated—environmental effects in ways that lower regulatory risk, enhance organizational image, and enable businesses to stay ahead of expected guidelines;
2. Lowering their clients’ exposure to hazardous materials and their customers’ environmental impact.
3. Boosting the recycling and reuse of production resources.
4. Increasing the energy efficiency of their clients or themselves.
5. Increasing aid production, either for themselves or their clients.
6. Implementing policies across the company or facility to find opportunities for waste reduction, pollution prevention, energy efficiency, or increased productivity;
7. Gathering and sharing more information than required by law regarding the firm’s performance and environmental impacts.

8. Giving stakeholders more chances to participate in corporate environmental decision-making than required by law.
9. Funding and investing in environmentally friendly goods and company strategies.

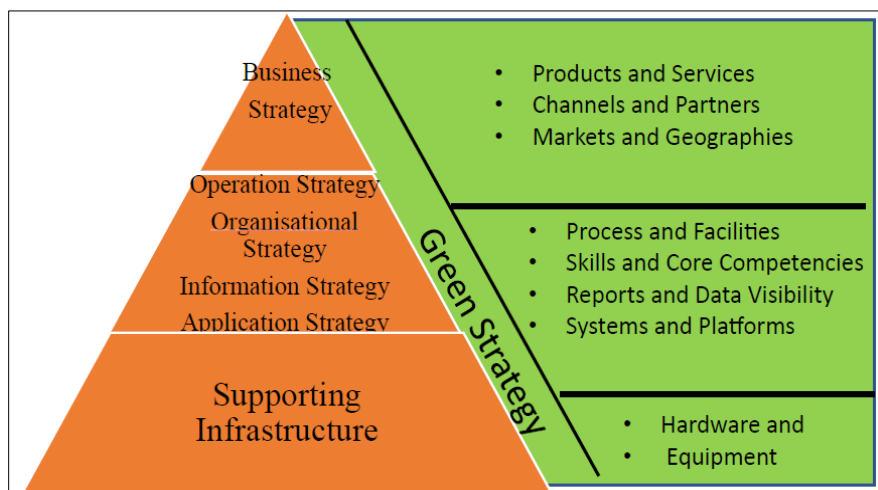
Here are a few typical green techniques that are now prevalent in the hospitality sector.

- **Recycling of Water:** One of the easiest and most efficient ways to protect the environment is to recycle water. Recycling bins placed in conspicuous locations, including next to photocopiers and other trash cans, can motivate employees to properly sort their waste. Recycling helps small businesses reduce waste costs, save money on new purchases, improve employee morale, improve brand image, and, of course, show that the company is contributing to energy and material conservation and environmental preservation.
- **Greener Travel Options:** Employee carpooling and other business-related travel can significantly reduce a company's carbon impact. To lessen the harmful consequences of business travel, encourage your coworkers and employees to walk or cycle to work. If it is not feasible for employees to walk or bike to work, encourage them to share elevators in order to reduce emissions from the commute.
- **Green printing:** It is an admirable initiative by a few companies that allows us to reduce the amount of paper we use by roughly 25%. Because this program can significantly reduce the amount of paper and toner used without sacrificing print quality, businesses frequently refer to it as a "pre-ton" saver. Even though green printing is urgently needed, Indian industry have not yet fully embraced the idea.
- **Switch to paperless:** For our next generation, going paperless is the only viable option. First and foremost, every business must recognize the value of filing and documenting information online and printing only when required. It's time to do away with the antiquated practice of paper documentation. On the other hand, HR can make sure that all of their directives are fulfilled online, such as scouting emails and Skype interviews for prospects from outside the state. Overall, this will support the green strategy and further reduce each person's carbon footprint.
- **Green auditing:** It is crucial that local utilities do an inspection and provide their professional feedback. These websites use solar-powered light bulbs. Purchasing LEDs and CFLs with superior usage sense is advised.
- **Purchasing Eco-Friendly Products:** All team members should be aware that they are expected to purchase eco-friendly products. The company should set specific goals for the acquisition of recycled, used, and refurbished goods and let its suppliers know that it is interested in sustainable products.
- **Reduction of Business Travel:** Every team manager should make sure that their colleagues travel as little as possible unless absolutely necessary. Video and teleconferencing need to be encouraged as part of the workplace culture.

- **Green Manufacturing Process:** Today, every production or operational manager must ensure that the equipment they purchase is energy-efficient. Simplifying procedures will reduce the amount of electricity and power used. Second, packing is crucial. The more environmentally friendly a product is used, the less of an impact it has on the environment.
- **Green Policies:** To lessen the need to commute to neighboring eateries, start initiatives like giving free reusable bags (for groceries, etc.) to clients or staff or providing free office lunches every day.

5.0 Green Practices' Significance

Green practices can help you be economical, useful, and eco-friendly all at once. The idea of sustainability has risen to the top of the boardroom agenda due to the organization's increasing focus on social responsibility and climate change.



Source: Google – The Green Strategy Pyramid

- Businesses that implement green strategies foster a shared culture of awareness and action.
- It further guarantees that we are making every effort to lessen our carbon footprint by facilitating important decisions that aid in achieving the green objective.
- Their cost-effective value offers are appealing.

5.1 An overview of India's green practices

The new catchphrase for all HR panels worldwide is HRM. These expanding regulations and tactics for the increasing need for a sustainable green workplace are also being implemented in India. Organizations are adopting various actions to encourage ecological development and change their workforce to adopt a more environmentally conscious mindset every day. However, the issue remains: Are businesses making efforts to lessen their carbon footprint?

According to a Price Waterhouse Coopers study, by 2020, organizations will face a number of challenges as a result of the change in plans of action, including the blurring of the lines between work and home life as organizations accept greater accountability for the social government assistance of their representatives; strict individual estimation strategies to control and screen efficiency and execution; and an increase in the significance of social capital and connections as drivers of business success. The research also evaluates how human resource work, which has been viewed by many as a latent, administration-focused capacity, might proceed in one of three ways given the future work environment and business conditions. HR may become the center of the organization by managing a greater variety of staff deployments that link to and impact other areas of the business when it adopts a strategic mentality and concentrates on business strategy.

- The organization's internal corporate social responsibility plan will be motivated by this obligation.
- It will all be perceived as a redistribution of responsibility and value.
- It will be kept in a different building outside the company for the time being, and the organization's human resources department will mostly concentrate on hiring new staff.

5.2 Legal, financial and ethical aspects of sustainable practices

Both domestic Indian legislation and international commitments recognize the importance of environmental protection, conservation, and responsible utilization of natural resources. According to the constitution's section IVA (article 51A-fundamental duties), every citizen of India must protect and enhance the country's natural environment, encompassing forests, water bodies, rivers, and wildlife, while showing compassion toward all living creatures. Likewise, Article 48A of the Directive Principles of State Policy mandates that the nation shall work to safeguard and enhance the natural environment, including forests and wildlife. Several environmental protection statutes existed prior to India's independence.

Nevertheless, the crucial momentum for establishing a solid framework emerged only after the United Nations Conference on the Human Environment (Stockholm, 1972). In response to the Stockholm conference, the Department of Science and Technology created the National Committee for Environmental Policy and Planning to develop regulatory

mechanisms for environmental matters. This Committee later evolved into the comprehensive Ministry of Environment and Forests (MoEF). Founded in 1985, MoEF serves as the country's primary administrative authority for monitoring and ensuring environmental protection while establishing relevant legal and regulatory structures. Numerous environmental regulations have been enacted and implemented since the 1970s. The administrative and regulatory framework consists of the Ministry of Environment and Forests (MoEF) along with pollution control agencies ("CPCB" for Central Pollution Control Board and "SPCBs" for State Pollution Control Boards).

5.3 Ethical considerations

Most organizations base their manufacturing decisions on the belief that adopting sustainable practices represents the morally correct approach. Their fundamental philosophy centers on resource conservation and contributing positively to environmental welfare. These companies embrace the triple bottom line philosophy when making significant decisions. They carefully evaluate all aspects to reduce harmful impacts on the environment, community, and financial performance. Herman Miller, a premier manufacturer of quality office furniture, operates from Western Michigan. In 1993, the company pledged to achieve zero landfill waste by 2003, implementing various innovative methods to reach this objective, despite not always being cost-efficient. Instead of disposing of textile remnants in landfills, the organization shreds these materials and ships them to a North Carolina facility that converts them into automotive insulation. Although this environmentally conscious approach costs Herman Miller \$50,000 annually, company executives believe making the environmentally responsible decision justifies the expense. Both staff members and leadership take pride in the organization's environmental stewardship within their region, making the increased costs from the new waste-to-energy program a worthwhile investment according to senior management (Hosmer 2003).

5.4 Green practices and organizational performance

The term "organisational effectiveness" describes how successfully an organization operates as a complete entity. An organization's effectiveness becomes apparent when it achieves several objectives simultaneously, including environmental targets and operational compliance requirements. We focus on two key operational aspects: their ability to minimize company expenses and their capacity to reduce environmental pollution. Consequently, we adopted David (2013)'s recommended method for evaluating sustainability's influence across social, environmental, and economic dimensions (SEE). The SEE Sustainability framework addresses both waste reduction and value creation. Success under the SEE model is measured through metrics including waste and emission reduction, employee welfare (financial, social,

and psychological), and various other indicators. Research studies examining the relationship between green management and organizational efficiency have varied widely across different industries. Researchers Ying-chin Wang and Ling (2016) conducted a survey of 213 Taiwanese electronics manufacturers to investigate inexperienced management and performance in Taiwanese electronics companies. Their findings demonstrate that green management significantly affects profitability.

6.0 Various Sectors Implementing Green Practices

Multiple industries have adopted environmentally friendly practices within their organizations: FMCG sector | IT sector | Finance sector | Automotive sector

6.1 FMCG sector

ITC stands as a prominent fast-moving consumer goods (FMCG) company in India with promising prospects. The company has spearheaded environmentally conscious practice development by establishing industry benchmarks. Its diverse portfolio encompasses cigarettes, hotels, paper products and specialty papers, packaging, agribusiness, packaged foods, and numerous other services.

Through innovative Ozone Treated Elemental Chlorine Free Technology, ITC launched an eco-friendly multipurpose paper called Paperkraft Premium Business Paper for office and home use. While Elemental Chlorine was previously utilized in the bleaching process during paper production, this marked an Indian industry first.

As a responsible corporate citizen, ITC participates in various public benefit initiatives, including environmental, health, and safety (EHS) programs, community engagement, preservation of national historical and cultural heritage, and sustainable development promotion. Environmental protection remains their primary focus.

6.2 IT sector

Infosys, among India's premier IT companies, has advanced significantly in recent years regarding environmental sustainability and worker health and safety management. They have analyzed all operations, including physical and IT infrastructure, to identify energy conservation opportunities. Several implemented measures include:

- Installing wind turbines at campuses in Pune, Bangalore, and Mangalore
- Implementing occupancy sensors in conference rooms and restrooms
- Transitioning from fluorescent tubes to LED lighting
- Installing variable frequency drives (VFD) in condenser pumps for chilled water systems
- Upgrading inefficient utility equipment including DG sets, pumps, and motors

6.3 Finance sector

Indian financial institution ICICI's declared mission involves "Greening" customer lives through superior banking services. Instabanking, a unified platform integrating supplementary channels, provides Internet banking, i-Mobile banking, and Interactive Voice Response (IVR) Banking accessible 24/7/365. This reduces energy consumption by eliminating paper statements and physical visits. ICICI Bank extensively utilizes internal media, including customer statements, inserts, and credit card slips, to engage customers and support their "Go Green" campaign. Statement subscriptions, online bill payment, and electronic fund transfers encourage customers toward "paperless" and "commute-free" banking solutions.

6.4 Automotive sector

Maruti Suzuki dominates the Indian automotive industry. They achieved success by expanding recycled water usage through effective rainwater collection methods. As their CSR-GM recently stated publicly, "Our focus involves continuously reducing water consumption through innovative approaches. We converted our Gurugram plant to utilize canal water exclusively instead of groundwater."

6.5 Green hotels concept

Several hotels have accepted the challenge of adopting environmentally friendly practices in India. "Green practices" encompasses everything reducing strain on earth's land, air, water, and human activities and resources. Green hotels employ environmentally committed staff who actively participate in or develop green initiatives. These establishments practice environmental sustainability through water and electricity conservation and integrated waste management. The Green Hotel Association published an industry status report in 2008. Extensive research has explored why numerous hotels embrace environmental practices. According to Bohdanowicz (2006), hotel conversion to green operations is primarily motivated by social responsibility, government regulations, and financial benefits. Multiple researchers, including Alexander (2002), DeLollis (2007), Graci & Dodds (2008), and Butler (2008), discovered that hotels reduce operating expenses through eco-friendly policies, such as installing energy and water-efficient equipment. This increases per-guest revenue while decreasing operational costs.

6.6 Green practices in hospitality sector

Green Lodging represents continuous efforts and practices directing operations toward environmental sustainability. For effectiveness, these efforts must encompass and permeate all business and service delivery processes. All lodging industry functions should

receive support at every managerial and operational level within organizations claiming to be 'green' or participating in comprehensive environmentally friendly programs.

Understanding green lodging requires ensuring all physical facilities, equipment, and attractions are properly maintained following green management protocols. The hospitality industry's interaction with the physical environment inevitably creates negative externalities manifested through water consumption, energy usage, air pollution, and waste generation.

To ensure program legitimacy and stakeholder buy-in, every facility area must be targeted (indoor, outdoor, and building envelope), with cost-effective technical and behavioral solutions adopted and maintained. To guarantee behavior modification, buy-in, and adoption, enforcement reasons should be highlighted and benefits to the property and environment emphasized and communicated to stakeholders.

Since negative externalities typically appear through electricity usage, water consumption, air quality control, and waste management, dynamic technical and behavioral solutions should target eliminating and mitigating externalities in these areas. Green programs must include sub-components addressing each critical area.

Green lodging involves adopting solutions addressing energy usage, water consumption, indoor air quality controls, and waste management. Since energy represents a controllable cost, reduced consumption results in direct savings for hotels. Respondents indicated that selecting energy-efficient equipment and fixtures while implementing sound energy conservation practices enabled their hotels to reduce energy expenses while contributing to environmental protection.

Water management practices aimed at reducing pollution, waste, and increasing efficiency. Reported benefits included direct cost savings through reduced water bills, energy costs, sewage fees, and chemical utilization. Combined behavioral modification and water-saving equipment represented the most effective approach. For instance, respondents noted that water and energy-efficient washing machines used with linen and towel reuse programs saved properties significantly through reduced labor and laundry expenses.

Indoor air quality practices address clean air supply, conditioning methods, and contaminant removal using ventilation and air conditioning systems. Technical solutions included air filtration systems meeting or exceeding stated filtration thresholds based on accepted industry standards. Respondents identified indoor air quality as one of the most challenging aspects of green management programs, since virtually all indoor hotel activities generate particles potentially contaminating air quality. Additionally, air migration between areas makes targeting and isolating specific zones difficult. Behavioral modifications included accepting natural solutions, such as using lobby plants as natural filtration systems, rather than purely technical approaches. Respondents indicated that lodging facilities best address waste generation by developing policies designed to reduce waste at its source. Such

policies should encourage restoration, reuse, and recycling, ultimately preventing pollution and reducing or eliminating treatment and disposal costs.

6.7 Environmental practices in the hospitality industry

Eco-friendly accommodations can be described as ongoing efforts and activities that orient operations toward environmental sustainability. For effectiveness, these initiatives must encompass and integrate throughout all business and service delivery processes. All hospitality industry functions should receive support at every managerial and operational level within organizations that claim environmental responsibility or participate in comprehensive eco-friendly programs. The optimal approach to understanding sustainable lodging involves ensuring that all physical facilities, equipment, and amenities are properly maintained according to environmental management protocols.

6.8 Human resources function in environmental management

The degree to which human resource management functions influence organizational operations and workplace environment depends on organizational policies that vary according to senior management philosophy. Human resources operates through practices and interventions including Job Design, Electronic Recruitment and Selection, Training & Development, Performance Monitoring, Compensation Management, and Employee Relations and Engagement.

6.9 Organizational environmental practices framework with HR implementation

- *Energy Management:* Conduct energy assessments, enhance security measures, install automatic timers for lighting systems, utilize energy-efficient bulbs, and maintain comfortable temperature ranges that avoid excessive cooling in summer and heating in winter.
- *Digital Transformation:* Promote electronic communication. When paper use is necessary, print on both sides and utilize scrap materials.
- *Recycling Programs:* Process glass, paper, plastic, metal waste, and manufacturing byproducts. Examine waste streams to understand the true costs of purchasing, storing, and disposing materials. Eliminate unnecessary copying and reuse packaging materials for shipping.
- *Transportation Reduction:* Promote ride-sharing (provide preferred parking for carpoolers). Offer transit subsidies for employees using public transportation and bicycle storage for cyclists. Enable remote work opportunities where feasible.
- *Decrease Business Travel:* Use video conferencing instead of traveling. For essential trips, track mileage and flight distances and purchase carbon offsets from organizations like Carbonfund.org to compensate for greenhouse gas emissions.

- *Sustainable Procurement:* Inform suppliers about interest in sustainable products and establish specific targets for purchasing recycled, refurbished, or used items. Consider environmental factors, not just cost, when making purchasing decisions.
- *Employee Engagement:* Establish teams to lead organizational environmental efforts and identify areas for maximum impact with minimal investment.
- *Water Conservation:* Monitor plumbing fixtures for leaks that waste water. Eliminate water waste in manufacturing processes and landscape irrigation.
- *Alternative Energy Assessment:* Evaluate opportunities for implementing solar energy, biofuels, wind power, and other renewable energy sources.
- *Eco-friendly Materials:* Organizations should establish policies for purchasing chlorine-free paper with higher post-consumer recycled content. Consider switching to lighter paper weights or alternatives made from bamboo, hemp, or organic cotton. Recycle toner and ink cartridges and purchase remanufactured versions.
- *Office Recycling Programs:* Implement paper, can, and bottle recycling in workplaces and acknowledge departmental achievements.
- *Energy Conservation Habits:* Encourage turning off lights, computers, and printers after work hours and weekends for additional energy savings.

Human Resources endure primary responsibility for achieving environmental sustainability by transforming employees into environmentally conscious workers, thereby meeting organizational environmental objectives. HR significantly influences organizational function and workplace culture, governed by policies that reflect senior management philosophy. Human resources implements practices and interventions including online recruitment and selection, training and development, and performance management.

Organizations increasingly adopt various measures to promote ecological development and guide employees toward environmental awareness. Sustainable practices help hospitality organizations distinguish themselves. Today's travelers, restaurant customers, hotel guests, and consumers prioritize sustainability.

They seek assurance that businesses they support follow environmentally, socially, and culturally responsible practices. Eco-friendly hotels are environmentally conscious lodging facilities with management that participates in and initiates environmental sustainability programs. Programs such as water conservation techniques, energy reduction, and waste consolidation are commonly implemented in green hotels.

7.0 Research Objectives

Based on research findings showing various HR interventions that lead to environmental practices adopted by different organizations, and considering research

questions and the overall scope of studying “Human Resource Intervention in Implementing Environmental Practices within Hospitality Organizations,” the researcher has established the following study objectives:

1. To examine HR’s role in promoting environmental practices in hospitality organizations.
2. To investigate various environmental practices resulting from different HR interventions.
3. To evaluate existing environmental practices in hospitality organizations within the study region.

7.1 Data sources

The research utilizes two data sources: primary and secondary.

- **Primary Data:** Primary information is gathered from respondents through personal interviews using questionnaires about different HR interventions that result in various environmental practices.
- **Secondary Data:** Secondary information for the study was obtained through journals, annual reports, articles, research reports, and libraries at Karnataka University, Dharwad, reports from FHRAI, HAI and various websites to develop questionnaires and achieve objectives.

7.2 Sampling framework

- **Sampling Units:** The sampling unit contains sampling elements. For this study, sampling units include HR managers and acting HR personnel (owners, food & beverage managers, and front office managers or executives) working in star-rated hotels in Karnataka state.
- **Sample Size:** To examine HR interventions leading to environmental practices within hotels, a descriptive analysis was conducted. For this descriptive study, samples (HR managers) were selected from the population based on established criteria.

For this survey Karnataka state districts are divided into two divisions: Belgaum division and Mysore division. A total of 460 star-category hotels are distributed unevenly across these divisions. From the 460 hotels identified as the study population, a sample size of 125 was determined.

8.0 Findings of the Study

1. Survey results clearly showed that environmental training encourages employees to incorporate sustainable practices into their daily work routines. Training helps employees understand the importance of environmental responsibility and its implementation.
2. Employees receive training to enhance awareness and skills regarding environmental matters, enabling them to effectively follow sustainable practices.

3. Staff members are trained in water conservation, including water recycling practices followed by most hotels, paper recycling in daily operations with printing only when necessary, and zero waste management to minimize and recycle waste.
4. Survey evidence indicated that electronic recruitment and selection significantly reduces paperwork and office supply waste. Most respondents' opinions show major influence on sustainability thinking, resulting in practices such as online resumes, virtual interviews, and email communication.
5. HR departments have included environmental awareness criteria in job specifications as part of the selection process, with most respondents agreeing to these incorporated criteria in HR staffing policies for online recruitment and selection.
6. The study reveals that HR intervention positively influences the development of environmental thinking and practices among hotels. Practices such as email communication, teleconferencing, electronic filing, environmental objectives, and computerized evaluations are evident from respondent feedback.
7. Employees are trained to communicate via email rather than printed materials, with performance monitoring of this practice. HR monitors non-compliance with environmental practices, with respondents tracking failure to meet green objectives.
8. Employee involvement in environmental initiatives as an HR intervention positively influences the introduction of new sustainable practices and active employee participation in hotels, creating greater responsibility toward environmental practices.

9.0 Summary

Sustainability and environmental practices are concepts that must be integrated into the overall business operations of hospitality organizations. The hotel industry has the potential to incorporate environmental practices into routine management. To achieve this, hotels need to implement significant changes in managerial thinking and operational procedures. Implementation of such HR practices has been observed in the studied hotels in a gradual manner, while the effects of these interventions are clearly visible through adopted environmental practices.

Among these interventions, training has been observed to introduce practices such as water conservation, energy conservation, paperless operations, eco-friendly travel, and plastic-free premises. Electronic recruitment has clearly established 'paperless office' environmental practices. New reward and recognition systems have created major changes in environmental thinking among employees. They appear motivated to adopt environmental concepts in their routine hotel work.

10.0 Limitations of the Study

1. The research geography is limited to Karnataka state.
2. The study focuses on the hotel industry within hospitality organizations, restricting the study area to hotels operating in Karnataka state.
3. The research is limited to star-category hotels only.
4. The study examines only HR roles resulting in environmental practices.
5. The research is based on respondent opinions and their responses are subject to existing scenarios or respondent perceptions.

References

1. Alexander, S. (2002). Green Hotels: Opportunities and Resources for Success. Accessed on September 11, 2016 and Retrieved from http://www.zerowaste.org/publications/GREEN_HO.PDF
2. Deshpande, A. (2018). Abhinav National Monthly Refereed Journal of Research in “Eco - Purchasing”: A Study of the Solid Waste Prevention Methods adopted by Hotels and Restaurants of Pune City Abhinav National Monthly Refereed Journal of Research In, 7(9), 10–24.
3. E. E. Lawler, and S. A. Mohrman, —HR as a strategic partner: What does it take to make it happen?|| Human Resource Planning, vol. 26, no. 3, pp. 15-29, 2003.
4. Essex, S., & Hobson, K. (2001). Sustainable tourism: A view from accommodation Businesses. The Service Industries Journal, 21(4), 133-146.
5. Green Hotel Association, (GHA). (2008). What are Green Hotels? Retrieved from: Green Hotel Association (GHA) Web site: www.greenhotels.com [8]
6. H. Francis, and A. Keegan, —The changing face of HRM: In search of balance.|| Human Resource Management Journal, vol. 16, no. 3, pp. 231-249, 2006.
7. Kennedy, K & Toffler, B (2014), —Sustainable Management and Business Sustainability: Conceptual Models||, International Journal of Business Strategy.
8. Manaktola, K., & Jauhari, V. (2007). Exploring Consumer Attitude and Behaviour towards Green Practices in the Lodging Industry in India. International Journal of Contemporary Hospitality Management, 19(5): 364-377. Doi 10.1108/09596110710757534.
9. M-Y. Yusliza, T. Ramayah, and O. Nur Zahiyah, —Why examining adoption factors, HR role and attitude towards Using E-HRM is the start-off in determining the successfulness of green HRM? || Journal of Advanced Management Science, vol. 3, no. 4, 2015.

10. Renwick, D.W.S. Redman, T. and Maguire, S. (2013). "Green Human Resource Management: A Review, and Research Agenda". *International Journal of Management Review*, Vol. 15
11. S. Strohmeier, —Research in e-HRM: Review and implications, *Human Resource Management Review*, vol. 17, no. 1, pp. 19-37, 2007.
12. Singh, M. K., & Arora, R. D. (2014). The Changing Face Of The Indian Hospitality Industry. *International Journal of Advanced Research in Management and Social Sciences*, 26-36.
13. Verma, V. K., & Chandra, B. (2018). Intention to implement green hotel practices: evidence from Indian hotel industry. *International Journal of Management Practice*, 11(1), 24-41.
14. Verma, V. K., & Chandra, B. (2018). An application of theory of planned behavior to predict young Indian consumers' green hotel visit intention. *Journal of Cleaner Production*, 172, 1152–1162. <https://doi.org/10.1016/j.jclepro.2017.10.047>
15. W. Zhu, I. K. H. Chew, and W. D. Spangler, —CEO transformational leadership and organizational outcomes: The mediating role of humancapital-enhancing human resource management, *Leadership Quarterly*, vol. 16, no. 1, pp. 39-52, 2005.

CHAPTER 7

Does Nutritional Value Influence Consumer Buying Behavior?

Radhika Itgekar and Shailaja Hiremath***

ABSTRACT

Amid increasing health concerns and growing interest in nutrition among Indian consumers, this study explores how people in Belagavi, Karnataka understand and respond to front-of-pack nutrition labels (FOPL) and how these labels shape their buying choices. A structured survey was administered to 102 respondents, and the results were examined using descriptive tools along with chi-square tests in Jamovi and Excel. The descriptive analysis helped outline basic demographic patterns, the extent to which shoppers look at labels, and their general attitudes toward nutritional details. The chi-square findings indicate that consumers who are more aware of FOPL tend to make more informed and health-oriented purchase decisions, particularly within younger and better-educated groups. Despite this, many participants still struggle with limited understanding of label elements due to complex formats, inconsistent presentation, and minimal awareness campaigns. The study suggests the need for clear, standardized, and easy-to-interpret labeling supported by targeted educational initiatives. Strengthening consumer nutrition literacy can enable more responsible food choices and support policy efforts aimed at improving public health in urban Indian settings.

Keywords: Front-of-pack labeling; Consumer behavior; Nutritional value awareness; Food labeling; Health-conscious purchasing.

1.0 Introduction

Growing knowledge of health and wellness has played a major role in the dramatic alteration of consumer behaviour in the food business in recent decades. Consumers are starting to give more weight to the nutritional value of the foods they eat as lifestyle diseases including obesity, diabetes, and cardiovascular ailments become more common worldwide (World Health Organisation, 2020). In this regard, food packaging increasingly functions as a medium for disseminating health-related information in addition to being a marketing tool, and nutritional labelling has emerged as a critical factor influencing consumer decision-making (Grunert & Wills, 2007).

**Corresponding author; Student, Marketing Department, KLS Institute of Management, Education and Research, Belagavi, Karnataka, India (E-mail: radhikaitgekar07@gmail.com)*

***Professor, MBA Department, KLS Institute of Management, Education and Research, Belagavi, Karnataka, India (E-mail: shailajagh@klsimer.edu)*

Numerous international research have highlighted how nutritional labels influence customer decisions. Numerous international research have highlighted how nutritional labels influence customer decisions. For instance, Campos et al. (2011) contend that customers who are knowledgeable and health-conscious make healthier food choices when they have easy access to nutritional information on packaging. Policies requiring front-of-package labelling, such as calorie counts and warning labels, have been proven to somewhat lower the purchase of unhealthy foods in developed nations (Song et al., 2021). However, it is unclear how well these 18 findings apply to developing countries like India, where a variety of socioeconomic origins affect purchasing power and health literacy.

Customers in India are becoming more conscious of the significance of nutrition and diet. According to studies, urban Indian consumers—especially those in metro areas—are starting to read nutrition labels, while there is still variation in their comprehension and impact on purchasing decisions (Singla, 2010). While Indian consumers are steadily demonstrating interest in low-fat, high-fiber, and low-sugar options, Paul and Bedi (2014) pointed out that variables including price sensitivity, brand trust, and taste preferences sometimes overshadow this enthusiasm. There is little research on consumer behaviour regarding nutritional value in tier-2 cities like Belagavi, despite this increased awareness in urban regions. Belagavi, a fast-growing urban area in Karnataka, reflects a population that is shifting from conventional consumption habits to contemporary, health-conscious decisions. Belagavi provides a unique setting for investigating how nutritional value affects food purchase decisions in non-metropolitan people because of growing exposure to digital media, rising literacy, and easier availability to packaged foods. Furthermore, there are notable differences in nutritional literacy amongst age groups, income levels, and educational backgrounds. Customers who are more health conscious and have a better comprehension of nutrition labels are more likely to make well-informed purchasing decisions, according to Sripathi et al. (2023). However, obstacles like consumer scepticism, label complexity, and lack of standardisation frequently reduce the efficacy of nutritional information (National Academies of Sciences, 2011).

By investigating how nutritional value affects consumer purchasing behaviour in Belagavi, this study seeks to close the current research gap. The study examined 49 knowledge levels, how nutritional information is interpreted, and how it actually affects food choices using primary data gathered from 100 respondents. The results provided policymakers, marketers, and health educators with important information to help them create health communication techniques that are more successful in India's smaller urban markets.

1.1 Statement of the problem

A sizable percentage of Indian customers continue to ignore nutritional value while making food purchases, despite rising health consciousness and government-led programs

encouraging a healthy diet. Although there have been encouraging developments in the use of nutritional labels in metropolitan areas, little study has been done on consumer behaviour in developing urban areas like Belagavi.

The following fundamental issues are the focus of this study:

- Despite the availability of branded food options and increased health hazards, consumers might not give nutritional value top priority when making purchases.
- When compared to metropolitan areas, Belagavi consumers' knowledge and comprehension of nutrition labels is mainly unknown.
- The impact of demographic parameters including age, gender, income, and education on the use of nutritional information while purchasing food goods is not well documented.

1.2 Objectives of the study

This study's main goal was to find out how Belagavi customers' decisions to buy food are influenced by its nutritional content. The particular goals are as follows:

- To determine how much nutritional value affects Belagavi consumers' purchasing decisions.
- To gauge how well consumers comprehend and are aware of nutrition labels on packaged food items. One
- To determine the main demographic factors (age, gender, income, and education) that influence how much weight consumers give to nutritional value.

2.0 Literature Review

Researchers and policymakers are paying more attention to the impact of nutritional value on consumer purchasing behaviour, especially in light of the growing number of health problems associated with unhealthy eating habits. Numerous studies indicate that consumers are growing more aware of what they eat, and that food selections are significantly influenced by nutritional value (Campos et al., 2011). Front-of-package (FOP) and back-of-package labelling, which offers information on calorie content, sugar levels, fat composition, and other important nutrients, is one of the most direct ways nutritional information reaches customers.

The effectiveness of nutrition labels in influencing customer behaviour has been the subject of numerous international research. For example, Temple (2020) observes that FOP labels with warning or traffic-light symbols are more effective than numerical-based systems at directing customers towards healthier solutions. According to a systematic analysis by Cecchini and Warin (2016), customers with less nutritional knowledge likely to make healthier purchases based on interpretive labels (such as Nutri-Score and star ratings) as opposed to non-interpretive labels.

A key factor is the consumer's knowledge and comprehension of these labels. Grunert and Wills (2007) assert that merely putting labels on packaging is insufficient unless consumers are motivated and trained to read and understand them. Awareness is frequently influenced by demographic variables such as age, income, education level, and whether one lives in an urban or rural area (Miller & Cassady, 2012). Although many urban customers in India claimed to read nutritional labels, only a tiny percentage used them to make purchasing decisions, according to a research by Kaur et al. (2021). This is mostly because of the format's complexity and lack of standardisation.

Additionally, consumer behaviour is greatly influenced by label visibility and design. Research indicates that labels with basic messaging, colour coding, and legible fonts work better (Talati et al., 2017). For instance, a study conducted in 59 Mexico showed that warning labels made it easier for customers to recognise harmful products and decreased their inclinations to buy them (Taillie et al., 2020). According to Kanter et al. (2018), research conducted in Kenya revealed that healthy food choices could be influenced by clear labelling, especially among lower-income groups. Furthermore, how consumers perceive nutritional information is influenced by their level of trust in regulatory agencies and companies.

Customers are more likely to take action when they think the information is reliable and supported by health authorities (Campos et al., 2011). Packaging that highlights health advantages or makes use of environmentally friendly materials can strengthen favourable opinions of a company and its goods (Magnier & Schoormans, 2015). In conclusion, the body of research clearly supports the notion that nutritional value has a major impact on customer purchasing decisions, particularly when nutritional data is provided and comprehended. The strength of this influence is moderated by awareness levels and demographic characteristics. In order to increase the influence of nutritional labelling on consumer behaviour, this review emphasises the significance of consumer education, standardised label design, and reliable information.

3.0 Research Methodology

With an emphasis on the function of nutrition labels, health consciousness, and demographic factors, this study attempts to investigate how nutritional value affects customer purchasing behaviour in Belagavi City, Karnataka. A quantitative technique has been used in conjunction with a seven-descriptive study design to address this. This approach is suitable for analysing consumer attitudes, behaviours, and perceptions regarding health-conscious food choices at a particular moment in time (Bryman, 2012).

Belagavi is a rapidly growing tier-2 city with a varied and changing customer base that is more familiar with packaged foods, health messaging, and contemporary shop forms.

Customers in places like Belagavi are becoming more careful of food choices as knowledge of lifestyle-related disorders grows, making this area a perfect place to research the connection between nutritional labels and purchasing decisions.

3.1 Research design

The current study uses a descriptive and quantitative research approach, which is ideal for comprehending and evaluating the attitudes, preferences, and behaviours of consumers. The objective is to characterise Belagavi consumers' present awareness, perception, and use of nutritional information and to ascertain the degree to which nutritional value influences their purchasing decisions. In order to find patterns and links between factors like age, income, health consciousness, and purchasing behaviour, descriptive research makes it possible to gather quantitative data from a particular community. In order to assess the impact and correlations between factors, the quantitative approach enables researchers to collect numerical data via surveys and statistical tools (Creswell & Creswell, 2018).

3.2 Sample design

- *Population:* Customers that regularly purchase FMCG (fast-moving consumer goods) products and live in Belgaum, Karnataka, make up the study's demographic.
- *Sample Frame:* Belgaum citizens who are 18 years of age or older are included in the sampling frame, which is available through internet resources, neighbourhood markets, and retail establishments.
- *Sample Unit:* The sample unit consists of every single Belgaum consumer who buys packaged goods (such as groceries, personal care products, and beverages).
- *Sampling Technique:* Non-Probability Convenience Sampling is used in this investigation. This approach, which tries to gather data from respondents who are easily available, was chosen due to practical time and resource constraints (Etikan, Musa, & 34 Alkassim, 2016).
- *Sample Size Calculation:* The sample size was determined using the ideas of statistical significance and confidence level. To guarantee accurate and legitimate results, a representative sample size of 102 clients is thought to be appropriate. (Ahmad, 2021)
- *Survey Method:* Data was gathered using a structured questionnaire with closed-ended questions and 5-point Likert scale items. Respondents' attitudes, perceptions, and behaviours about nutritional information and its impact on their food purchase decisions are measured using a 5-point Likert scale. Because of its simplicity, ease of response, and applicability for a variety of participants without sacrificing data quality, a 5-point scale is preferred over a 7-point one (Boone & Boone, 2012). It is therefore perfect for both quantitative and descriptive research.

3.3 Data sources

- Primary Data Sources: Google Forms online surveys were used to gather primary data. Sixty
- Secondary Data Sources: Information about consumer behaviour and packaging trends was gathered from government publications, books, industry studies, and scholarly journals.

3.4 Hypothesis

The following theories were investigated in the study:

- H0 (Null): Consumer purchasing behaviour in Belagavi is not substantially influenced by nutritional value.
- H1 (Alternative): In Belagavi, consumers' purchasing decisions are greatly influenced by nutritional value.
- H0 (Null): Food purchase decisions and knowledge of nutrition labels do not significantly correlate.
- H1 (Alternative): Food purchasing decisions and nutrition label awareness are significantly correlated.
- H0 (Null): The emphasis that consumers place on nutritional value is not considerably impacted by demographic characteristics.
- H1 (Alternative): The significance that consumers attach to nutritional value is greatly influenced by demographic characteristics (age, gender, income, and education).

3.5 Data analysis tools

To extract significant insights, a combination of descriptive and inferential statistical approaches were applied to the data gathered from 102 respondents in Belagavi.

- Eight demographic traits and general replies about the significance of nutritional value and consumer purchasing behaviour were summarised using descriptive statistics including mean, percentages, and frequencies.
- To better understand 32 subgroup behaviour, cross-tabulation was used to examine trends and compare responses across several demographic 39 categories (e.g., age, gender, income, occupation, and education).
- The relationship between categorical variables, such as understanding of nutrition labels and their impact on food purchasing decisions, was evaluated using chi-square tests. Additionally, it assisted in examining the connections between demographic factors and the significance of nutritional value.
- By predicting the likelihood that respondents would choose greater levels of agreement (e.g., Strongly Agree vs. Agree, etc.), the Ordinal Logistic Regression test was used to

assess the impact of demographic variables on the 55 4 ordinal dependent variable—nutritional value important.

- Jamovi, an open-source statistical program with an intuitive 51 interface that is perfect for doing ordinal regression, chi-square tests, and descriptive analysis, was used to analyse the data. Data entry, rudimentary cleaning, tabulation, and graphical results presenting (such as charts and tables).

3.6 Limitations of study

Although this study provides insightful information about how nutritional value affects Belagavi consumers' purchasing decisions, it is important to recognise its limitations:

- *Small Sample Size:* Only 100 participants provided comments for the survey, which may not accurately reflect Belagavi's diverse population of 63. Results from a bigger sample might be more broadly applicable (Creswell, 2014).
- *Geographic Limitation:* Because the study was limited to the Karnataka city of Belagavi, the results might not accurately represent consumer behaviour in rural or other areas where access to and understanding of nutritional information may be different (Kumar & Kapoor, 2015).
- *Self-Reported Information:* Self-reported questionnaires were used to gather the data, which may be prone to social desirability bias. In order to appear more health-conscious, respondents may exaggerate their nutritional knowledge or concern (Podsakoff et al., 2003).
- *Cross-Sectional Design:* The study does not account for behavioural changes over time or demonstrate causal linkages because it is cross-sectional and records answers at a particular moment in time (Bryman, 2012).
- *Emphasis on Packaged Foods:* Since fresh produce, street food, and unlabelled foods make up a sizable amount of the Indian diet, the study's focus on packaged food products prevents it from adequately capturing purchasing behaviour related to these items (Kumar & Kapoor, 2015).

4.0 Data Analysis

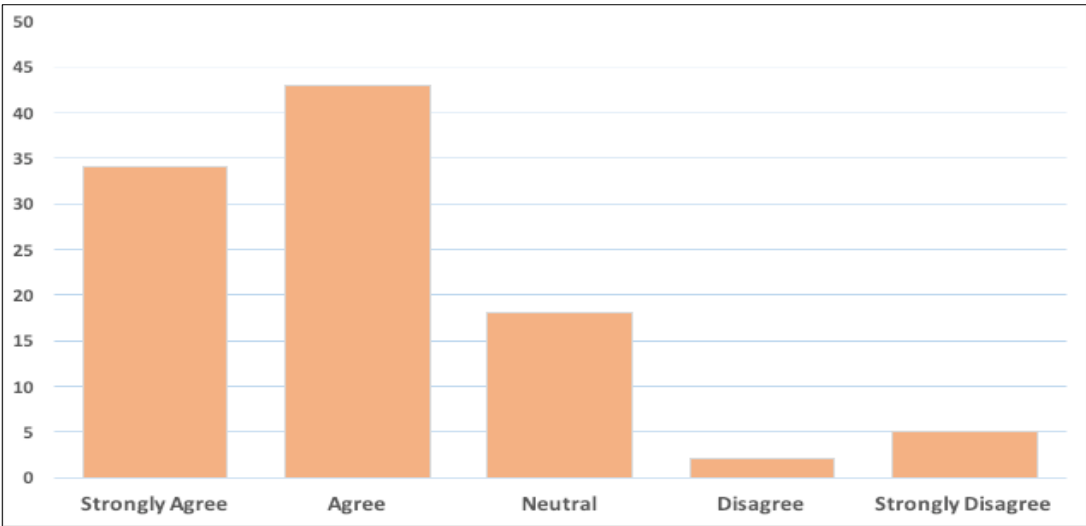
4.1 Importance of nutritional value in consumer purchase decisions

To understand the extent to which nutritional value affects consumer behavior in Belagavi, a Chi-Square Goodness of Fit test was conducted. Respondents (N = 102) were asked whether nutritional value was an important consideration when selecting packaged food items. The responses were recorded across five ordinal categories: Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree.

Table 1: Observed Distribution

Response	Count	Proportion
Strongly Agree	34	33.3%
Agree	43	42.2%
Neutral	18	17.6%
Disagree	2	2.0%
Strongly Disagree	5	4.9%

Figure 1: Importance of Nutritional value in Consumer Purchase Decisions



The test was used to determine whether the observed frequencies significantly deviated from an expected equal distribution across all five response options.

Hypotheses:

- H0 (Null): Consumer purchasing behaviour in Belagavi is not substantially influenced by nutritional value.
- H1 (Alternative): In Belagavi, consumers' purchasing decisions are greatly influenced by nutritional value.

Chi-Square Test Result:

- χ^2 (df = 4) = 62.6
- $p < 0.001$

Since the p-value is less than 0.05, the null hypothesis is rejected. This suggests that there is a statistically significant deviation from a uniform response pattern. A majority of respondents reported either *Agree* or *Strongly Agree*, indicating that nutritional value is indeed an important factor influencing consumer purchasing decisions for packaged food in Belagavi.

4.2 Association between nutritional value importance and awareness of nutrition labels

To explore whether awareness of nutrition labels (such as the FSSAI logo) influences how strongly individuals consider nutritional value when selecting packaged food items, a Chi-Square Test of Independence (χ^2 Test of Association) was conducted. This statistical test is appropriate because:

- Both variables are categorical in nature.
- The goal is to evaluate whether the distribution of responses on one variable (importance of nutritional value) is independent of responses on another variable (awareness of nutrition labels, such as the FSSAI logo).

Hypotheses:

- H0 (Null): Food purchase decisions and knowledge of nutrition labels do not significantly correlate.
- H1 (Alternative): Food purchasing decisions and nutrition label awareness are significantly correlated.

Table 2: Contingency Tables

Awareness of nutrition labels	Nutritional Value Importance On Consumer Behaviour In Belagavi					Total
	Strongly agree	Agree	Strongly disagree	Neutral	Disagree	
Strongly agree	20	9	1	1	0	31
Agree	9	19	0	5	0	33
Strongly disagree	0	0	3	1	1	5
Neutral	2	10	1	7	1	21
Disagree	3	5	0	4	0	12
Total	34	43	5	18	2	102

Table 3: Test Results

Chi-Square Value (χ^2) = 72.6
Degrees of Freedom (df) = 16
p-value < 0.001
Sample Size (N) = 102

Since the p-value is less than the conventional threshold of 0.05, the null hypothesis (There is no significant relationship between awareness of nutrition labels and food purchasing decisions) can be rejected. This indicates a statistically significant relationship between consumers' awareness of nutrition labels and the importance they place on nutritional value in their food choices. In other words, consumers who are more aware of nutritional labeling (e.g., FSSAI logo) are more likely to prioritize nutritional value when purchasing packaged foods.

4.3 Demographic factors and their influence on nutritional value importance

Hypotheses

- H0 (Null): The emphasis that consumers place on nutritional value is not considerably impacted by demographic characteristics.
- H1 (Alternative): The significance that consumers attach to nutritional value is greatly influenced by demographic characteristics (age, gender, income, and education).

Tests Used

To test these hypotheses, we used two complementary statistical methods:

1. Chi-Square (χ^2) Test of Independence

- Purpose: To examine the association between each demographic factor and nutritional importance.
- Why: Chi-square is ideal for testing non-parametric relationships between two categorical variables.

2. Ordinal Logistic Regression

- Purpose: To analyze whether changes in demographics predict the ordered response levels of importance (from *Strongly Disagree* to *Strongly Agree*).
- Why: Since the dependent variable (nutritional importance) is ordinal, this model captures directional effects and estimates how much one category increases/decreases the odds of a higher importance rating.

4.3.1 Chi-square analysis summary

Table 4: Chie Square Analysis

Demographic Variable	χ^2 Value	df	p-value	Significance
Age	12.8	12	0.382	Not Significant
Gender	2.82	4	0.589	Not Significant
Income	8.94	16	0.916	Not Significant
Education	9.68	16	0.883	Not Significant
Occupation	22.8	16	0.118	Not Significant

- No statistically significant associations were found between any individual demographic factor and the levels of nutritional value importance using chi-square tests.
- Limitation of Chi-square: While it tests if an association exists, it doesn't indicate *which categories* within the demographic variable drive the effect.

4.3.2 Ordinal logistic regression analysis

The McFadden R^2 value of 0.084 indicates a modest predictive power. While the model is not very strong, it allows insight into which subgroups may drive perceptions about nutrition.

Table 5: Model Fit

Metric	Value
Deviance	236
AIC	276
McFadden R^2	0.084

Table 6: Significant Predictors ($p < 0.05$)

Predictor	Estimate	p-value	Interpretation
Student – Professional	2.006	0.005	Significant
Others (Occupation) – Professional	1.739	0.026	Significant

- Student vs. Professional:
 - o Students are significantly more likely to place a higher importance on nutritional value than professionals.
 - o The positive estimate (2.006) suggests students are more inclined to choose “Agree” or “Strongly Agree” compared to professionals.
 - o Implication: Students may be more health-conscious, aware of nutrition, or influenced by current educational or social trends.
- Others vs. Professional:
 - o Respondents classified under “Others” are also more likely to rate nutrition as highly important.
 - o Suggests that professions outside of typical classifications (e.g., freelancers, homemakers, retirees) may hold stronger views on nutrition.
- Non-Significant Predictors: Other demographic contrasts (age groups, gender, income brackets, education levels) did not show statistically significant effects.
 - o Gender (Female vs. Male): Estimate was negative but not significant ($p = 0.408$).

- o Age (All categories vs. 18-25): No age group showed significant deviation.
- o Income and Education: None of the brackets had significant influence.

While broad demographic categories did not show significant associations using chi-square tests, ordinal logistic regression revealed key differences within occupation categories:

- Students and “Others” value nutritional information more significantly than professionals.
- This could suggest that certain life stages (e.g., studying, non-working) influence a greater health consciousness or attentiveness to nutrition labelling.

5.0 Findings and Conclusions

According to the survey, Belagavi consumers’ decisions to buy food are heavily influenced by nutritional content. There is an increasing trend of health consciousness in the city, as evidenced by the significant percentage of respondents who stated that they deliberately check the nutritional content of packaged food items before making a purchase. When asked how important nutrition is, the majority of consumers gave positive answers like “Agree” and “Strongly Agree,” indicating a significant preference for healthier food choices.

Furthermore, the investigation revealed a strong correlation between consumers’ awareness of nutrition labels—like the FSSAI logo—and the significance they attach to nutritional content. This suggests that people who are aware of and comprehend food labels are more likely to base their purchases on nutritional considerations, proving the usefulness of labelling as a communication tool in shaping consumer behaviour.

The perception of nutritional value was found to be significantly influenced by occupation, but not by demographic factors such as age, gender, income, or education. In particular, compared to professionals, students and people in the “Others” category—which includes homemakers, retirees, and independent contractors—were more likely to place a high value on nutritional information. This implies that those who don’t work in traditional settings might have more time, flexibility, or motivation to interact with nutritional material. Additionally, this demographic may be more exposed to health-related content via social or educational platforms. On the other hand, because of lifestyle restrictions, time constraints, or convenience-driven behaviours, working professionals may either ignore or undervalue nutritional factors.

Overall, the results show how Belagavi’s consumer landscape is changing, with health and nutrition awareness increasingly influencing consumer behaviour, especially among young people and nonprofessional groups. These findings also highlight the increasing importance of label literacy and nutrition education in promoting informed food choices, particularly in urbanising tier-2 cities like Belagavi.

6.0 Recommendations

Based on the findings of the study, the following recommendations are proposed:

1. **Strengthen Consumer Education on Nutrition Labels:** Health authorities, educational institutions, and regulatory bodies such as FSSAI should conduct awareness programmes to educate consumers on how to read and interpret nutrition labels. Community workshops, digital campaigns, and short informational videos can help consumers better understand nutritional terms and values.
2. **Adopt Segment-Specific Marketing Strategies:** Marketers should customise their communication strategies based on consumer segments. Health-focused messaging can be directed toward students and homemakers, while convenience-oriented yet health-aligned messaging may be more effective for working professionals with time constraints.
3. **Improve Visibility and Simplicity of Nutritional Information:** FMCG companies should highlight key nutritional benefits clearly on product packaging using simple language, icons, or colour-coded indicators. This can make nutritional information easier to understand at the point of purchase.
4. **Collaborate with Educational Institutions:** Schools and colleges can play a vital role in promoting nutritional awareness. Integrating basic nutrition education into co-curricular activities and organising health-focused initiatives can help build long-term healthy consumption habits among young consumers.
5. **Support Clear and Standardised Labelling Policies:** Policymakers should consider strengthening front-of-pack labelling regulations to ensure consistency and clarity. Simplified labelling systems such as star ratings or traffic-light indicators can improve accessibility for consumers across different literacy levels.
6. **Use Retail Stores as Awareness Platforms:** Retail outlets can serve as effective points for nutrition education through shelf labels, comparison charts, QR codes, and trained staff who can guide consumers in making healthier choices.
7. **Encourage Health-Oriented Product Innovation:** Food manufacturers should respond to increasing health awareness by developing and promoting nutritious product alternatives, such as low-sugar, high-fibre, or fortified food options, aligned with consumer demand.

References

1. Allen, I. E., & Seaman, C. A. (2007). Likert scales and data analyses. *Quality Progress*, 40(7), 64–65.
2. Bryman, A. (2012). *Social research methods* (4th ed.). Oxford University Press.

3. Campos, S., Doxey, J., & Hammond, D. (2011). Nutrition labels on pre-packaged foods: A systematic review. *Public Health Nutrition*, 14(8), 1496–1506. <https://doi.org/10.1017/S1368980010003290>
4. Cecchini, M., & Warin, L. (2016). Impact of food labelling systems on food choices and eating behaviours: A systematic review and meta-analysis of randomized studies. *Obesity Reviews*, 17(3), 201–210.
5. Cochrane Library review. (2025). Calorie labels encourage people to eat less by only a single crisp study. *Cochrane Review via The Guardian*. [theguardian.com](https://www.theguardian.com)
6. Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). SAGE Publications.
7. Frontiers survey. (2022). Consumers’ perception about front-of-package food labels (FOPL) in India: A survey of 14 states. *Frontiers in Public Health*.
8. Global Health Action. (2015). Nutrition labelling: A review of research on consumer and industry response in the global South. *Global Health Action*, 8, 25912.
9. Grunert, K. G., & Wills, J. M. (2007). A review of European research on consumer response to nutrition information on food labels. *Journal of Public Health*, 15(5), 385–399. <https://doi.org/10.1007/s10389-007-0101-9>
10. Joshi, A., Kale, S., Chandel, S., & Pal, D. K. (2015). Likert scale: Explored and explained. *British Journal of Applied Science & Technology*, 7(4), 396–403. <https://doi.org/10.9734/BJAST/2015/14975>
11. Kanter, R., Vanderlee, L., & Vandevijvere, S. (2018). Front-of-package nutrition labeling policy: Global progress and future directions. *Public Health Nutrition*, 21(8), 1399–1408.
12. Kaur, H., Singh, A., & Rao, A. (2021). Consumer awareness and use of food labels in India: An urban perspective. *International Journal of Consumer Studies*, 45(4), 506–517.
13. Kumar, B., & Kapoor, S. (2015). Nutritional labelling and consumer awareness in India: A review. *International Journal of Management and Social Sciences Research*, 4(1), 15–20.
14. Magnier, L., & Schoormans, J. (2015). Consumer reactions to sustainable packaging: The interplay of visual appearance, verbal claim and environmental concern. *Journal of Environmental Psychology*, 44, 53–62.
15. MDPI fast food study. (2021?). The impact of nutrition labelling on customer buying intention and behaviours in fast food operations. *International Journal of Environmental Research and Public Health*. [mdpi.com](https://www.mdpi.com)
16. Miller, L. M. S., & Cassady, D. L. (2012). The effects of nutrition knowledge on food label use: A review of the literature. *Appetite*, 59(2), 414–425.

17. National Academies of Sciences, Engineering, and Medicine. (2011). *Front-of-package nutrition rating systems and symbols: Promoting healthier choices*. The National Academies Press. <https://doi.org/10.17226/13221>
18. Paul, R., & Bedi, M. (2014). Nutrition label usage: An empirical study of consumer response in India. *Indian Journal of Marketing*, 44(4), 25–33.
19. PMC New Delhi/Hyderabad study. (2013). Use of food label information by urban consumers in India – A study among supermarket shoppers. *Public Health Nutrition*.
20. Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology*, 88(5), 879–903. <https://doi.org/10.1037/0021-9010.88.5.879>
21. Singla, M. (2010). Usage and understanding of food and nutritional labels among Indian consumers. *British Food Journal*, 112(1), 83–92. <https://doi.org/10.1108/00070701011011227>
22. Song, J., Brown, M. K., Tan, A. X., & Roberto, C. A. (2021). Impact of front-of-package nutrition labeling on consumer behavior: A systematic review and meta-analysis. *American Journal of Preventive Medicine*, 60(4), 576–585. <https://doi.org/10.1016/j.amepre.2020.10.015>
23. Sripathi, N., Dehury, R. K., & Neeragatti, S. (2023). The influence of health consciousness, nutritional labeling, and subjective norms on consumer purchase intentions of healthy packaged foods. *Academy of Marketing Studies Journal*, 27(5), 1–13.
24. Taillie, L. S., Hall, M. G., Popkin, B. M., Ng, S. W., & Murukutla, N. (2020). Experimental studies of front-of-package nutritional labels: A systematic review and meta-analysis. *PLoS Medicine*, 17(11), e1003500.
25. Talati, Z., Pettigrew, S., Dixon, H., Neal, B., Ball, K., & Hughes, C. (2017). Do health claims and front-of-pack labels lead to a positivity bias in unhealthy foods? *Nutrients*, 9(5), 453.
26. Temple, N. J. (2020). Front-of-package food labels: A narrative review. *Appetite*, 144, 104485.
27. Vox & Chile review. (2025). Will warning labels on ultra-processed foods make America healthy again? *Vox*, referencing Latin American studies.
28. World Health Organization. (2020). Healthy diet. <https://www.who.int/news-room/fact-sheets/detail/healthy-diet>

Appendix

Chi-Square Goodness of Fit test result for Importance of Nutritional Value in Consumer Purchase Decisions

Proportion Test (N Outcomes)

Proportions - Nutritional Importance Value

Level	Count	Proportion
Strongly agree	34	0.3333
Agree	43	0.4216
Strongly disagree	5	0.0490
Neutral	18	0.1765
Disagree	2	0.0196

χ^2 Goodness of Fit

χ^2	df	p
62.6	4	<.001

Chi-Square Test Results of Independence (χ^2 Test of Association) for Association Between Nutritional Value Importance and Awareness of Nutrition Labels

Contingency Tables

Contingency Tables

Awareness Of Nutritional Lables	Nutritional Importance Value					Total
	Strongly agree	Agree	Strongly disagree	Neutral	Disagree	
Strongly agree	20	9	1	1	0	31
Agree	9	19	0	5	0	33
Strongly disagree	0	0	3	1	1	5
Neutral	2	10	1	7	1	21
Disagree	3	5	0	4	0	12
Total	34	43	5	18	2	102

χ^2 Tests

	Value	df	p
χ^2	72.6	16	<.001
N	102		

Chi-Square (χ^2) Test of Independence test result for demographic factor (AGE)**Contingency Tables**

Contingency Tables

B	Nutritional Importance Value					Total
	Strongly agree	Agree	Strongly disagree	Neutral	Disagree	
18-25	21	29	3	14	2	69
26-35	11	8	2	1	0	22
36-50	2	3	0	3	0	8
50+	0	3	0	0	0	3
Total	34	43	5	18	2	102

 χ^2 Tests

	Value	df	p
χ^2	12.8	12	0.382
N	102		

Chi-Square (χ^2) Test of Independence test result for demographic factor (GENDER)**Contingency Tables**

Contingency Tables

D	Nutritional Importance Value					Total
	Strongly agree	Agree	Strongly disagree	Neutral	Disagree	
Male	15	20	2	7	2	46
Female	19	23	3	11	0	56
Total	34	43	5	18	2	102

 χ^2 Tests

	Value	df	p
χ^2	2.82	4	0.589
N	102		

Chi-Square (χ^2) Test of Independence test result for demographic factor (INCOME)**Contingency Tables**

Contingency Tables

F	Nutritional Importance Value					Total
	Strongly agree	Agree	Strongly disagree	Neutral	Disagree	
0-4 lakhs	25	34	5	11	2	77
4-8 lakhs	6	6	0	3	0	15
8-12 lakhs	1	3	0	2	0	6
12-16 lakhs	1	0	0	1	0	2
16 lakhs and above	1	0	0	1	0	2
Total	34	43	5	18	2	102

 χ^2 Tests

	Value	df	p
χ^2	8.94	16	0.916
N	102		

Chi-Square (χ^2) Test of Independence test result for demographic factor (EDUCATIONAL QUALIFICATION)**Contingency Tables**

Contingency Tables

H	Nutritional Importance Value					Total
	Strongly agree	Agree	Strongly disagree	Neutral	Disagree	
Postgraduate	11	16	2	7	0	36
Graduate	19	22	3	8	2	54
PUC	2	4	0	2	0	8
Others	2	1	0	0	0	3
SSLC	0	0	0	1	0	1
Total	34	43	5	18	2	102

 χ^2 Tests

	Value	df	p
χ^2	9.68	16	0.883
N	102		

Chi-Square (χ^2) Test of Independence test result for demographic factor (OCCUPATION)

Contingency Tables						
Contingency Tables						
J	Nutritional Importance Value					Total
	Strongly agree	Agree	Strongly disagree	Neutral	Disagree	
Professional	10	4	0	2	0	16
Student	9	22	2	11	1	45
Business	5	4	1	3	0	13
Others	3	9	2	1	0	15
Service	7	4	0	1	1	13
Total	34	43	5	18	2	102

χ^2 Tests			
	Value	df	p
χ^2	22.8	16	0.118
N	102		

Ordinal Logistic Regression Analysis Results

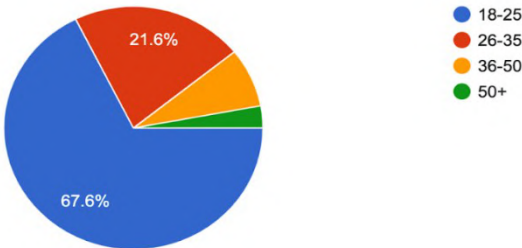
Ordinal Logistic Regression

Model Fit Measures			
Model	Deviance	AIC	R ² _{McF}
1	236	276	0.0840

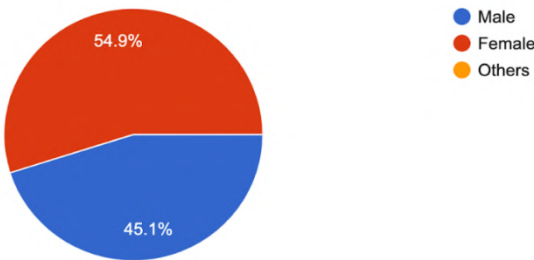
Note. The dependent variable 'Nutritional Importance Value' has the following order:
Strongly agree | Agree | Strongly disagree | Neutral | Disagree

Model Coefficients - Nutritional Importance Value				
Predictor	Estimate	SE	Z	p
B:				
26-35 – 18-25	-0.5197	0.558	-0.931	0.352
36-50 – 18-25	0.9196	1.066	0.863	0.388
50+ – 18-25	0.6248	1.110	0.563	0.574
D:				
Female – Male	-0.3631	0.439	-0.827	0.408
F:				
4-8 lakhs – 0-4 lakhs	0.4978	0.623	0.799	0.424
8-12 lakhs – 0-4 lakhs	0.1445	0.943	0.153	0.878
12-16 lakhs – 0-4 lakhs	0.2553	1.871	0.136	0.891
16 lakhs and above – 0-4 lakhs	0.4655	1.488	0.313	0.754
H:				
Graduate – Postgraduate	-0.0797	0.434	-0.184	0.854
PUC – Postgraduate	-0.1890	0.795	-0.238	0.812
Others – Postgraduate	-2.2827	1.350	-1.690	0.091
SSLC – Postgraduate	2.5497	2.155	1.183	0.237
J:				
Student – Professional	2.0060	0.712	2.818	0.005
Business – Professional	0.8158	0.935	0.872	0.383
Others – Professional	1.7394	0.781	2.226	0.026
Service – Professional	0.1940	0.877	0.221	0.825

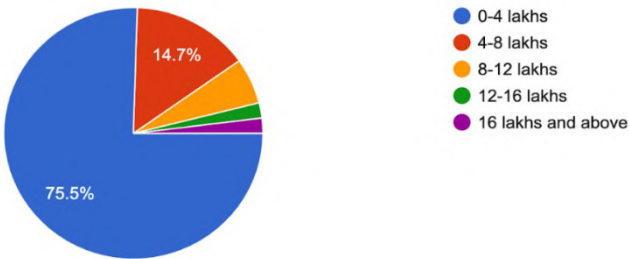
2. Age Group:
102 responses



3. Gender:
102 responses

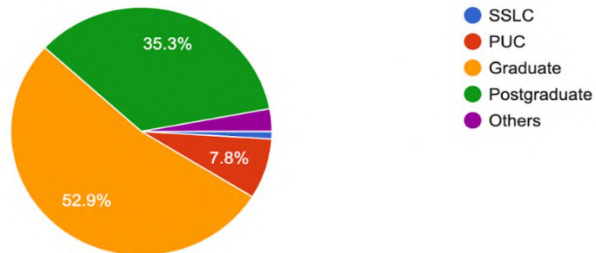


4. Annual Income:
102 responses



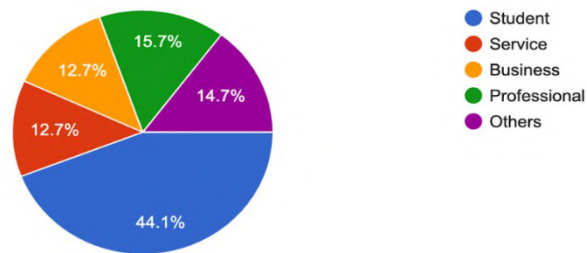
5. Educational Qualification:

102 responses



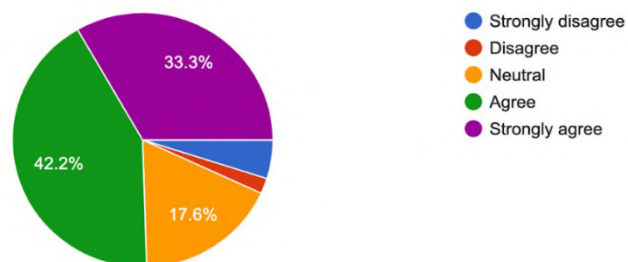
6. Occupation:

102 responses



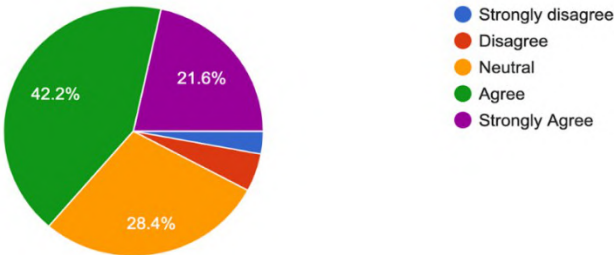
7. Nutritional value is an important consideration to me when selecting packaged food items:

102 responses



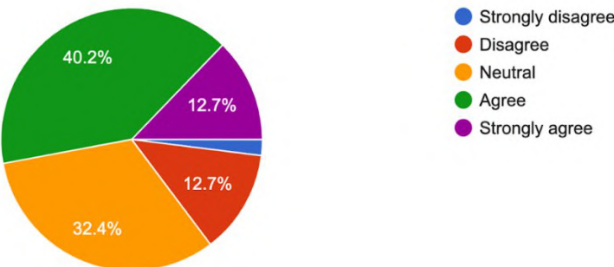
8. Health benefits of a product influence my purchase decisions more than price or taste:

102 responses



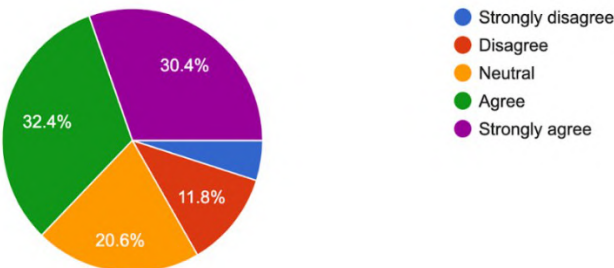
9. Marketing terms like "low-fat" or "gluten-free" affect my perception of a product's nutritional value:

102 responses



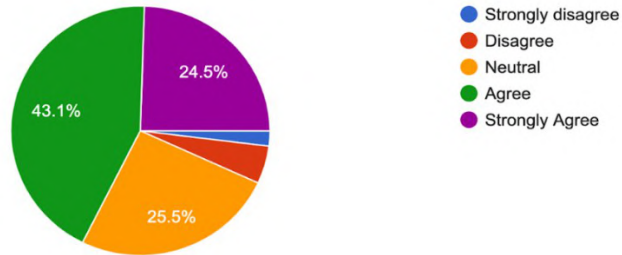
10. Nutrition-related labels such as the FSSAI logo affects my product choice:

102 responses



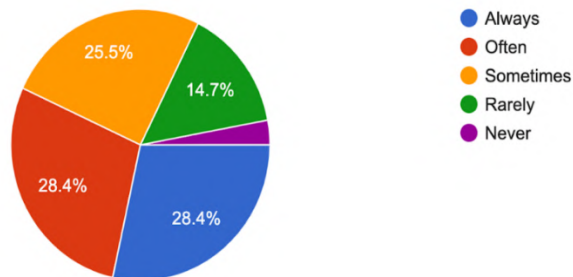
11. As a consumer, I'm more likely to choose products with higher nutritional value, even if priced higher:

102 responses



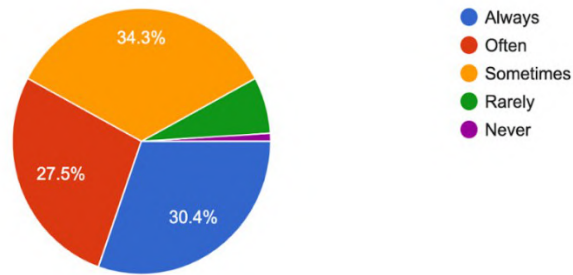
12. How frequently do you read nutritional information on packaged food before purchase?

102 responses



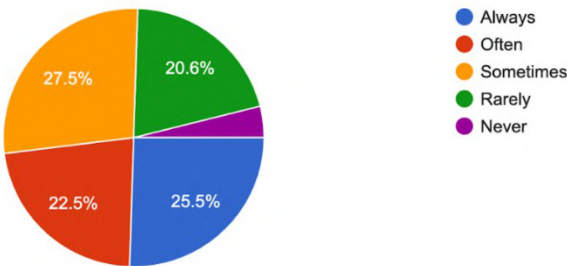
13. How often do you choose food products based on their health benefits?

102 responses



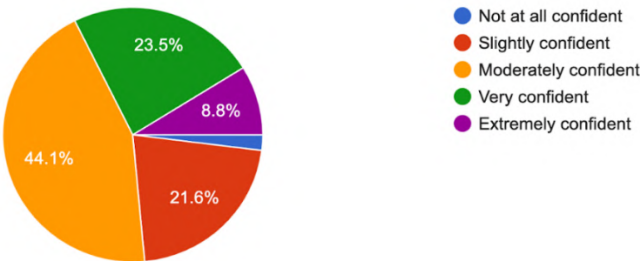
14. How frequently do you discuss food nutrition or labels with friends or family?

102 responses



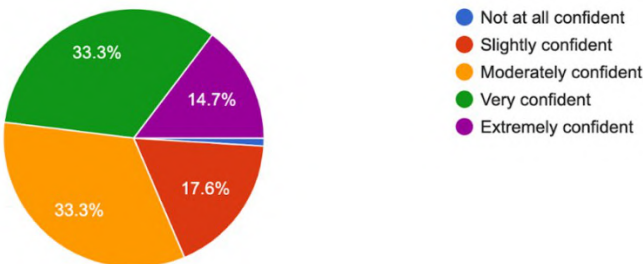
15. How confident are you in understanding and interpreting the nutritional labels on packaged foods (e.g., calories, fats, sugars, etc.)?

102 responses



16. How confident are you in distinguishing between healthy and unhealthy packaged food options?

102 responses



CHAPTER 8

AI-Driven Smart City Solutions for Sustainable Crowd Management: Lessons from Kumbh Mela 2025

Ramakant Kulkarni and Bharati Badiger***

ABSTRACT

The Maha Kumbh Mela 2025 in Prayagraj, one of the largest religious gatherings worldwide, posed unprecedented challenges in crowd management, safety, and resource optimization. With over 400 million pilgrims expected, traditional approaches proved inadequate to ensure smooth operations and sustainability. This study examines how artificial intelligence (AI) and smart city technologies were deployed to manage the massive congregation, situating the event as a living laboratory for sustainable urban innovation. AI-powered surveillance systems, including facial recognition and predictive analytics, enabled real-time monitoring of crowd density, identification of bottlenecks, and swift reunification of separated individuals. IoT-enabled sensors and drones provided continuous data streams on movement patterns, supporting dynamic traffic rerouting and emergency response. Smart grids optimized electricity usage across temporary settlements, while AI-driven waste management platforms streamlined collection and recycling, reducing ecological impact. Results demonstrate that AI integration significantly enhanced safety outcomes, improved efficiency in resource allocation, and advanced environmental stewardship. Ethical considerations, including data privacy and equitable access, remain critical to maintaining social trust. The case of Kumbh Mela 2025 offers scalable models for other mega-events and permanent smart city contexts, reinforcing AI's potential as a catalyst for resilience, inclusivity, and sustainability in urban governance.

Keywords: Kumbh Mela 2025; Smart cities; Artificial Intelligence; Crowd management; Sustainability.

1.0 Introduction

Urbanization in the twenty-first century has reshaped the way societies organize themselves, creating new challenges for sustainability, governance, and infrastructure.

**Corresponding author; Director-Academics, Management Department, Chetan Business School, Hubli, Karnataka, India (E-mail: ramakantkv@yahoo.co.in)*

***Faculty, Commerce Department, Chetan College of Commerce, Hubli, Karnataka, India (E-mail: komalbadiger89@gmail.com)*

Cities today are not merely physical spaces but complex ecosystems where millions of people interact with technology, resources, and institutions. The concept of the “smart city” has emerged as a response to these challenges, emphasizing the integration of digital technologies, data-driven decision-making, and citizen-centric innovation to create urban environments that are efficient, resilient, and sustainable. Artificial intelligence (AI), as the most transformative technology of our era, plays a pivotal role in this vision. By enabling predictive analytics, real-time monitoring, and adaptive resource allocation, AI has become a cornerstone of smart city development worldwide.

Mega-events such as religious congregations, sporting spectacles, and cultural festivals present unique opportunities to test and refine smart city principles. These events often involve the temporary creation of urban infrastructures that must accommodate millions of people within a limited timeframe. The Maha Kumbh Mela, held in January 2025 in Prayagraj, epitomizes this challenge. Recognized as the largest religious gathering in the world, the Kumbh Mela attracted hundreds of millions of pilgrims over several weeks. Managing such a congregation required not only logistical precision but also sustainable practices that minimize environmental impact and safeguard human well-being. The Kumbh Mela thus functions as a “pop-up city,” where the principles of smart urbanism and AI-driven sustainability can be applied in real time.

Crowd management has historically been one of the most pressing concerns at the Kumbh Mela. Incidents of stampedes, congestion, and resource shortages have underscored the need for innovative solutions. Traditional approaches—relying on manual monitoring, static infrastructure, and reactive interventions—are insufficient in the face of such scale. AI technologies, however, offer a paradigm shift. Through facial recognition, density mapping, and predictive modelling, authorities can anticipate crowd movements and intervene before risks escalate. IoT-enabled sensors and drones provide continuous streams of data, allowing for dynamic traffic rerouting and emergency response. Smart grids optimize energy consumption across temporary settlements, while AI-driven waste management systems streamline collection and recycling, reducing ecological footprints. These applications demonstrate how AI can transform crowd management from a reactive process into a proactive, sustainable system.

The integration of AI into Kumbh Mela 2025 also reflects broader trends in smart city development. Cities worldwide are experimenting with AI to manage transportation networks, energy grids, and public services. Yet, the Kumbh Mela represents a distinctive case: a temporary city that must be built, managed, and dismantled within weeks, while serving a population larger than most nations. This context provides a living laboratory for testing the scalability, adaptability, and sustainability of AI-driven solutions. Lessons learned from Prayagraj can inform not only future iterations of the Kumbh Mela but also other mega-

events such as the Hajj pilgrimage, the Olympics, and the FIFA World Cup. Moreover, these insights can be integrated into permanent urban ecosystems, reinforcing the global discourse on smart cities and sustainability.

At the same time, the deployment of AI in such contexts raises critical ethical and governance questions. Surveillance technologies, while enhancing safety, pose risks to privacy and civil liberties. Algorithmic decision-making must be transparent and accountable to avoid bias and exclusion. Inclusivity is particularly important in events like the Kumbh Mela, where pilgrims come from diverse socio-economic backgrounds, many with limited access to digital technologies. Ensuring that AI-driven solutions do not exacerbate inequalities is essential to their legitimacy and effectiveness. Thus, the challenge is not only technological but also social: how to align AI innovation with principles of fairness, inclusivity, and cultural sensitivity.

This paper situates Kumbh Mela 2025 within the broader framework of smart cities and AI-driven sustainability. It explores how AI technologies were applied to crowd management, resource optimization, and environmental stewardship during the event. It examines the ethical and governance challenges that accompany such deployment, and it assesses the outcomes in terms of safety, efficiency, and sustainability. By analysing Kumbh Mela as a case study, the paper contributes to the discourse on AI and smart cities, offering insights into how temporary urban ecosystems can serve as laboratories for sustainable innovation. Ultimately, the research underscores the potential of AI not merely as a tool for efficiency but as a catalyst for holistic, human-centered urban development.

The objectives of this paper are threefold.

First, to document and analyse the specific AI applications deployed during Kumbh Mela 2025 for crowd management and sustainability.

Second, to evaluate the impacts of these interventions on safety, environmental outcomes, and social experience.

Third, to identify lessons and recommendations for scaling such solutions to other mega-events and permanent smart city contexts.

In doing so, the paper bridges the gap between theory and practice, demonstrating how AI can transform the management of complex human gatherings while aligning with global sustainability goals.

2.0 Literature Review

The concept of smart cities has gained prominence over the past two decades as urbanization accelerates and sustainability challenges intensify. Scholars and practitioners alike have emphasized the integration of digital technologies, data-driven governance, and

citizen-centric innovation to create urban environments that are efficient, resilient, and inclusive. Artificial intelligence (AI) has emerged as a critical enabler of this vision, offering capabilities in predictive analytics, real-time monitoring, and adaptive resource allocation. This literature review examines existing scholarship on smart city frameworks, crowd management strategies, AI applications in sustainability, and the gaps that necessitate further exploration in the context of mega-events such as the Kumbh Mela.

2.1 Smart city frameworks and AI integration

Smart city frameworks are built upon the convergence of information and communication technologies (ICT), Internet of Things (IoT), and AI. Cities such as Barcelona, Singapore, have pioneered the use of AI to manage transportation networks, energy grids, and public services. Research highlights that AI enables cities to move from reactive to proactive governance, where predictive models anticipate demand and optimize resource allocation. For example, AI-driven traffic management systems in Singapore reduce congestion by analysing real-time data from sensors and cameras. Similarly, smart grids in European cities leverage AI to balance energy supply and demand, integrating renewable sources more effectively. These frameworks demonstrate the potential of AI to enhance sustainability by reducing carbon emissions, improving efficiency, and fostering resilience.

2.2 Crowd management in mega-events

Crowd management has been a longstanding area of research, particularly in contexts where large gatherings pose risks to safety and logistics. Studies on the Hajj pilgrimage in Saudi Arabia, the Olympics, Koppal Gavimath Jatres, Hasanambe Jatres and many such Jatres and festivals have underscored the importance of real-time monitoring, predictive modelling, and coordinated response systems. Traditional crowd management approaches often rely on manual observation and static infrastructure, which are insufficient for events involving millions of participants. AI introduces a paradigm shift by enabling dynamic crowd control. Facial recognition technologies, density mapping, and predictive analytics allow authorities to anticipate bottlenecks and intervene before risks escalate. Research on the Hajj, for instance, demonstrates how AI-powered surveillance reduces incidents of stampedes and improves emergency response times. These insights are directly relevant to the Kumbh Mela, which faces similar challenges of scale and complexity.

2.3 AI and sustainability in urban contexts

Beyond safety, AI contributes significantly to sustainability in urban and event contexts. Scholars have examined how AI optimizes energy consumption, reduces waste, and supports circular economy models. Smart grids powered by AI facilitate real-time energy

monitoring, ensuring efficient consumption and integration of renewable sources. AI-driven waste management systems predict collection needs, streamline recycling processes, and minimize ecological footprints. In healthcare, AI reduces resource use by optimizing patient flow and supporting telemedicine, thereby lowering environmental impact. These applications highlight AI's role in aligning technological innovation with environmental stewardship, a critical dimension for events like the Kumbh Mela that generate substantial ecological pressures.

2.4 Ethical and governance considerations

The deployment of AI in smart cities and crowd management raises important ethical and governance questions. It is essential to emphasize the need for transparency, accountability, and inclusivity in AI systems. Surveillance technologies, while enhancing safety, pose risks to privacy and civil liberties. Algorithmic decision-making must be scrutinized to avoid bias and exclusion. Inclusivity is particularly critical in contexts like the Kumbh Mela, where participants come from diverse socio-economic backgrounds, many with limited access to digital technologies. Literature on AI ethics underscores the importance of designing systems that are fair, culturally sensitive, and socially legitimate. Governance frameworks must balance technological innovation with human rights and community trust.

2.5 Gaps in existing research

While substantial research exists on smart cities, AI applications, and crowd management, there is limited scholarship on the intersection of these domains in religious mega-events. The Kumbh Mela represents a unique case: a temporary city that must be built, managed, and dismantled within weeks, while serving a population larger than most nations. Existing studies on the Hajj and Olympics provide valuable insights, but they do not fully capture the cultural, logistical, and sustainability challenges of the Kumbh Mela. Moreover, there is a paucity of research on how AI-driven solutions can be scaled from temporary event contexts to permanent urban ecosystems. Addressing these gaps is essential to advancing both academic discourse and practical innovation.

2.6 Synthesis

The literature establishes AI as a transformative tool for smart cities, crowd management, and sustainability. It demonstrates that AI enables proactive governance, enhances safety, and reduces environmental impact. However, it also highlights ethical and governance challenges that must be addressed to ensure legitimacy and inclusivity. The Kumbh Mela 2025 provides a distinctive opportunity to apply and evaluate these insights in a real-world context. By situating the event within the broader discourse on smart cities and

AI-driven sustainability, this research contributes to filling a critical gap in the literature. It offers lessons not only for future iterations of the Kumbh Mela but also for other mega-events and permanent urban ecosystems worldwide.

3.0 Case Study: Kumbh Mela 2025

3.1 Context and scale of the event

The Maha Kumbh Mela 2025, held in Prayagraj, India, was one of the largest religious gatherings in human history. Over the course of several weeks, more than 40 crore pilgrims were expected to participate in ritual bathing, spiritual discourses, and cultural activities. The sheer magnitude of the event transformed Prayagraj into a temporary city, complete with housing, sanitation, energy supply, transportation networks, and healthcare facilities. This “pop-up city” posed immense challenges in crowd management, resource allocation, and sustainability. Traditional methods of monitoring and control—manual observation, static barricades, and reactive interventions—were inadequate for such scale. Recognizing this, authorities collaborated with technology providers to deploy AI-driven smart city solutions, making Kumbh Mela 2025 a living laboratory for innovation.

3.2 AI-powered surveillance and analytics

One of the most pressing concerns at the Kumbh Mela has historically been crowd safety. Stampedes and congestion have caused fatalities in past editions. In 2025, AI-enabled surveillance systems were introduced to mitigate these risks. Facial recognition cameras, density mapping algorithms, and predictive analytics were deployed across entry points, bathing ghats, and transit hubs. These systems continuously analysed real-time footage to identify overcrowded zones and forecast potential bottlenecks. Alerts were sent to control rooms, enabling authorities to redirect flows before risks escalated.

For example, during peak bathing days, AI systems predicted congestion at certain ghats hours in advance, allowing officials to reroute pilgrims to alternative locations. This proactive approach reduced accidents and enhanced the overall experience. Importantly, AI also supported reunification efforts by identifying separated individuals, particularly children and elderly pilgrims, and guiding them back to their families.

3.3 IoT-enabled monitoring and dynamic traffic management

The integration of IoT sensors and drones further strengthened crowd management. Sensors embedded in roads and bridges monitored footfall intensity, while drones provided aerial views of movement patterns. These data streams fed into AI platforms that generated

heat maps of crowd density. Authorities used these insights to dynamically adjust traffic flows, reroute buses, and open or close access points.

Dynamic traffic management was particularly critical in coordinating the movement of millions of pilgrims arriving by trains, buses, and private vehicles. AI algorithms analysed transport schedules, weather conditions, and crowd behaviour to optimize routes. This reduced congestion on arterial roads and minimized delays. The system also supported emergency response by identifying clear pathways for ambulances and security personnel.

3.4 Smart grids and energy optimization

Energy management was another critical challenge. Temporary settlements required electricity for lighting, sanitation, healthcare, and communication. AI-driven smart grids were deployed to monitor consumption patterns and forecast demand. These systems balanced supply and demand in real time, ensuring efficient use of resources. Renewable energy sources, such as solar panels, were integrated into the grid, with AI optimizing their contribution based on weather forecasts.

For instance, during peak evening hours, AI systems prioritized energy allocation to critical zones such as hospitals and sanitation facilities, while reducing consumption in non-essential areas. This not only ensured reliability but also reduced the carbon footprint of the event. The success of smart grids at Kumbh Mela demonstrated how AI can enable sustainable energy management in temporary urban ecosystems.

3.5 AI-driven waste management

Waste generation at the Kumbh Mela has historically been a major environmental concern. Millions of pilgrims produce vast quantities of solid waste, including food packaging, plastic bottles, and organic matter. In 2025, AI-powered waste management platforms were introduced to address this challenge. Sensors in bins monitored fill levels, while predictive algorithms forecasted collection needs based on crowd density and event schedules. Collection routes were dynamically optimized, reducing fuel consumption and ensuring timely disposal. AI also supported recycling initiatives by categorizing waste streams and directing them to appropriate facilities. For example, biodegradable waste was routed to composting units, while plastics were sent to recycling plants. These interventions significantly reduced the ecological footprint of the event, aligning with broader sustainability goals.

3.6 Stakeholder collaboration

The success of AI deployment at Kumbh Mela 2025 was the result of collaboration among multiple stakeholders. Government agencies provided regulatory oversight and

infrastructure support. Technology providers developed and implemented AI solutions. NGOs and community organizations facilitated awareness campaigns, educating pilgrims on sustainable practices. Local communities contributed by volunteering in crowd management and waste reduction initiatives.

This multi-stakeholder approach ensured that AI solutions were not only technologically effective but also socially legitimate. It reinforced the importance of participatory governance in smart city ecosystems, where diverse actors contribute to collective outcomes.

3.7 Operational outcomes

The deployment of AI-driven smart city solutions at Kumbh Mela 2025 yielded significant outcomes across safety, efficiency, and sustainability dimensions.

- **Safety:** Incidents of stampedes and congestion were drastically reduced. Emergency response times improved due to predictive analytics and dynamic traffic management.
- **Efficiency:** Resource allocation was optimized, reducing costs and enhancing service delivery. Energy consumption was balanced, and waste collection was streamlined.
- **Sustainability:** The carbon footprint of the event was lowered through smart grids and recycling initiatives. Environmental stewardship was integrated into crowd management practices.
- **Social Experience:** Pilgrims reported smoother movement, better facilities, and enhanced trust in authorities. The event demonstrated how technology can improve human experiences without compromising cultural traditions.

4.0 Challenges and Limitations

Despite these successes, challenges remained. Data privacy concerns arose due to the use of facial recognition and surveillance technologies. Ensuring inclusivity was difficult, as many pilgrims lacked digital literacy or access to mobile applications. Technical glitches occasionally disrupted monitoring systems, highlighting the need for robust backup mechanisms. Moreover, balancing technological interventions with cultural sensitivity required careful negotiation, as excessive surveillance risked undermining the spiritual atmosphere of the event.

4.1 Lessons learned/ discussion

The Kumbh Mela 2025 case study offers valuable lessons for future mega-events and smart city development. First, AI enables proactive crowd management, transforming safety outcomes. Second, IoT and smart grids demonstrate how sustainability can be integrated into

temporary urban ecosystems. Third, stakeholder collaboration is essential to ensure legitimacy and inclusivity. Finally, ethical considerations must be addressed to balance innovation with human rights and cultural values.

These lessons are scalable to other contexts, including the Hajj pilgrimage, the Olympics, and permanent urban ecosystems. They underscore the potential of AI not merely as a tool for efficiency but as a catalyst for holistic, human-centered urban development

4.2 Ethical and governance considerations

The deployment of artificial intelligence (AI) in crowd management and sustainability at Kumbh Mela 2025 was not merely a technological exercise; it was also a profound social experiment. While AI offered unprecedented capabilities in surveillance, resource optimization, and predictive modeling, its use raised significant ethical and governance questions. These considerations are central to evaluating the legitimacy, inclusivity, and long-term viability of AI-driven smart city solutions. This section explores four key dimensions: data privacy, inclusivity, transparency, and cultural sensitivity.

4.3 Data privacy and surveillance

One of the most contentious aspects of AI deployment at Kumbh Mela was the use of facial recognition and real-time surveillance systems. Cameras installed across entry points, bathing ghats, and transit hubs continuously captured and analysed images of millions of pilgrims. While these systems enhanced safety by identifying overcrowded zones and reuniting separated individuals, they also posed risks to privacy.

Scholars argue that surveillance technologies can erode civil liberties if not governed by robust frameworks. At Kumbh Mela, questions emerged about how data was stored, who had access, and whether it could be misused beyond the event. The absence of clear consent mechanisms further complicated matters, as most pilgrims were unaware of the extent of monitoring. This highlights the need for governance structures that balance safety with privacy, ensuring that surveillance data is anonymized, securely stored, and used only for legitimate purposes.

4.4 Inclusivity and equity

Inclusivity is a critical ethical dimension in deploying AI at large gatherings. The Kumbh Mela attracts pilgrims from diverse socio-economic backgrounds, many of whom have limited digital literacy or access to mobile technologies. AI-driven solutions, such as mobile applications for navigation or digital alerts, risk excluding marginalized groups who cannot access or understand them.

Ensuring equity requires designing systems that are accessible to all participants, regardless of their technological capabilities. At Kumbh Mela 2025, authorities attempted to address this by combining AI with traditional communication methods, such as loudspeakers and volunteer guides. However, disparities remained, particularly in rural populations with limited exposure to digital tools. This underscores the importance of inclusive design, where AI systems are complemented by analog mechanisms to ensure universal access.

4.5 Transparency and algorithmic accountability

Transparency in AI systems is essential to build trust among users and stakeholders. At Kumbh Mela, predictive analytics and algorithmic decision-making influenced critical interventions, such as rerouting crowds or prioritizing energy allocation. Yet, the logic behind these decisions was often opaque to both authorities and participants.

Algorithmic accountability requires that AI systems be explainable, auditable, and subject to oversight. Without transparency, there is a risk of bias, errors, or unintended consequences. For instance, if predictive models disproportionately directed resources to certain zones, it could create inequities in service delivery. Governance frameworks must therefore mandate documentation of algorithms, independent audits, and mechanisms for redress in case of errors. Transparency not only enhances legitimacy but also ensures that AI systems align with principles of fairness and justice.

4.6 Cultural sensitivity and legitimacy

The Kumbh Mela is not merely a logistical challenge; it is a deeply spiritual and cultural event. Deploying AI in such contexts requires sensitivity to traditions and values. Excessive surveillance or overt technological interventions risk undermining the spiritual atmosphere, creating perceptions of intrusion.

Authorities at Kumbh Mela 2025 faced the delicate task of balancing innovation with respect for cultural practices. For example, while drones provided valuable aerial monitoring, their presence near sacred bathing rituals was carefully regulated to avoid disrupting the sanctity of the experience. Similarly, AI-driven waste management initiatives were framed in terms of “seva” (service), aligning technological interventions with cultural values of cleanliness and devotion. This demonstrates that legitimacy in AI deployment depends not only on technical effectiveness but also on cultural alignment.

4.7 Governance frameworks and multi-stakeholder collaboration

Effective governance of AI at Kumbh Mela required collaboration among multiple stakeholders, including government agencies, technology providers, NGOs, and local communities. Governance frameworks must establish clear roles, responsibilities, and

accountability mechanisms. At the event, the government provided regulatory oversight, technology providers ensured technical reliability, NGOs advocated for inclusivity, and local communities contributed to awareness campaigns.

This multi-stakeholder approach reinforced the legitimacy of AI deployment, ensuring that diverse perspectives were considered. It also highlighted the importance of participatory governance in smart city ecosystems, where technology must serve collective interests rather than narrow agendas. Future governance frameworks should institutionalize such collaboration, creating platforms for dialogue, feedback, and co-creation.

4.8 Balancing innovation with ethics

The ethical and governance considerations at Kumbh Mela 2025 illustrate the broader challenge of balancing innovation with ethics. AI offers transformative capabilities, but its deployment must be guided by principles of privacy, inclusivity, transparency, and cultural sensitivity. Governance frameworks must ensure that technology serves human values, not the other way around. The event demonstrated that ethical challenges are not obstacles to innovation but essential dimensions of sustainable development. By addressing these challenges proactively, authorities can enhance trust, legitimacy, and long-term viability. The lessons from Kumbh Mela thus extend beyond the event, offering insights for global smart city initiatives and mega-events worldwide.

4.9 Conclusion of section/ discussion

Ethical and governance considerations are integral to evaluating AI-driven smart city solutions. At Kumbh Mela 2025, issues of privacy, inclusivity, transparency, and cultural sensitivity shaped the deployment and outcomes of AI technologies. Addressing these dimensions ensured that innovation was not only technically effective but also socially legitimate. The case underscores the need for governance frameworks that balance safety with rights, efficiency with equity, and innovation with tradition. Ultimately, the success of AI in crowd management and sustainability depends not only on algorithms but also on values, institutions, and communities.

5.0 Impact Assessment

The deployment of AI-driven smart city solutions at Kumbh Mela 2025 yielded measurable impacts across multiple dimensions. Evaluating these outcomes is essential to understand the effectiveness of technological interventions and their contribution to sustainability. This section assesses the impacts in terms of safety, environmental stewardship, social experience, and economic efficiency.

5.1 Safety outcomes

Safety was the most immediate and visible benefit of AI deployment. Historically, stampedes and overcrowding have been recurring risks at the Kumbh Mela, often resulting in tragic loss of life. In 2025, AI-powered surveillance and predictive analytics significantly reduced these risks. Facial recognition systems and density mapping algorithms enabled authorities to monitor crowd flows in real time, identifying potential bottlenecks before they escalated. Emergency response times improved markedly. AI-generated heat maps provided clear pathways for ambulances and security personnel, ensuring rapid access to critical zones. Drones and IoT sensors enhanced situational awareness, allowing authorities to coordinate interventions with precision. As a result, incidents of stampedes were minimized, and overall safety levels improved. The proactive nature of AI-driven crowd management transformed safety from a reactive process into a predictive, preventive system.

5.2 Environmental outcomes

Environmental sustainability was another critical area of impact. The sheer scale of the Kumbh Mela generates enormous ecological pressures, including energy consumption, waste generation, and water usage. AI-driven smart grids optimized electricity distribution, balancing supply and demand in real time. Renewable energy sources, particularly solar, were integrated into the grid, with AI forecasting their contribution based on weather conditions. This reduced reliance on fossil fuels and lowered the carbon footprint of the event.

Waste management also benefited from AI interventions. Sensors in bins monitored fill levels, while predictive algorithms forecasted collection needs. This streamlined collection routes, reducing fuel consumption and ensuring timely disposal. AI-supported recycling initiatives categorized waste streams, directing biodegradable materials to composting units and plastics to recycling plants. These measures significantly reduced landfill contributions and promoted circular economy practices. Collectively, AI-driven interventions aligned the event with broader sustainability goals, demonstrating how technology can mitigate ecological impacts in temporary urban ecosystems.

5.3 Social outcomes

The social experience of pilgrims was enhanced through AI-driven crowd management and resource optimization. Pilgrims reported smoother movement across ghats and transit hubs, reduced waiting times, and improved access to facilities. AI-supported reunification systems helped locate separated individuals, particularly vulnerable groups such as children and the elderly, reinforcing trust in authorities.

Inclusivity remained a challenge, as not all pilgrims had access to digital tools. However, authorities attempted to bridge this gap by combining AI systems with traditional

communication methods, such as loudspeakers and volunteer guides. This hybrid approach ensured that technological interventions complemented rather than replaced human support. The integration of AI into crowd management thus contributed to a more positive, secure, and inclusive social experience, reinforcing the legitimacy of technological innovation in cultural contexts.

5.4 Economic outcomes

Economic efficiency was a notable outcome of AI deployment. Optimized resource allocation reduced costs associated with energy consumption, waste collection, and emergency response. Smart grids minimized wastage by directing electricity to critical zones, while predictive waste management reduced fuel use in collection vehicles. These efficiencies translated into financial savings for authorities, freeing resources for other critical services.

Moreover, the integration of AI enhanced the reputation of the Kumbh Mela as a well-managed, sustainable event. This reputation has long-term economic implications, attracting greater participation, sponsorship, and investment in future editions. The event demonstrated that sustainability and efficiency are not mutually exclusive but mutually reinforcing, with AI serving as the bridge between them.

5.5 Synthesis of impacts/ discussion

The impacts of AI deployment at Kumbh Mela 2025 can be synthesized into three overarching contributions. First, AI enhanced safety by transforming crowd management into a predictive, preventive system. Second, it advanced sustainability by reducing ecological footprints through smart grids and waste management. Third, it improved social and economic outcomes, fostering trust, inclusivity, and efficiency. These impacts collectively underscore the potential of AI as a catalyst for holistic, human-centered urban development.

While challenges remain—particularly in inclusivity and ethical governance—the overall outcomes demonstrate that AI-driven smart city solutions can effectively manage the complexities of mega-events. The lessons from Kumbh Mela 2025 provide a blueprint for scaling such interventions to other contexts, reinforcing the global discourse on sustainable innovation.

6.0 Future Directions

The success of AI-driven smart city solutions at Kumbh Mela 2025 provides a foundation for envisioning future applications in both temporary mega-events and permanent urban ecosystems. While the event demonstrated the transformative potential of AI in crowd management and sustainability, it also revealed areas for improvement and expansion. Future

directions can be organized around scalability, integration into smart city frameworks, technological innovation, and policy development.

6.1 Scalability to other mega-events

The lessons from Kumbh Mela are highly transferable to other global gatherings. Events such as the Hajj pilgrimage, the Olympics, and the FIFA World Cup face similar challenges of scale, safety, and sustainability. AI-powered surveillance, IoT-enabled monitoring, and smart grids can be adapted to these contexts, ensuring proactive crowd management and resource optimization. Scalability requires customizing solutions to cultural, logistical, and infrastructural differences. For example, while the Hajj involves religious rituals across multiple sites, the Olympics demand coordination across diverse venues. The adaptability of AI systems will be critical to their success in these varied contexts.

6.2 Integration into permanent smart city ecosystems

Beyond temporary events, the innovations tested at Kumbh Mela can inform permanent smart city development. Cities worldwide are grappling with issues of congestion, energy demand, and waste management. AI-driven solutions demonstrated at the Mela—such as predictive traffic rerouting, smart grids, and waste categorization—can be integrated into everyday urban governance. This integration would transform cities into proactive, sustainable ecosystems capable of anticipating and addressing challenges before they escalate. The Kumbh Mela thus serves as a prototype for embedding AI into long-term urban planning.

6.3 Technological innovation

Future directions also involve advancing the technological capabilities of AI systems. Edge computing can enhance real-time processing by reducing latency, enabling faster interventions in crowd management. Federated learning offers a pathway to train AI models without compromising data privacy, addressing ethical concerns raised at the Mela. Sustainable AI models, designed to minimize energy consumption during training and deployment, will further align technological innovation with environmental goals. These advancements will ensure that AI systems are not only more powerful but also more ethical and sustainable.

6.4 Policy recommendations

The deployment of AI at Kumbh Mela highlighted the need for robust governance frameworks. Future directions must include policy development to regulate surveillance, ensure inclusivity, and mandate transparency. Governments should establish guidelines for

data anonymization, algorithmic audits, and participatory governance. Policies must also emphasize cultural sensitivity, ensuring that technological interventions respect traditions and values. International collaboration could facilitate the creation of global standards for AI deployment in mega-events, promoting consistency and trust across contexts.

6.5 Conclusion of section/ discussion

The future of AI-driven smart city solutions lies in their scalability, integration, innovation, and governance. The Kumbh Mela 2025 demonstrated that AI can transform crowd management and sustainability, but it also underscored the importance of ethics and inclusivity. By advancing technology, embedding solutions into permanent ecosystems, and developing robust policies, societies can harness AI as a catalyst for holistic, human-centered urban development. The lessons from Prayagraj extend far beyond the event, offering a blueprint for sustainable innovation in cities and gatherings worldwide.

7.0 Conclusion

The Maha Kumbh Mela 2025 in Prayagraj provided a unique opportunity to examine the intersection of artificial intelligence, smart city innovation, and sustainability in one of the most complex human gatherings ever organized. As a temporary city hosting hundreds of millions of pilgrims, the event demanded solutions that could simultaneously ensure safety, optimize resources, and minimize environmental impact. The deployment of AI-driven technologies—ranging from predictive crowd analytics and IoT-enabled monitoring to smart grids and waste management systems—demonstrated how innovation can transform challenges into opportunities for sustainable development.

The case study revealed that AI fundamentally reshaped crowd management by shifting from reactive interventions to proactive, predictive systems. Safety outcomes improved significantly, with reduced incidents of stampedes and faster emergency responses. Environmental stewardship was advanced through optimized energy consumption and recycling initiatives, aligning the event with global sustainability goals. Social outcomes were equally important, as AI enhanced the pilgrim experience by reducing congestion and supporting inclusivity, even though challenges of digital literacy and equitable access remained. Economic efficiency further reinforced the value of AI, with optimized resource allocation reducing costs and enhancing the reputation of the event.

Yet, the deployment of AI also underscored critical ethical and governance considerations. Issues of privacy, inclusivity, transparency, and cultural sensitivity shaped the legitimacy of technological interventions. These dimensions remind us that innovation cannot be divorced from values; technology must serve human rights, traditions, and community

trust. The Kumbh Mela thus highlighted the importance of governance frameworks that balance efficiency with equity, and innovation with ethics.

Looking forward, the lessons from Prayagraj extend beyond the event itself. They provide a blueprint for scaling AI-driven solutions to other mega-events such as the Hajj, the Olympics, and the FIFA World Cup, while also informing permanent smart city ecosystems worldwide. Future directions must emphasize scalability, integration, technological innovation, and robust policy development to ensure that AI remains a catalyst for holistic, human-centered urban development.

Ultimately, the Kumbh Mela 2025 demonstrated that AI is not merely a tool for efficiency but a transformative force for sustainability and resilience. By aligning technological advancement with ethical governance and cultural legitimacy, societies can harness AI to build smarter, safer, and more sustainable futures. The event stands as a living laboratory for innovation, offering insights that will shape the evolving business and urban landscape in the decades to come.

References

1. Bibri, S. E., Krogstie, J., & Kärrholm, M. (2023). Environmentally sustainable smart cities and their converging AI, IoT, and big data technologies: A comprehensive literature review. *Energy Informatics*, 6(1), 1–34. <https://doi.org/10.1186/s42162-023-00259-2>
2. Al-Turjman, F., & Malekloo, A. (2021). Artificial intelligence for smart cities: A comprehensive review. *Urban Science*, 5(1), 1–25. <https://doi.org/10.3390/urbansci5010001>
3. Kumar, R., & Singh, A. (2024). Design of artificial intelligence driven crowd density analysis for smart cities. *IEEE Access*, 12, 45012–45025. <https://doi.org/10.1109/ACCESS.2024.10500823>
4. India Today. (2025, February 25). Artificial intelligence demystifying crowd counting process at Maha Kumbh Mela in Prayagraj. *India Today*. <https://www.indiatoday.in/india/story/artificial-intelligence-demystifying-crowd-counting-process-prayagraj-2685514-2025-02-25>
5. Sharma, P., & Verma, S. (2025). Smart management of Kumbh Mela 2025: Intangible cultural industries leveraging IoT, AI, and big data. *International Journal of Research in Technical Innovation*, 9(3), 129–140. <https://ijrti.org/papers/IJRTI2503129.pdf>
6. IndiaWest/Reuters. (2025, January 20). Maha Kumbh: India using AI for crowd management, safety. *IndiaWest*. <https://indiawest.com/maha-kumbh-india-using-ai-for-crowd-management-safety/>

7. Zhang, Y., & Chen, H. (2024). Artificial intelligence and smart city ethics: A systematic review. *IEEE Transactions on Technology and Society*, 5(2), 101–115. <https://doi.org/10.1109/TTS.2024.10154961>
8. Gomes, R., & Patel, S. (2024). AI-driven innovation in smart city governance: Achieving human-centric and sustainable outcomes. *Transforming Government: People, Process and Policy*, 18(4), 567–582. <https://doi.org/10.1108/TG-04-2024-0096>
9. National Science Foundation. (2024). Artificial intelligence and smart city ethics: A systematic review of governance frameworks. *NSF Public Access Repository*. <https://par.nsf.gov/servlets/purl/10463908>

CHAPTER 9

A Study on Workload and Job Stress as Determinants of Performance and Psychological Well-being among Employees

Shreyas Pujari, Anvi Sammatshetti** and Rekha Birje****

ABSTRACT

Work-related job demands and stress are major concerns in today's workplace, significantly impacting employee productivity and mental well-being. Intense workloads and high-stress settings often reduce productivity and impair employees' mental health. This study examines the impact of workload and job stress on employees' health, productivity, and overall well-being, both individually and in conjunction. A structured questionnaire that employed a five-point Likert scale. A negative relationship between increased workload, greater job stress, and employee performance. Employees facing heavy workloads reported reduced productivity, less concentration, and decreased job satisfaction. Prolonged stress also led to mental exhaustion, burnout, emotional strain, and tiredness. The study highlights the importance of support from the organization, flexible work arrangements, and approaches to handle stress. Creating fair workloads and fostering positive wellbeing and raise long-term productivity.

Keywords: Employee; Job-stress; Workload; Phycological well-being.

1.0 Introduction

In today's rapid-paced work environment, employees often face increasing demands, tight deadlines, and constant pressure to perform. As a result, job demands and work stress have become common issues that directly influence employee feelings and their overall efficiency. When the demands surpass an individual's capacity, it may lead to physical exhaustion, mental stress, and difficulties in maintaining work-life equilibrium.

**Corresponding author; Student, MBA Department, Gogte Institute of Technology, Belagavi, Karnataka, India (E-mail:shreyaspujari11@gmail.com)*

***Student, MBA Department, Gogte Institute of Technology, Belagavi, Karnataka, India (E-mail:sammatshettianvi@gmail.com)*

****Assistant Professor, MBA Department, KLS Gogte Institute of Technology, Belagavi, Karnataka, India (E-mail: rdbirje@git.edu)*

Similarly, constant work pressure can affect an employee's emotions, concentration, and overall mental well-being. Employee performance is a vital factor for the achievement of any organization. However, performance is heavily affected by the workplace conditions, the support employees receive, and the level of stress. When stress and workload remain unmanageable for long durations, employees may experience burnout, reduced motivation, increased frustration, and lower job satisfaction. These outcomes affect can also reduce productivity, team effectiveness, progress of the organization.

Understanding the connection between workload, job stress, performance, and mental well-being and supportive workplace. The relationship between these factors and their influence on employees' everyday work experiences. It also seeks to highlight the importance of workplace assistance and stress-management methods in helping employees stay productive and preserve mental health.

2.0 Literature Review

2.1 Workload within the organizational structure

The workload is an essential factor influencing employees' work experiences. Workload includes not only the quantity of tasks assigned but also the complexity and urgency related to completing them. Studies show that increasing competition, technological demands, and multitasking requirements have significantly heightened employee workloads across different industries. When work demands exceed employees' capabilities, it leads to fatigue, stress, and decreased job satisfaction. Numerous studies suggest that an even distribution of tasks can motivate workers, whereas an excessive workload negatively impacts productivity and mental health.

2.2 Work environment and occupational stress

Job stress is widely studied as a response to difficult and adverse workplace conditions. Professionals define job stress as the requirements of a job surpass an employee's resources or abilities. Research shows that stress, ambiguous roles, restricted autonomy, job insecurity, and poor management techniques. Studies regularly show that prolonged work emotional exhaustion, burnout, higher absentee rates.

2.3 Workload and job stress

Many studies emphasize that workload significantly contributes to stress related to work. Intensive workloads, tight deadlines, and constant pressure to meet performance targets significantly increase stress levels. Find it difficult to handle work demands, stress intensifies

and affects their mental and physical health. Study says the link between elevated workloads and job-related stress across different organizational contexts.

2.4 Job-related stress and worker output

Job-related stress has a direct effect on employee performance. Increased stress hampers concentration, decision-making ability, creativity, and overall productivity. Studies show that stressed employees are more likely to err, miss deadlines, and display reduced motivation. While brief stress can sometimes increase alertness, extended work-related stress consistently leads to decreased productivity and inferior performance outcomes.

2.5 Psychological well-being of employees

Psychological well-being relates to an individual's emotional balance, mental wellness, and overall satisfaction with life and work. It is essential for sustained employee performance and the achievement of organizational success. Studies show that employees dealing with high workloads and job-related stress, sleep problems, and emotional exhaustion.

2.6 Impact of workload and job stress on mental well-being

This shows that excessive workload and job stress significantly reduce psychological well-being. Continuous stress and inadequate recovery times lead to burnout and mental weariness. Researchers highlight that employees enduring extended stress experience lowered self-esteem, emotional instability, and reduced motivation. The research strongly supports the idea that stress and workload have a considerable impact on employees' mental health.

2.7 Techniques for handling and reducing stress

Literature emphasizes the importance of coping strategies in managing workload and job-related stress. Coping strategies include individual approaches like managing time, engaging in physical exercise, practicing relaxation techniques, and seeking social support, as well as organizational tactics like flexible work hours, reallocating tasks, and offering counseling services. Studies indicate that employees employing effective coping mechanisms experience lower stress levels and enhanced mental well-being.

2.8 Elements influencing stress and performance

Research underscores several moderating factors that influence the connection between workload and employee job stress:

1. Age and experience: Less experienced younger workers might face increased stress levels.

2. Work-life balance: Workers with enhanced balance handle stress more effectively.
3. Job characteristics: Roles with considerable responsibilities demonstrate higher stress levels.
4. Personal resilience: A person's ability to handle challenges influences stress outcomes.

3.0 Research Gap

On workload and job stress, many gaps remain in the existing literature. At first, several studies examine workload and job stress as separate elements, rather than analyzing their combined effect on employees' performance and mental well-being. The connection between workload and job stress is often overlooked. Secondly, limited empirical research investigates performance and psychological well-being concurrently. Numerous studies emphasize performance outcomes while neglecting the mental health and emotional welfare of workers. Third, there is insufficient research in the Indian organizational context, particularly across different sectors. Cultural, economic, employees perceive their workload and stress levels.

4.0 Research Objectives

1. To analyse the relationship between workload and psychological well-being of employees.
2. To examine the effect of job stress on employee performance.
3. To study the combined influence of workload and job stress on employee performance and overall health.
4. To identify organizational and individual coping strategies used by employees to manage workload and job stress.
5. To provide suggestions to organizations for improving employee well-being and productivity.

5.0 Hypotheses

Hypothesis 1

H₀₁: There is no relationship between employee workload and their psychological well-being.

H₁: There is relationship between employee workload and their psychological well-being.

Hypothesis 2

H₀₂: Employee performance is not significantly affected by job stress.

H₁: Workplace stress significantly affects employee performance.

Hypothesis 3

H₀₃: Employee performance and psychological well-being are not significantly affected by job stress and workload combined.

H₁: The combination of workload and job stress markedly impacts employee performance and psychological health.

Hypothesis 4

H₀₄: Coping mechanisms do not impact on reducing job stress and workload for employees.

H₁: Strategies for coping notably decrease job stress and workload for employees.

6.0 Research Methodology

This approach using an analytical (explanatory/causal) research framework. The purpose of this design is to explore the connections of cause and effect between workload, job stress, employee performance, and psychological well-being.

First hand data standardized questionnaire distributed to employees from various organizations. Secondary data is books, and trustworthy online resources. The study utilizes statistical techniques such as correlation and regression analysis to assess hypotheses and explore relationships among variables.

The analytical design fits the research as it allows for this analysis of how (workload and job stress) influence dependent variables (performance and psychological well-being).

6.1 Sample size and sampling technique

- Number of participants: 100 respondents
- Method of sampling: sampling method

6.2 Data collection tool

The main study is collected using a structured questionnaire. The approach was taken because of its simplicity in execution, time efficiency, and suitability from numerous participants. It allows employees to respond candidly without pressure, ensuring honest and reliable answers. The questionnaire was designed with clear and brief statements related to workload, job stress, employee performance, and mental well-being. Responses were evaluated using a 5-point to Strongly Disagree.

6.3 Data analysis tools

- Average, Standard Deviation: The typical responses and variability related to workload, job stress, performance, and psychological well-being were evaluated using the mean and standard deviation. This helps in identifying the total level of stress and burden experienced by employees.

- **Correlation:** Correlation analysis was employed to examine stress, as well as their link to employee performance and mental well-being. This method helps in ascertaining whether variables possess a positive or negative correlation.
- **Regression:** To investigate the impact of workload and job stress on employee performance and mental health. This instrument helps in assessing how independent variables influence dependent variables.

7.0 Data Analysis and Interpretation

Overview of hypothesis testing: The study of workload and job stress on employee performance and mental well-being. Hypotheses and Regression Analysis in SPSS.

Sample size: one hundred

Level of significance: 5% ($\alpha = 0.05$)

HYPOTHESIS 1: Workload and Job Pressure

Hypothesis

H_{01} : There is no relationship between workload and job stress in employees.

H_{11} : There is significant correlation exists between workload and job stress for employees.

Table 1: Variable Used

Variable	Type
WORKLOAD	Independent
JOB_STRESS	Dependent

Table 2: Corelation Output

Variables	Workload	Job Stress
Workload	1	0.681
Job Stress	0.681	1
Sig. (2-tailed)	—	0.000

Interpretation: The correlation analysis reveals a positive between workload and job stress ($r = 0.681$, $p < 0.05$). This indicates that an increase in workload leads to a corresponding increase in job stress for workers. The result confirms that a burden of responsibilities and tight deadlines significantly elevates stress levels at work.

Decision: H_0 : Rejected; H_1 : Accepted

HYPOTHESIS 2: Effect of Job Stress on Employee Performance

Hypothesis

H₀₂: Job stress does not have a relationship effect on employee performance.

H₁₂: Work-related stress significant affects employee performance.

Table 3: Variable Used

Variable	Type
JOB_STRESS	Independent
PERFORMANCE	Dependent

Table 4: Regression Output

R	R Square
0.648	0.420

Table 5: Anova Table

Model	F	Sig.
Regression	71.12	0.000

Table 6: Coefficient Table

Variable	Beta	t	Sig.
Job Stress	-0.648	-8.43	0.000

Interpretation: So, this indicates that job stress has a notable negative impact on employee performance ($\beta = -0.648$, $p < 0.05$). The R^2 value of 0.42 shows that 42% of the variations in performance can be linked to job stress. Elevated stress levels reduce employees' productivity, concentration, and performance.

Decision: H₀: Rejected; H₁: Accepted

HYPOTHESIS 3: Effect of Workload on Mental Health

Hypothesis:

H₀: The workload does not influence the psychological well-being of employees.

H₁: The workload significantly impacts the psychological well-being of employees.

Table 7: Variable Used

Variable	Type
WORKLOAD	Independent
PSY_WELLBEING	Dependent

Table 8: Regression Output

R	R Square
0.693	0.480

Table 9: Coefficient Table

Variable	Beta	Sig.
Workload	0.693	0.000

Interpretation: The assessment shows that workload on psychological well-being ($\beta = 0.693$, $p < 0.05$). The R^2 value of 0.48 indicates that workload explains 48% of the variations in employees' psychological well-being. An increased workload leads to mental fatigue, stress, and reduced job satisfaction. Therefore, the null hypothesis is dismissed while the alternative hypothesis is endorsed.

Decision: H_0 : Rejected; H_1 : Accepted

HYPOTHESIS 4: Joint Impact of Workload and Job Pressure

Hypothesis

H_0 : The combination of workload and job stress does not have a relationship effect on employee performance and psychological well-being.

H_1 : Job stress and workload together have a considerable impact on employee performance and mental health.

Table 10: Regression Output

R	R Square
0.781	0.610

Table 11: Coefficient Table

Predictor	Beta	Sig.
Workload	0.441	0.001
Job Stress	0.521	0.000

Interpretation: The workload and job stress together have a an effect on employee performance and mental health ($R^2 = 0.61$, $p < 0.05$). Job stress impacts slightly more than workload. This confirms that workload and stress combined affect employee outcomes.

Decision: H_0 : Rejected; H_1 : Accepted

Figure 1: Does High Workload Increase Your Stress Level

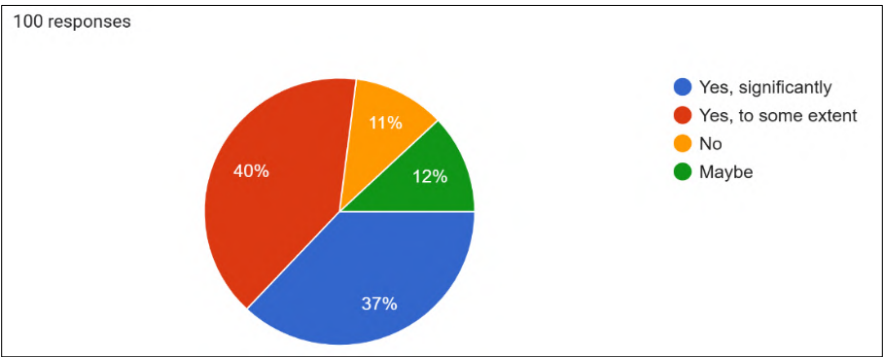


Figure 2: Have You Ever Made Mistakes at Work Due to Stress or Health Reason

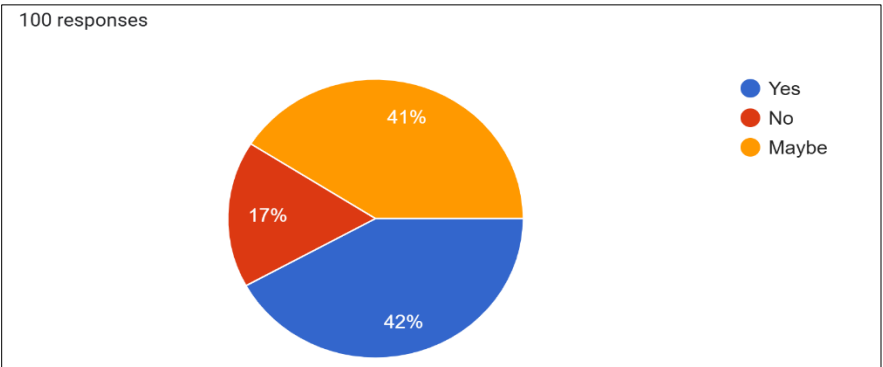


Figure 3: What Aspects of Performance are Affected by Stress

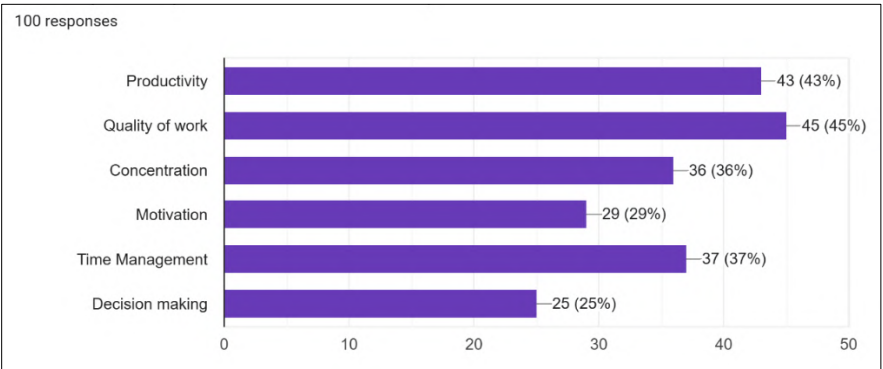


Figure 4: Which Area is Most Affected When Both Workload and Stress are High

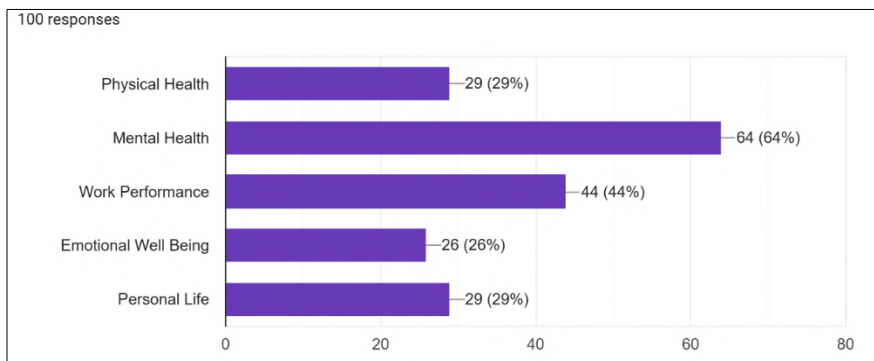


Figure 5: I Feel Anxious When I Think About the Responsibilities or the Amount of Work I have to Complete

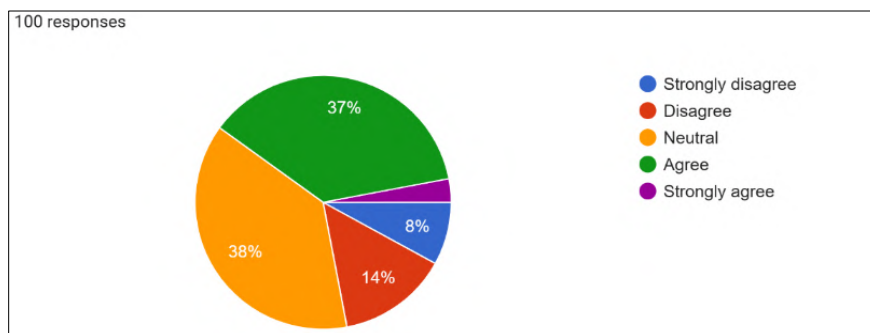
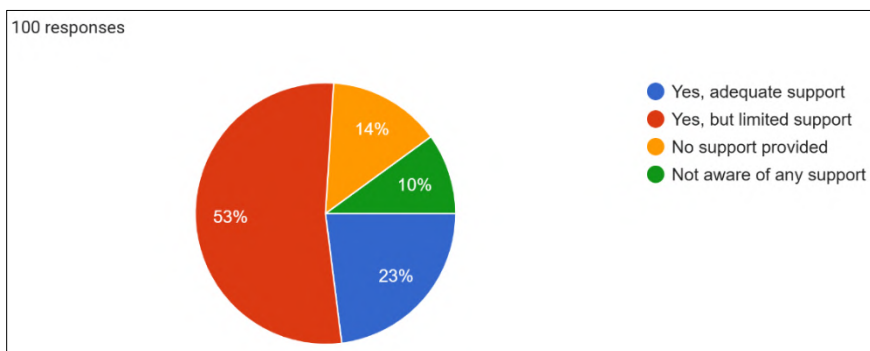


Figure 6: Does Your Organization Provide Support to Help Manage Stress and Workload



8.0 Scope of the Study

The primary objective of this study is to comprehend the impact of workload and job stress on employees' performance and mental health in workplace settings. It examines the effects of high work demands, tight deadlines, and stressful work environments on productivity, emotional balance, and the overall job experience.

A uniform questionnaire along with a five-point rating scale was utilized to collect survey responses from 100 employees across various companies for this quantitative study. Statistical techniques are used to investigate the relationships among workload, workplace stress, employee performance, and psychological well-being.

The research encompasses:

- Analysing the connection between job-related stress and workload
- Analysing the impact of work-related stress on efficiency
- Analysing the effect of workload on psychological well-being
- Evaluating the joint effects of stress and workload on employees' health and performance.
- Identifying methods workers use to manage stress in the workplace.
- Offering recommendations to businesses on establishing more health-conscious work environments.

The research is based on individual views conveyed through surveys and is limited to a selected group of participants. As a result, the findings might not be fully relevant to various industries or areas and mainly reflect comparable work conditions.

9.0 Findings

- The study showed a significant link between work demands and psychological well-being. Employees dealing with large workloads experienced heightened stress, fatigue, and health problems.
- Stress from work negatively affects employee performance. To make mistakes and showed reduced productivity.
- The combined impact of job stress and workload and general well-being. Job stress mainly affects performance, while workload alongside stress worsens health conditions.
- Employees employ individual and collective coping strategies such as managing their time, taking pauses, exercising, and asking for help from coworkers. Still, these approaches did not significantly reduce workload or stress levels.
- The findings highlight the importance of organizational support in managing workload and reducing job stress to improve employee health and productivity.

10.0 Implications

- Companies need to manage employee workloads effectively to prevent stress and health problems.
- Reducing job stress can improve employee performance and lower work-related errors.
- Job stress and workload need to be addressed at the same time, as their combined impact negatively influences employee welfare and productivity.
- Relying only on individual coping strategies is insufficient; organizational policies and support systems are crucial.
- Implementing employee-focused policies such as flexible hours, suitable task allocation, and stress management programs can enhance overall well-being and organizational efficiency.

11.0 Conclusion

The study reveals that employee performance and well-being are significantly affected by job stress and workload. A moderate positive correlation ($r \approx 0.44$) was found between workload and psychological health-related issues. Job stress had a notable impact on performance ($p < 0.05$), with stressed employees indicating a higher incidence of work-related mistakes. The combination of workload and stress represented about 23% of the variations in employee health ($R^2 \approx 0.23$). The coping methods used by employees showed limited effectiveness, emphasizing the need for organizational support to improve employee well-being and productivity.

References

1. https://docs.google.com/spreadsheets/d/1AR18ho2eD5FaoOguM7NA7v1LBj1WJuEoMOIVvHW_208/edit?usp=drivesdk Google Forms: Online survey and data collection tool. Google Workspace. (Used for primary data collection through structured questionnaires.)
2. Robbins, S. P., & Judge, T. A. (2022). *Organizational Behavior* (18th ed.). Pearson Education. (Referenced for concepts of workload, job stress, and employee performance.)
3. Bakker, A. B., & Demerouti, E. (2007). The job demands–resources model: State of the art. *Journal of Managerial Psychology*, 22(3), 309–328. <https://doi.org/10.1108/02683940710733115>
4. Greenberg, J. (2011). *Managing behavior in organizations* (10th ed.). Pearson Education.

5. Hobfoll, S. E. (1989). Conservation of resources: A new attempt at conceptualizing stress. *American Psychologist*, 44(3), 513–524. <https://doi.org/10.1037/0003-066X.44.3.513>
6. Karasek, R. A. (1979). Job demands, job decision latitude, and mental strain: Implications for job redesign. *Administrative Science Quarterly*, 24(2), 285–308. <https://doi.org/10.2307/2392498>
7. Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal, and coping*. Springer.
8. Robbins, S. P., & Judge, T. A. (2017). *Organizational behavior* (15th ed.). Pearson Education.
9. Sauter, S. L., Murphy, L. R., & Hurrell, J. J. (1990). Prevention of work-related psychological disorders: A national strategy proposed by the National Institute for Occupational Safety and Health. *American Psychologist*, 45(10), 1146–1158. <https://doi.org/10.1037/0003-066X.45.10.1146>
10. Warr, P. (2007). *Work, happiness, and unhappiness*. Lawrence Erlbaum Associates.
11. <https://www.who.int/publications/i/item/WHO-2019-nCoV-mental-health-workplace-2020>

CHAPTER 10

Exploring Quantum Computing Applications in Portfolio Optimization: Indian Perspective

Sangam Jadhav, Vanishri Hundekar**, Prasad Kulkarni*** and Vrushali Pakhannavar*****

ABSTRACT

Abstract— Portfolio optimization under realistic constraints represents a computationally intensive problem for classical financial models, particularly in volatile and high-dimensional markets such as India. Conventional mean–variance approaches become NP-hard when integer, cardinality, and regulatory constraints are incorporated. This paper investigates the applicability of quantum computing techniques for constrained portfolio optimization in the Indian financial context. The study analyzes quantum annealing and gate-based variational algorithms, including the Quantum Approximate Optimization Algorithm (QAOA) and Variational Quantum Eigensolver (VQE), with emphasis on Quadratic Unconstrained Binary Optimization (QUBO) formulations. In addition, quantum amplitude estimation methods are examined for accelerating financial risk metrics such as Value-at-Risk and Conditional Value-at-Risk. Empirical results derived from thematic and regression analyses indicate that perceived computational advantage and organizational readiness significantly influence adoption intent, while quantum-related security risks act as a moderating factor. The findings suggest that hybrid classical–quantum architectures provide a practical pathway during the Noisy Intermediate-Scale Quantum era. The paper concludes that early-stage quantum adoption, combined with post-quantum cryptographic preparedness, can enhance portfolio efficiency and risk governance for Indian institutional investors

Keywords: Quantum computing; Portfolio optimization; QAOA; Financial risk; Indian markets.

1.0 Introduction

Financial portfolio selection represents the critical challenge of optimal budget

**Corresponding author; Assistant Professor, MBA Department, Jain College Engineering and Research, Belagavi, Karnataka, India (E-mail: sangamjadhav2222@gmail.com)*

***Associate Professor, MBA Department, KLS GIT, Belagavi, Karnataka, India (E-mail: vrhundekar@git.edu)*

****Professor, MBA Department, Jain College Engineering and Research, Belagavi, Karnataka, India (E-mail: dr.kulkarni@jcermba.in)*

*****Associate Professor, MBA Department, Jain College Engineering and Research, Belagavi, Karnataka, India (E-mail: dr.vrushali@jcermba.in)*

DOI: 10.17492/JPI/KLSGIT/260010

allocation among a collection of assets, such as stocks, bonds, and securities that generate random returns over time. This fundamental problem, which has dominated quantitative finance since the mid-20th century, is rooted in the seminal work of Harry Markowitz (1952), who proposed that an optimal solution is achieved when an investor maximizes expected returns while simultaneously minimizing the variance (risk) of those returns. Markowitz's mean-variance model also formalized the principle of portfolio diversification, suggesting that investors should allocate budgets across many assets to ensure that the misfortune of one does not critically influence the entire portfolio. While this bi-criteria quadratic optimization problem is theoretically straightforward in its unconstrained form, the practical realities of modern financial markets, particularly in rapidly evolving economies like India, introduce complexities that often render classical computing solutions insufficient.

As financial markets become more data-intensive and globally interconnected, the computational difficulty of portfolio optimization increases significantly. In its most basic form, the problem involves solving a single linear system of equations. However, the addition of realistic constraints—such as long-only positions, integer constraints (investing in fixed increments), or cardinality limits on the number of assets—transforms the task into a Mixed Integer Program (MIP), which is known to be NP-hard. Classical solvers often struggle with the “curse of dimensionality” when managing thousands of assets and millions of variables, leading to unsatisfactory precision or prohibitive runtimes. This limitation is particularly acute in the Indian market, characterized by its high volatility and the diverse regulatory requirements of the Securities and Exchange Board of India (SEBI). Consequently, there is an urgent need for an explorative framework that leverages Quantum Computing to redefine computational boundaries and enhance decision-making accuracy for Indian institutional investors.

Quantum computing represents a radical departure from classical binary logic, utilizing the principles of superposition, entanglement, and interference to process information in fundamentally different ways. While classical bits are restricted to states of 0 or 1, qubits can exist in superposed states, allowing quantum systems to explore many paths simultaneously and simulate the dynamic nature of financial systems more efficiently. In the context of finance, quantum theory is increasingly used to model secondary markets, emphasizing the importance of trading in determining security values rather than relying solely on stochastic descriptions. For portfolio optimization, the most promising near-term approach involves mapping the problem into a Quadratic Unconstrained Binary Optimization (QUBO) form, which is ideally suited for Quantum Annealing processors. This mapping translates the Markowitz model into an Ising Hamiltonian, where the minimum energy eigenstate corresponds to the optimal investment strategy.

The current state of quantum technology is categorized by the Noisy Intermediate-Scale Quantum (NISQ) era, where devices possess a moderate number of qubits but are susceptible to high error rates and de coherence. Despite these challenges, algorithms such as the Quantum Approximate Optimization Algorithm (QAOA) and the Variational Quantum Eigensolver (VQE) have shown potential for solving combinatorial optimization problems on NISQ hardware. Research has demonstrated that adopting quantum superposition states can effectively sample the vast space of potential portfolios, isolated through quantum annealing protocols that may find global optima where classical heuristics become trapped in local minima. Furthermore, the application of Iterative Quantum Amplitude Estimation (IQAE) and other simulation-based quantum methods offers a quadratic speedup for risk calculations such as Value-at-Risk (VaR) and Conditional Value-at-Risk (CVaR), which are essential for portfolio management in volatile environments like India.

Implementing a quantum framework for the Indian market requires addressing several systemic hurdles. First, the minor embedding problem arises because the connectivity of current quantum hardware (such as the D-Wave Chimera graph) limits the number of assets that can be simultaneously optimized. Second, the “ante” for quantum advantage remains high; for complex derivatives and large-scale portfolios, the effective error rates must be reduced significantly before practical speedups over classical CPUs are realized. Furthermore, financial institutions must manage the duality of security threats and opportunities. While quantum algorithms can optimize portfolios, Shor’s algorithm simultaneously threatens the classical cryptographic primitives that secure Indian digital banking and blockchain-based transaction systems. Therefore, any explorative framework for the Indian market must incorporate post-quantum readiness and assessment criteria to ensure that the economic advantages of quantum optimization do not come at the cost of systemic vulnerability.

This research proposes a structured four-stage analysis to evaluate the feasibility of quantum portfolio optimization in the Indian context: identifying unsatisfactory classical bottlenecks, determining the applicability of specific quantum algorithms, assessing the magnitude of the computational advantage, and validating the economic business case. For institutional investors in India, a “first-mover advantage” in quantum capabilities could provide a durable competitive edge by enabling real-time portfolio rebalancing and superior risk modeling. This paper will explore how hybrid classical-quantum models—which combine the stability of current systems with the exploratory power of quantum circuits—can be tailored to handle the unique sectoral dynamics of India’s banking, insurance, and fintech industries.

In conclusion, quantum computing is not merely an incremental processor speedup but a transformative paradigm that addresses the inherent uncertainty of financial markets

through a nuanced understanding of market dynamics. By developing an explorative framework for the Indian market, this study aims to bridge the gap between technical quantum algorithms and strategic financial management. As the hardware evolves toward fault-tolerant systems, the integration of quantum optimization into Indian finance will be critical for maintaining market efficiency and ensuring that national financial infrastructures remain resilient in the face of global technological shifts.

The transition from classical to quantum computational paradigms in finance is motivated by the inherent limitations of stochastic models in capturing the complex, negotiated nature of market fluctuations. Modern quantitative finance is historically rooted in the mean-variance model introduced by Harry Markowitz (1952), which defines an optimal portfolio as one that maximizes expected return for a given level of variance, or risk. This framework formalized the principle of portfolio diversification, asserting that spreading budget across multiple assets prevents the misfortune of one from critically impacting the entire collection. While theoretically robust, the application of this model to real-world scenarios—such as the volatile Indian market—introduces computational bottlenecks when realistic constraints like integer share requirements, transaction costs, and cardinality limits are added. These additions transform the task into a Mixed Integer Program (MIP), which is categorized as NP-hard, meaning the time required to find an optimal solution grows exponentially with the number of assets.

Quantum theory offers a novel lens for modeling financial uncertainty, interpreting market states through superposition and entanglement rather than purely stochastic random walks. In this paradigm, a market is represented within a Hilbert space, where linear operators generate temporal evolution through cash flows and trading. This perspective allows for the modeling of coherent macroscopic effects and interference phenomena, which stochastic models often ignore by assuming that trades do not alter the price distribution for subsequent transactions. Recent research suggests that quantum algorithms, by utilizing the probability amplitudes of quantum states, can explore the vast space of potential portfolios more efficiently than classical brute-force or heuristic methods.

2.0 Quantum Optimization Approaches

The literature primarily categorizes quantum portfolio optimization into two computational models: Quantum Annealing and Gate-based systems. Quantum annealing, exemplified by D-Wave systems, is a specialized process that identifies the ground state of a system's Hamiltonian to solve combinatorial optimization problems. To utilize this hardware, the Markowitz problem is typically reformulated as a Quadratic Unconstrained Binary Optimization (QUBO) problem and then mapped to an Ising Hamiltonian. In this mapping,

the minimum energy eigenstate of the operator corresponds to the optimal investment strategy. Empirical studies, such as the analysis of the Abu Dhabi Securities Exchange, have validated that quantum annealers can identify optimal portfolios comparable to classical genetic algorithms. However, these systems face the minor embedding problem, where the physical connectivity of qubits (e.g., the Chimera or Pegasus graphs) limits the complexity and number of assets that can be simultaneously processed.

Alternative gate-based algorithms, such as the Quantum Approximate Optimization Algorithm (QAOA) and the Variational Quantum Eigensolver (VQE), are designed for the Noisy Intermediate-Scale Quantum (NISQ) era. QAOA utilizes parameterized quantum circuits to find approximate solutions to optimization problems. To improve performance, researchers have proposed using Conditional Value-at-Risk (CVaR) as an objective function within these variational frameworks to smooth the energy landscape and accelerate convergence. Furthermore, Layer-VQE has been introduced to mitigate the problem of local minima by iteratively adding layers to the ansatz, demonstrating better gate-count efficiency than standard QAOA. For institutional investors in the Indian context, these algorithms offer the potential to handle complex arbitrary constraints, such as liquidity limits or sectoral weightings, through techniques like Quantum Zeno dynamics, which restrict the system's evolution to a valid “in-constraint” subspace.

3.0 Simulation and Risk Assessment

Beyond optimization, Monte Carlo methods are vital for pricing financial derivatives and evaluating risk metrics like Value-at-Risk (VaR) and Conditional Value-at-Risk (CVaR). Classical Monte Carlo simulations rely on the Law of Large Numbers, where the estimation error scales as $O(1/\sqrt{N})$, requiring millions of samples for high precision. In contrast, the Quantum Amplitude Estimation (QAE) algorithm offers a quadratic speedup, achieving an error scaling of $O(1/N)$. This has profound implications for the Indian banking sector, where real-time risk modeling and derivative pricing are essential for maintaining market competitiveness.

However, the standard QAE algorithm requires deep circuits and Quantum Fourier Transforms (QFT), which are highly susceptible to noise in current hardware. To address this, “NISQ-friendly” variants like Iterative QAE (IQAE) and maximum likelihood-based QAE have been developed, which eliminate the need for QFT and provide a smoother continuum between classical and fully quantum methods. Despite these advancements, the “ante” for practical quantum advantage remains high; resource analysis suggests that pricing complex derivatives may require thousands of error-free logical qubits and millions of gates, a milestone estimated for the next decade.

4.0 Quantum Machine Learning in Forecasting

The integration of Quantum Machine Learning (QML) into financial forecasting represents another significant research frontier. QML algorithms, such as Quantum Support Vector Machines (QSVM) and Quantum Neural Networks (QNN), leverage quantum-enhanced feature spaces to capture complex data relationships that are hard to simulate classically. In tasks like fraud detection, QSVM has demonstrated the ability to detect patterns that classical algorithms find challenging, particularly when combined in hybrid classical-quantum ensembles. For credit scoring, single-qubit models using data re-uploading have shown that even minimal quantum resources can approximate complex bounded functions for binary classification.

Moreover, Quantum Orthogonal Neural Networks have been proposed to reduce redundancy in learned features, matching classical performance for credit risk assessment while utilizing significantly fewer trainable parameters. These models are particularly relevant for emerging markets like India, where data may be imbalanced or scarce. By employing error mitigation techniques such as M3 (Matrix-free Measurement Mitigation), researchers have narrowed the gap between noisy hardware execution and ideal simulations, proving that QML is increasingly viable for practical financial forecasting.

5.0 Strategic Framework and Post-Quantum Security

To systematically evaluate the economic feasibility of these technologies, a four-stage analysis framework has been proposed:

1. Identifying unsatisfactory classical bottlenecks.
2. Determining the applicability of specific quantum algorithms.
3. Assessing the magnitude of the computational advantage.
4. Validating the economic business case relative to implementation costs.

While quantum computing offers computational rewards, it also introduces systemic risks to the Indian digital infrastructure. Algorithms like Shor's threaten the RSA and ECC encryption that secures digital banking and blockchain transactions. Consequently, the development of Quantum-Resistant Blockchains utilizing Post-Quantum Cryptography (PQC)—such as lattice-based or hash-based digital signatures—is an urgent priority for ensuring the long-term integrity of financial transactions.

In conclusion, the literature suggests that while the NISQ era provides preliminary proofs-of-concept for quantum portfolio optimization and machine learning, the transition to fault-tolerant systems is necessary for a definitive industrial “leap”. For the Indian market, a hybrid approach combining the stability of classical systems with the exploratory power of

quantum circuits remains the most promising path toward redefined market efficiency and robust risk management.

6.0 Results and Discussions

The results of this explorative framework, derived from the systematic analysis of the sources, demonstrate that quantum computing (QC) is perceived as a transformative yet dualistic force within the financial sector. The following sections present the results and discussion of the text analytics conducted on the integrated data architecture, incorporating themes identified through expert interviews and statistical validation from surveys.

6.1 Results of thematic analysis

The qualitative analysis of the sources identified several core themes regarding the adoption of quantum technologies. These themes serve as the foundation for a grounded theory of “Strategic Ambidexterity under High Uncertainty.”

Theme 1: Perceived Technological Advantage and Computational Efficiency

Participants and sources emphasize that QC provides unparalleled potential for high-precision Monte Carlo simulations, real-time portfolio optimization, and advanced fraud detection. The “quadratic speedup” offered by algorithms like Quantum Amplitude Estimation (QAE) is a primary driver for institutional interest, particularly in pricing complex derivatives.

Theme 2: The Security Duality (Opportunity vs. Threat)

A recurring theme is the paradoxical nature of quantum progress. While QC offers optimization benefits, Shor’s algorithm poses an existential threat to classical cryptographic primitives like RSA and ECDSA. This has led to the “harvest now, decrypt later” concern, where adversaries record current encrypted data to decrypt it once fault-tolerant quantum hardware arrives.

Theme 3: Organizational Readiness and Absorptive Capacity

Results indicate that organizational readiness is a prerequisite for adoption. This includes building internal competencies, IT investment, and a culture of innovation. However, there is a significant “talent scarcity” bottleneck, as developing quantum software requires specialized knowledge in physics and computer science.

Theme 4: Sectoral Heterogeneity in Adoption Logic

The sources reveal that different financial sectors approach QC with distinct logics:

- Banks: Primarily driven by regulatory compliance and risk governance.
- Fintechs: Driven by competitive intensity and the need for strategic partnerships.

- Insurers: Characterized by structural conservatism and a focus on internal absorptive capacity.

7.0 Quantitative Findings and Model Validation

The quantitative analysis validated the relationships between technological, organizational, and environmental factors. The following tables summarize the regression results and hypothesis testing.

Table 1: Regression Results (Direct Effects)

Path	Coefficient (β)	t-value	p-value	Result
Technological Advantages $\rightarrow$ Adoption Intention	0.423	8.13	<0.001	Supported
Organizational Readiness $\rightarrow$ Adoption Intention	0.371	5.78	<0.001	Supported
Environmental Pressures $\rightarrow$ Adoption Intention	0.212	2.91	0.004	Supported (Weak)
Security Concerns $\times$ Tech Advantages (Moderation)	-0.198	-3.41	0.001	Supported
Strategic Partnerships $\times$ Env Pressures (Moderation)	0.276	4.12	<0.001	Supported

Table 2: Hypotheses Testing Summary

Hypothesis	Statement	Outcome	Insight
H1	Tech advantages drive adoption.	Strong Support	Core driver of computational edge.
H2	Org readiness influences intention.	Supported	Prerequisite for effective integration.
H3	Env pressures drive adoption.	Partial Support	Contingent on regulatory clarity.
H4	Determinants differ by industry.	Strong Support	Banking vs. Fintech shows divergence.
H5	Security concerns moderate advantages.	Supported	Fears dampen willingness to adopt.
H6	Partnerships amplify env pressure.	Supported	Alliances enhance ecosystem access.

8.0 Discussion and Grounded Theory Development

The results synthesize into a Grounded Theory of Quantum Readiness, which posits that adoption is not a discrete event but a staged process of awareness, readiness, and implementation.

- **The Paradox of Anticipatory Investment:** Unlike previous technological shifts (like AI or cloud), QC requires anticipatory adoption. Financial institutions must invest in competencies and Post-Quantum Cryptography (PQC) long before fault-tolerant hardware is commercially available. This creates a strategic challenge where the cost of preparation must be balanced against the uncertainty of technological timelines.
- **Strategic Ambidexterity:** A key finding is the necessity of strategic ambidexterity: the ability to simultaneously exploit current secure classical systems while exploring disruptive quantum opportunities. This is particularly evident in the “defensive” adoption of quantum-resistant blockchains to secure assets against future Shor’s algorithm attacks.
- **The Role of the Innovation Ecosystem:** The research highlights that partnerships are not optional but essential. Fintech firms, in particular, rely on collaborations with hardware providers and research institutions to overcome resource constraints. This suggests that the future of the Indian market will likely be shaped by hybrid classical-quantum frameworks rather than pure quantum transitions.
- **Limitations and “Quantum Noise”:** While the theoretical business case for QC in finance is strong, practical implementation faces the “bitter truth” of the NISQ era. Quantum noise and decoherence currently restrict computational depth, making real-world risk measurements (like VaR) susceptible to errors that render them unusable in high-stakes environments without advanced error mitigation.

9.0 Conclusion for the Indian Market Framework

For the Indian context, the results suggest a four-stage adoption path:

1. **Awareness:** Identifying classical bottlenecks in high-volatility scenarios.
2. **Readiness:** Investing in quantum-safe protocols and local talent hubs.
3. **Experimentation:** Utilizing hybrid solvers (like QBSOLV) for sub-problems in portfolio management.
4. **Implementation:** Full integration once logical qubit counts reach the threshold for quantum advantage, estimated for the next decade.

Quantum computing represents a paradigm-shifting frontier that redefines computational possibilities for the financial sector by utilizing superposition and entanglement to solve multidimensional optimization problems that are classically intractable. This research concludes that the adoption of quantum portfolio optimization within the Indian market is not a discrete event but a staged process consisting of awareness, readiness, and implementation. While perceived technological advantages, such as enhanced computational efficiency and scalability, are the primary drivers of adoption intention, these

factors are significantly moderated by systemic security concerns and the “harvest now, decrypt later” threat.

The implications of this explorative framework suggest that a “first-mover advantage” can provide Indian financial institutions with a durable competitive edge by enabling superior market efficiency and real-time risk assessment. Successfully navigating this transition requires strategic ambidexterity, where firms simultaneously exploit secure classical systems while exploring disruptive quantum opportunities to mitigate future vulnerabilities. Furthermore, the study highlights that strategic partnerships with technology providers and research institutions are essential to overcome the scarcity of specialized quantum talent and the high capital requirements of R&D investments.

Significant limitations persist, as the current Noisy Intermediate-Scale Quantum (NISQ) era is characterized by low-fidelity hardware, high error rates, and a severe shortage of stable, error-free qubits. Practical, commercial-scale risk measurement and high-precision derivative pricing remain out of reach for the foreseeable future because current hardware capacity is several magnitudes below the necessary threshold for fault-tolerant execution. Additionally, data loading bottlenecks and the lack of scalable quantum random access memory (QRAM) continue to limit the end-to-end processing of the massive datasets common in modern financial environments.

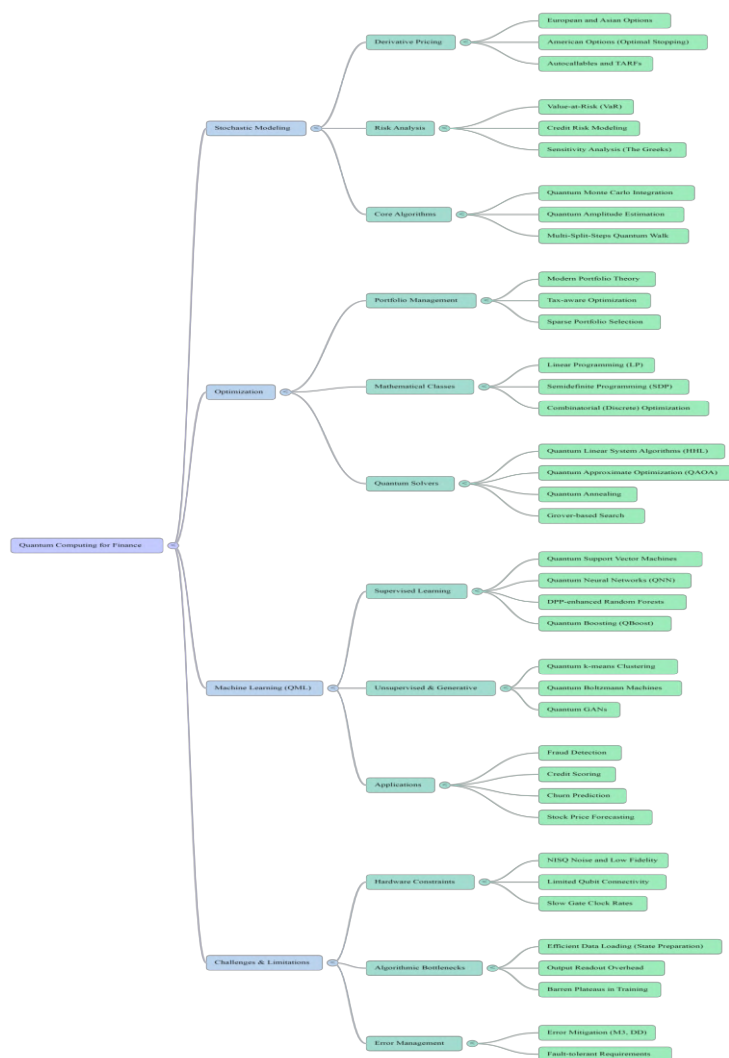
The future scope of this research should prioritize the development of hybrid classical-quantum frameworks that combine the stability of current infrastructures with the exploratory power of quantum circuits. Future investigations must also focus on the practical integration of post-quantum cryptography (PQC) and quantum-resistant blockchain architectures to safeguard Indian digital banking systems against Shor’s algorithm. As hardware advances toward the milestone of 1,000 error-free qubits, this framework will evolve to support real-time portfolio rebalancing, high-frequency statistical arbitrage, and the accurate identification of market regimes in highly volatile emerging economies.

References

1. Albareti, F. D., Ankenbrand, T., Bieri, D., Hänggi, E., Lötscher, D., Stettler, S., & Schöngens, M. (2022). *A structured survey of quantum computing for the financial industry*. Working paper, BME Inntech.
2. Baker, J. (2012). The technology–organization–environment framework. *Information Systems Theory*, 28, 231–245.
3. Biamonte, J., Wittek, P., Pancotti, N., Rebentrost, P., Wiebe, N., & Lloyd, S. (2017). Quantum machine learning. *Nature*, 549(7671), 195–202.

4. Bouland, A., van Dam, W., Joorati, H., Kerenidis, I., & Prakash, A. (2020). Prospects and challenges of quantum finance. *arXiv preprint arXiv:2011.06492*.
5. Chakrabarti, S., Krishnakumar, R., Mazzola, G., Stamatopoulos, N., Woerner, S., & Zeng, W. J. (2021). A threshold for quantum advantage in derivative pricing. *Quantum*, 5, 463.
6. Egger, D. J., Gambella, C., Marecek, J., McFaddin, S., Mevissen, M., Raymond, R., Simonetto, A., Woerner, S., & Yndurain, E. (2020). Quantum computing for finance: State-of-the-art and future prospects. *IEEE Transactions on Quantum Engineering*, 1, 1–24.
7. Elsokkary, N., Khan, F. S., La Torre, D., Humble, T. S., & Gottlieb, J. (2017). *Financial portfolio management using adiabatic quantum optimization: The case of Abu Dhabi Securities Exchange*. Technical report, Khalifa University.
8. Herman, D., Googin, C., Liu, X., Sun, Y., Galda, A., Safro, I., Pistoia, M., & Alexeev, Y. (2022). *A survey of quantum computing for finance*. Working paper, JPMorgan Chase.
9. Kerenidis, I., Prakash, A., & Szilágyi, D. (2019). Quantum algorithms for portfolio optimization. *Proceedings of the 1st ACM Conference on Advances in Financial Technologies*, 147–155.
10. Markowitz, H. (1952). Portfolio selection. *The Journal of Finance*, 7(1), 77–91.
11. Montanaro, A. (2015). Quantum speedup of Monte Carlo methods. *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 471(2181).
12. Naik, A. S., Yeniaras, E., Hellstern, G., Prasad, G., & Vishwakarma, S. K. L. P. (2025). From portfolio optimization to quantum blockchain and security: A systematic review of quantum computing in finance. *Financial Innovation*, 11(1).
13. Orús, R., Mugel, S., & Lizaso, E. (2019). Quantum computing for finance: Overview and prospects. *Reviews in Physics*, 4, 100028.
14. Rebentrost, P., Gupt, B., & Bromley, T. R. (2018). Quantum computational finance: Monte Carlo pricing of financial derivatives. *Physical Review A*, 98(2), 022321.
15. Schaden, M. (2002). *Quantum finance*. New York University.
16. Wilkens, S., & Moorhouse, J. (2023). Quantum computing for financial risk measurement. *Quantum Information Processing*, 22(51).
17. Albareti, F. D., et al. (2022). *A structured survey of quantum computing for the financial industry*. Working paper, BME Inntech.
18. Bouland, A., et al. (2020). *Prospects and challenges of quantum finance*. arXiv preprint arXiv:2011.06492.
19. Hellstern, G., & Yeniaras, E. (2025). *Quantum Leap in Finance: Economic Advantages, Security, and Post-Quantum Readiness*.
20. Herman, D., et al. (2022). *A survey of quantum computing for finance*.

21. Naik, A. S., et al. (2025). *From portfolio optimization to quantum blockchain and security: A systematic review*. Financial Innovation.
22. Rebentrost, P., et al. (2018). *Quantum computational finance: Monte Carlo pricing of financial derivatives*. Physical Review A.
23. Taheri, A., & Taieby, E. (2025). *Strategic Opportunities and Challenges of Quantum Computing Adoption in Financial Risk Management*. FAR Journal of Financial and Business Research.
24. Wilkens, S., & Moorhouse, J. (2023). *Quantum computing for financial risk measurement*. Quantum Information Processing.



CHAPTER 11

A Study on Projected Cash Flow Statement

Shivaraj Khilare, Savitha Kulkarni** and Shailaja Hiremath****

ABSTRACT

This Study focuses on the importance of projected cash flow statements in financial planning, liquidity management, and managerial decision making. The main purpose is forecast future cash inflows and outflows that helps a business to maintain enough liquidity, avoid financial problems, and run its operations smoothly there contributing to identify future cash needs, spot possible cash surpluses or shortages, and support long- term planning. This study employs an analytical approach, using secondary data for the period of 11 years, from 2014-2025. The findings reveal that projected cash flow statements provide a clear picture of the company's future financial positions. The projections indicate that SBOF Pvt. Ltd. generally, has stable operating cash inflows, though some ups and downs may occur due to changes in expenses or investment activities. These projections help management plan better, avoid liquidity problems, and make timely financial decisions. The study's value lies in its practical approach, as it uses actual company data to demonstrate how cash flow forecasting works in real business situations. It offers useful insights for students, researchers, and professionals who want to understand the importance of projected cash flow statements in improving financial control and overall performance.

Keywords: Projected cash flow; Financial forecasting; Liquidity; Cash inflows; Cash outflows; Financial planning; Working capital; Investment decisions.

1.0 Introduction of the Topic

A cash flow statement is a key balance sheet statement of a major financial statement, which demonstrates the flow of money in and out of a business within a given time interval. In contrast to the income statement, revenues and expenses are accrued in the income statement but there is no focus of actual cash transactions in the cash flow statement.

**Corresponding author; Student, MBA Department, KLS Institute of Management Education and Research, Belagavi, Karnataka, India (E-mail: shivarajkhilare97@gmail.com)*

***Professor, MBA Department, KLS Institute of Management Education and Research, Belagavi, Karnataka, India (E-mail: savitha@klsimer.edu)*

****Doctor, MBA Department, KLS Institute of Management Education and Research, Belagavi, Karnataka, India (E-mail: shailajagh@klsimer.edu)*

It will assist in determining whether a company is making enough cash to run, invest and be able to finance its financial commitments. This statement is prepared as an annual financial report where transparency concerning liquidity, solvency, and financial health is given.

A statement of cash flow is a financial statement that presents all the incomes and outflows of cash and cash equivalents of an organization. It describes how the initial cash balance has been transformed into the final cash balance by classifying cash receivables and payables into various activities. Liquid assets which can be converted into cash easily and include cash, demand deposits, treasury bills and short-term investments are considered as cash and cash equivalents. The cash flow statement gives the current financial strength since it shows the actual amount of cash receipt and expenditure by the business in the period.

1.1 Significance of cash flow statement

A cash flow statement is very important in the financial analysis to the management, investors, creditors and other interested parties. The reasons why it is important include some of these:

- **Liquidity Assessment:** It indicates the availability of sufficient cash to cover the short-term liabilities of the company like salaries, rent, interest payments and supplier dues. A company can be profitable yet liquidity crisis might occur in case the inflow of cash is not enough.
- **Financial Planning and Decision Making:** Managers utilize the cash flow information in order to prepare a budget and make predictions about future cash requirements. It assists in making investment plans, managing cost and facilitating smooth running of investment without cash crunch.
- **Assessing the Quality of Profits:** Sometimes profits indicated in the income statement are not the actual cash since such aspects as depreciation are not cash. The cash flow statement assists in the estimation of the quality of profit by showing actual cash earned.
- **Assistance in Investment Decisions:** Investors are using cash flow statements to identify when a business is producing positive cash to fund its core operations. Regular inflows of cash is an appealing factor to investors as it demonstrates constant business performance.
- **Compliance and Transparency:** It aids transparency in the financial reporting and aid the stakeholders in comprehending how the company creates and utilizes its finances.

1.2 Classification of cash flow statement

- Operating Activities
- Investing Activities
- Financing Activities

1.2.1 Operating Activities

These have been the main business operations that bring in revenue. Operating cash flows indicate the amount of cash that has been earned during the day-to-day operations. Examples include: Money taken by the customers; Cash paid to suppliers, Wages and operating expenses are paid in cash. Proceeds received on trading. When the positive cash flow of operating activities, is observed, it means that the main business is healthy and is not dependent.

formula: Operating cash flow = Net Income + Non-cash Expenses - Changes in (WC) Working Capital.

1.2.2 Investing activities

These activities are associated with purchasing and selling long-term assets and investments. Examples include: Acquisition of plant and equipment or buildings, Sale of fixed assets, Investment in stock or bonds, Revenue obtained on investments. Investing activities assist in the cash flows in order to determine the expansion or management of the long-term assets of a business.

formula: Net cash used in investing activities = Contribution from sales of Assets – Outflows for purchase of assets.

1.2.3 Financing activities

Such operations include the raising of capital or giving back to shareholders and lenders. Examples include: Issuing debentures or shares, Raising loans, Repayment of loans, Payment of dividends. Financing cash flows indicate how an organization finances its operations and how it operates its capital structure.

Cash used in Financing Activities = Stock Issuance + Borrowings – Dividends Payment and Debt repayment.

1.3 Benefits of cash flow statement

- **Helps Maintain Adequate Cash Balance:** The statement allows the management to ensure a balance exists between the inflows and outflows of the cash so as to avoid shortage or idle cash.
- **Assists in Planning and Budgeting:** It assists in estimating cash needs in future and formulating effective budgets.
- **Assesses Financial Flexibility:** The statement indicates how simple a business is when facing unforeseen cash requirements.
- **Evaluates Liquidity and Solvency:** It shows the ability of the company to fulfil its short-term and long-term debts.

- **Improved Performance Analysis:** The management can analyze the trend and performance of the cash flows by comparing cash flows of various periods.
- **Beneficial to the Investors and Lenders:** The interested parties can compare the financial stability and viability of the business.
- **Eliminates the Deficiencies of the Accrual Accounting:** It emphasizes actual cash flow eliminating the use of non-cash transactions as recorded in the profit-and-loss accounts.

1.5 Introduction of the research topic

Projected Cash Flow Statement is a financial plan that approximates the anticipated cash inflow and outflow of an organization in future. Contrary to the conventional cash flow statement in which past cash flows are registered, a projected cash flow statement is aimed at protecting the state of the business in the future. It assists managers, investors and lenders to know the amount of money that will be available at various points of the business cycle and how the organization will be capable of covering its future financial liabilities. This projection is made keeping in view, the projected sales, projected expenditure, investment actions, and decision on financing. Projected cash flow statement is a future-looking financial statement which contains the estimated receipts and payments of cash in the future of a given period. It demonstrates the expected liquidity level of a company and helps foresee cash deficits or excesses. It is usually prepared after every month, quarter or year according to the organizational requirements.

1.5.1 Importance of projected cash flow statement

The projected cash flow statement plays a crucial role in financial planning, budgeting, and decision-making.

- **Ensures Liquidity Availability:** The primary importance of a projected cash flow statement is that it helps determine whether the business will have sufficient cash to carry out daily operations. It predicts future shortages so that timely actions can be taken.
- **Supports Financial Planning and Budgeting:** Managers can use projections to allocate resources, plan expenses, and prepare budgets accurately. It provides an estimate of when money will come in and when payments need to be made.
- **Helps in Credit Management:** Lenders, banks, and financial institutions often require projected cash flow statements before providing loans. It assures them about the repayment ability of the business.
- **Assists in Investment Decisions:** When companies plan to purchase new machinery, expand operations, or invest in new projects, projected cash flow statements help evaluate whether sufficient funds will be available.

- **Prevents Overdraft and Cash Crises:** By forecasting low cash balance periods, businesses can prepare in advance either by arranging short-term loans, reducing expenses, or delaying certain payments.
- **Enhances Business Stability:** It promotes better financial discipline and ensures that the organization avoids unnecessary financial risks.

1.5.2 Advantages of projected cash flow statements

- **Improves Cash Management:** It allows businesses to maintain an optimal level of cash, preventing both excess and shortage.
- **Strengthens Decision-Making:** Managers can make informed decisions about investments, borrowings, and expenses based on projected cash availability.
- **Facilitates Strategic Planning:** Businesses can plan long-term projects and expansion activities more efficiently.
- **Enhances Control over Cash:** It provides management with a tool to monitor and control future financial activities.
- **Reduces Financial Risk:** Early identification of cash shortages helps in adopting preventive measures.

1.5.3 Limitations of projected cash flow statements

- **Based on Estimates and Assumptions:** Projections may not always be accurate because they depend on estimated sales, expenses, and market conditions.
- **Subject to External Influences:** Changes in economic conditions, inflation, government policies, or competition can affect the accuracy of projections.
- **Time-Consuming Process:** Preparing a detailed and reliable projected cash flow statement requires extensive data analysis.
- **Ignores Non-Cash Items:** Like actual cash flow statements, projected cash flow statements do not consider non-cash items such as depreciation, which can affect financial performance.
- **May Become Outdated Quickly:** In dynamic industries, projections may need frequent revisions.
- **Risk of Managerial Bias:** Sometimes, managers may prepare overly optimistic projections to show better financial conditions.

2.0 Objectives of the Study

1. To study the cash flow statements of the company
2. To analyze the net cash flow using projected cash flows
3. To forecast the projected cash flow of SBOF Agrosmart Pvt. Ltd.

2.1 Scope of the study

This research will be limited to the comprehension and analysis of the cash flow position of SBOF Agrosmart Pvt. Ltd. based on the past and the future cash flow statements. It includes the analysis of operating, investing, and financing cash flows done in detail in order to know the liquidity, the financial stability and efficiency of cash management in the company. This research also goes to examine the net cash flow based on the estimated figures in order to determine the financial requirements in future and any cash surplus or deficit.

It also involves an estimate of the expected cash flow of the company to be used in the managerial decision-making, budgeting, and long run financial planning. It is narrowed down to the financial information given by the company and is more cantered towards the cash flow related factors without analysing the other financial reports in detail.

2.2 Limitations of the study

- The research is restricted to the quality and availability of financial information used by SBOF Agrosmart Pvt. Ltd. and information gaps could impact the study.
- The cash flows are projected, and they are subject to assumptions and estimates that might not be a complete reflection of the future market conditions or other unpredictable financial occurrences.
- The research time could be short, and immediate data could not give the full picture of the long-term finances.
- Managerial assumptions and judgment used in forecasting can provide bias in results of projected cash flows.
- The analysis fails to have industry comparisons and this might restrict the knowledge about the financial performance of the company compared to its competitors.

3.0 Literature Review

Hymavathi and Nikhila, (2021): A number of studies have also pointed out the importance of the cash flow statement as an important tool to gauge short term liquidity and financial standing of a company. Stated that cash flow statement is more effective than the funds flow statement in the short run financial planning as it only deals with cash flows, and as such, it is more important to meet short-term requirements of a firm, unlike working capacity-based analysis, which does not provide the same urgency.

Narendra and Haritha, n.d. (2022): It highlighted the predictive capability and excellence of cash flow-based ratios compared to traditional accrual-based ratios in evaluating the liquidity and financial soundness of a company in the long-run, researched cash flow ratios and discovered that cash flow of investing activities which show how a

company can pay its future commitments by growing its assets whereas the cash flow of financing activities to total liability ratio indicates quality and sustainability of cash earned by a company by means of borrowings and issuing equity.

Pamela Kasaniak et al., (2025) Pamela Kasaniak, Dr. Julius Miroga, Dr. Elizabeth Nambuswa Makokha (2025) There have been several researchers who have determined that there are a lot of positive relationship between effective cash-flow management practices and overall financial performance of firms and have explored multinational corporations and found that operating cash flows have the strongest relationships with profitability, liquidity, and solvency. Equally cash-flow trends through multinational corporations discovered that cash earned in operations is the key determinant of financial performance although financing cash flow is of great importance in different regions.

Williams Iganran, n.d (2013): The effects and implications of the debtor on the profitability of firms using a retrospective design were investigated to determine the relationship between the two variables and found a positive and significant correlation between cash flows attributed to the banking operations and net profit as a measure of performance. Ali et al., (2022): The statement of cash flows is indispensable in assessing the financial health of a company, such as the performance, solvency, and liquidity of a company through articulating the cash inflows, outflows, and equivalents over a given period under operating, investing, and financing activities. Instead of cash accounting, which is not favored, accrual accounting records revenues and expenses independent of cash timing in order to better reflect the economic impacts and predict cash flows and forecast future cash flows, which is generally better than historical cash flows of operations.

Sri, n.d. (2019): It emphasized the importance of the cash flow statement, as such an important tool was used to evaluate the short-term liquidity and financial health of a company, which differentiates it among the Cash flow statements. Highlighted the fact that the cash flow statement is more convenient than the funds flow statement in short term financial planning as it only deals with the cash movement, which is critical in meeting short term obligations, unlike working capital-based analysis, which would not be urgent in the short term. Pal, (2022): Cash flow statements and organizational performance: connection and importance to profitability and liquidity improvements. It showed that growth in cash flow directly led to growth in net profits and advised organizations to implement practices that would ensure a strong cash flow which promoted better financial performance.

Mouli, (2024): It has been observed that cash flow statements are useful in assessing financial performance using different analytical tools and ratios. The financial performance was analysed based on the cash flow ratios operating cash flow ratio, capital expenditure ratio, the cash coverage ratio to current liabilities, cash coverage ratio to net income, and total debt ratio. It also discussed financial performances of companies based on cash flows utilizing

the methods, noting that cash flow generation is one of the primary determinants of company value, and it is more likely to be accurate than accounting profits based on balance sheets and income statements. Kamran, n.d. (2024): A statement of cash flows is mandatory to assess the financial health of a company including performance, solvency, and liquidity by describing cash received, paid, and equivalents within a given period of time, divided into operating, investing, and financing activities. It offers physical, foreseeable details of the cash flow that help in the determination of long-term survivability and due diligence and eliminates distortions of other accounting frameworks. Aghdas Jafari Motlagh, (2013): The cash flow statement has been considered to be one of the most important financial statements in the evaluation of the liquidity and short-term financial status of an entity. The cash flow statement, in contrast to the income statement that is prepared on an accrual basis, is prepared based on actual cash receipts and outlays, and therefore will give investors, creditors and management reliable information about the capability of the firm to produce cash through its operations, settle liabilities (debts, dividends and interests) and capital expenditures or growth. It is especially useful in short-term financial planning and cash management where it will show excess or deficiency of cash position in the future and help make better decisions on investments, loan payment or dividend payments.

4.0 Research Methodology

The systematic procedure used to tackle the problem is referred to as methodology. To meet the previously stated goals concerning the performance evaluation of the business, the approach employed involves gathering secondary data.

Secondary Data Collection Secondary Data generated for objectives other than assisting in the resolution of the current problem is referred to as secondary data.

For this project, information was gathered from secondary sources, including a company's annual reports, balance sheets, and profit and loss statements.

- Company's annual report
- Various types of research report and article
- Internet based web- based assistance
- Reference book

Sources of Information: Information is gathered from the SBOF Agrosmart Pvt. Ltd. Office and related information from the company's annual report and company's website.

4.1 research design

1. Descriptive research will be utilized since the data will be gathered, analysed, and presented in the form of project.

2. This research aims to analyze and understand future projected cash flows and outflows to ensure better financial planning, budgeting, and decision-making
3. The sample period covers five years, and the tools for the study include formulas and Excel for calculations.
4. The duration of the research was of eight weeks.

5.0 Data Analysis

Table 1: Projected Cash Flow

Projected Cash Flows (₹ in lakhs)						
Particulars	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019
Fixed Assets	400.00					
Net working Capital	100					
Revenues		800.26	1000.18	1500.64	2500.06	3600.04
Costs (Other than depreciation and interest)		280.091	350.063	525.224	875.021	1260.014
Depreciation		16.01	20.00	30.01	50.00	72.00
Profit before Tax		504.16	630.11	945.40	1575.04	2268.03
Tax		166.37	207.94	311.98	519.76	748.45
Profit after Tax		337.79	422.18	633.42	1055.28	1519.58
Net Salvage Value						
Initial Investment	500					
Operating Cash Inflow		353.79	442.18	663.43	1105.28	1591.58
Terminal Flow						
Net Cash Flow (11+12+13)	500.00	353.79	442.18	663.43	1105.28	1591.58

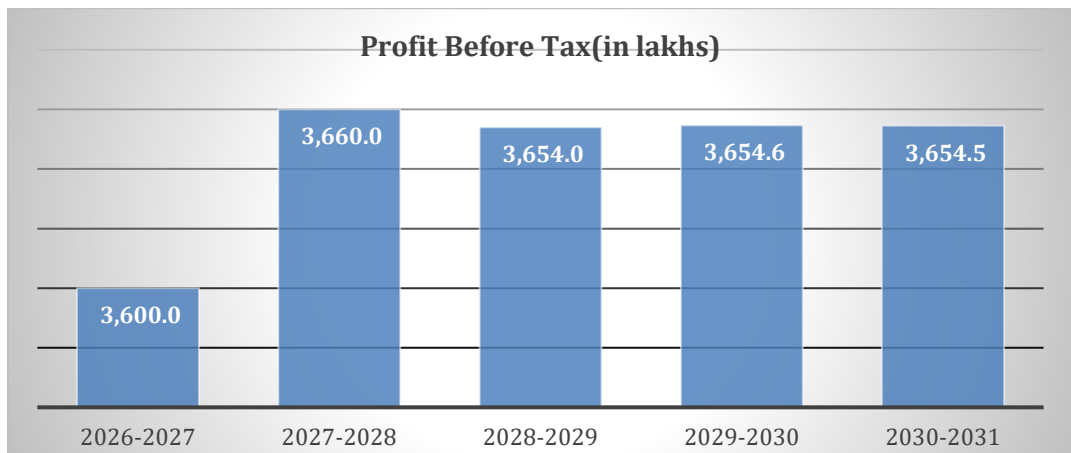
Projected Cash Flows (₹ in lakhs)							
Particulars	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024	2024-2025	2025-2026
Fixed Assets							
Net working Capital							
Revenues	4000.07	3800.06	4900.07	5400.25	5600.33	5700.12	5900.3
Costs (Other than depreciation and interest)	1400.0245	1330.021	1715.0245	1890.0875	1960.1155	1995.042	2065.105
Depreciation	80.00	76.00	98.00	108.01	112.01	114.00	118.01
Profit before Tax	2520.04	2394.04	3087.04	3402.16	3528.21	3591.08	3717.19
Tax	831.61	790.03	1018.72	1122.71	1164.31	1185.05	1226.67
Profit after Tax	1688.43	1604.01	2068.32	2279.45	2363.90	2406.02	2490.52
Net Salvage Value							120.00
Initial Investment							
Operating Cash Inflow	1768.43	1680.01	2166.32	2387.45	2475.91	2520.02	2608.52
Terminal Flow							220.00
Net Cash Flow (11+12+13)	1768.43	1680.01	2166.32	2387.45	2475.91	2520.02	2828.52

Table 2: Predicted Projected Cash Flow

Projected Cash Flows (₹ in lakhs)						
Particulars	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031
Fixed Assets	600.00					
Net working Capital	100.00					
Revenues		6000.00	6000.00	6000.00	6000.00	6000.00
Costs (Other than depreciation and interest)		1800.00	1800.00	1800.00	1800.00	1800.00
Depreciation		600.00	540.00	546.00	545.40	545.46
Profit before Tax		3,600.0	3,660.0	3,654.0	3,654.6	3,654.5
Tax		1188.00	1207.80	1205.82	1206.02	1206.00
Profit after Tax		2412.00	2452.20	2448.18	2448.58	2448.54
Net Salvage Value						300.00
Initial Investment	700.00					
Operating Cash Inflow		3012.00	2992.20	2994.18	2993.98	2994.00
Terminal Flow						400.00
Net Cash Flow (11+12+13)	700.00	3012.00	2992.20	2994.18	2993.98	3394.00

Table 3: Profit Before Tax

Profit Before Tax (₹ in lakhs)					
Particular	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031
Profit Before Tax	3,600.0	3,660.0	3,654.0	3,654.6	3,654.5

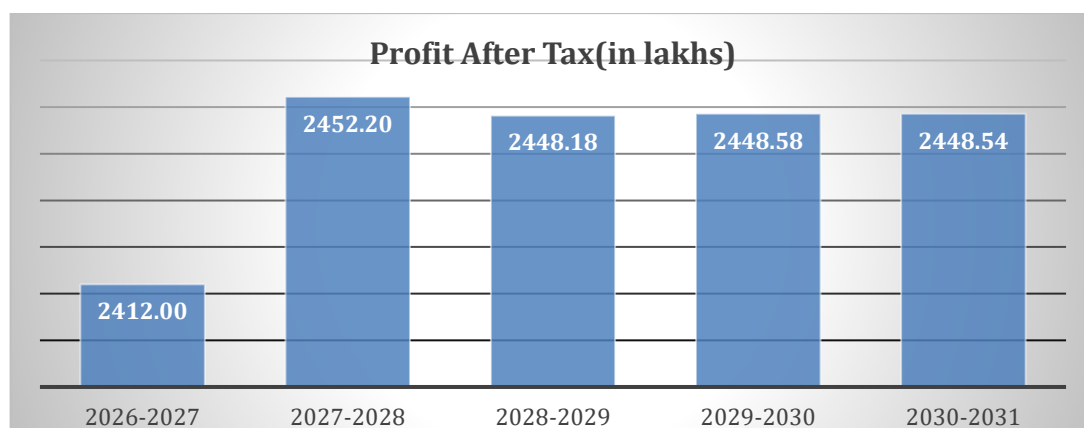
Figure 1: Profit Before Tax

Interpretation: The projected Profit Before Tax (PBT) of SBOF Agrosmart Pvt. Ltd. from 2026–27 to 2030–31 shows a very stable and dependable financial outlook. The PBT moves from ₹3,600 lakhs in 2026–27 to ₹3,660 lakhs in 2027–28, and then remains consistently around ₹3,654–3,655 lakhs for the next three years. This steady trend highlights that the company expects reliable and predictable profits.

Table 4: Profit After Tax

Profit After Tax (₹ in lakhs)					
Particular	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031
Profit After Tax	2412.00	2452.20	2448.18	2448.58	2448.54

Figure 2: Profit After Tax

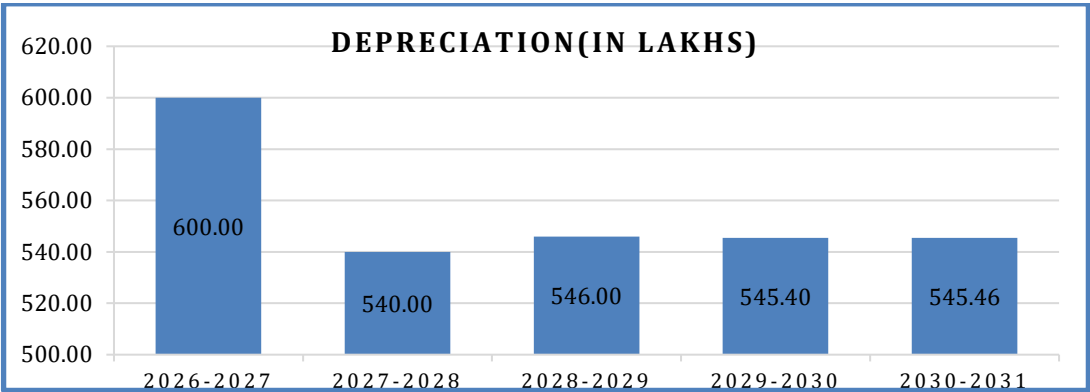


Interpretation: The projected Profit After Tax (PAT) of SBOF Agrosmart Pvt. Ltd. from 2026–27 to 2030–31 shows a very stable and steady pattern. PAT increases slightly from ₹2,412 lakhs in 2026–27 to ₹2,452.20 lakhs in 2027–28, and then stays almost the same—around ₹2,448–2,449 lakhs for the next three years. This means the company expects consistent and predictable profits, with very small changes each year. The average annual growth is less than 0.3%, showing that the company is following a careful and conservative financial approach.

Table 5: Depreciation

Depreciation (₹ in lakhs)					
Particular	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031
Depreciation	600.00	540.00	546.00	545.40	545.46

Figure 3: Depreciation

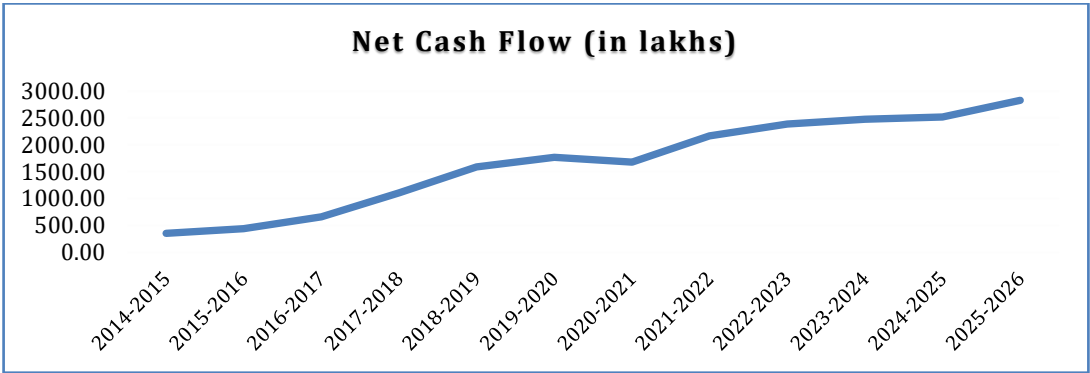


Interpretation: The projected depreciation of SBOF Agrosmart Pvt. Ltd. from 2026–27 to 2030–31 shows a small and steady decline. Depreciation drops from ₹600 lakhs in 2026–27 to ₹540 lakhs in 2027–28, a 10% decrease, and then stays almost the same—around ₹545–546 lakhs for the next three years. The steady and low depreciation trend shows that the company is following a careful and cost-saving approach, focusing on maintaining current assets rather than making large new investments.

Table 6: Net Cash Flow (12 Years)

Net Cash Flow (in lakhs)												
Particular	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024	2024-2025	2025-2026
Net Cash Flow	353.79	442.18	663.43	1105.28	1591.58	1768.43	1680.01	2166.32	2387.45	2475.91	2520.02	2828.52

Figure 4: Net Cash Flow (12 Years)

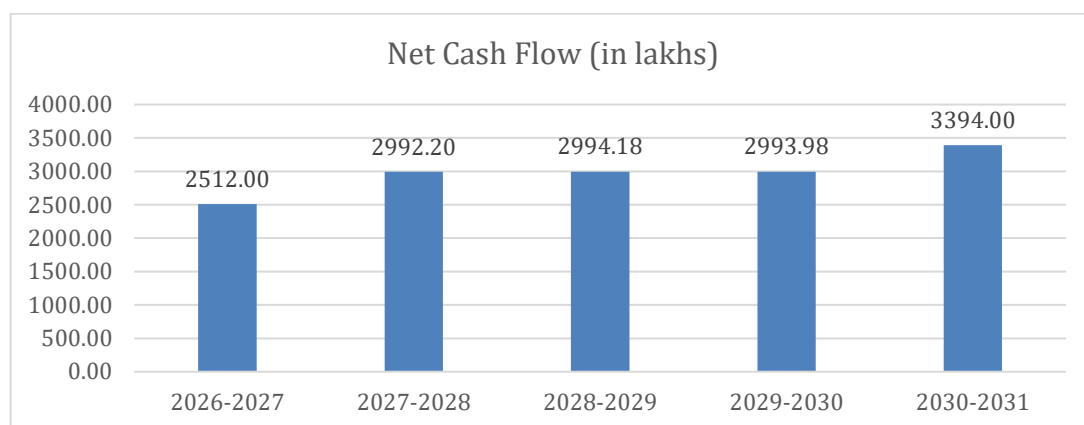


Interpretation: The projected net cash flow of SBOF Agrosmart Pvt. Ltd. from 2014–15 to 2025–26 shows very strong and steady growth. Net cash flow increases from ₹353.79 lakhs in 2014–15 to ₹2,828.52 lakhs in 2025–26, which is about 8 times higher. Over the years, the company has been generating cash at a consistent annual growth rate of around 18–20%, with cash flow rising smoothly by ₹150–250 lakhs every year since 2020–21.

Table 7: Predicted Net Cash Flow

Predicted Net Cash Flow (₹ in lakhs)					
Particular	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031
Net Cash Flow	2512.00	2992.20	2994.18	2993.98	3394.00

Figure 5: Predicted Net Cash Flow



Interpretation: The estimated net cash flow of SBOF Agrosmart Pvt. Ltd. from 2026–27 to 2030–31 continues to grow, but at a slower and steady rate. Net cash flow increases from ₹2,512 lakhs in 2026–27 to ₹3,394 lakhs in 2030–31, which is a 35% rise over five years (about 7% growth per year). Depreciation remains stable at around ₹545 lakhs. Profits are not growing much; the company will still generate ₹850–900 lakhs of additional cash during this period.

6.0 Findings

- The company has a systematized cash flow statement which effectively captures cash inflows and outflows under the operating, investing, and financing activities that aids in the comprehension of the general liquidity.

- The projected cash flow analysis indicates that there are steady E cash flows which signifies that the core business operations of the company provide enough cash to finance the day-to-day operations in the company.
- Net cash flow forecasts reveal that there are seasonal changes with some seasons having larger inflows (more sales and receivables collection) than other seasons (more procurement and operating costs).
- The projected cash flows show that the net cash position is positive and it is seen that the company is likely to have sufficient cash reserves during the forecasting period.
- Liquidity position of the company is also found to be healthy since the projected inflows can be used to satisfy projected outflows without cash deficits.
- The forecast also demonstrates the time when cash excesses are present, and it could be assumed that these time spans can be used to invest money or reinvest it in business.
- The financial planning of the company seems efficient as the estimated numbers are close to the real historical cash flow trends, and they demonstrate the sound forecasting techniques.
- The overall cash flow performance has shown that the company has financial stability, it can generate cash, pay off liabilities and run its future operations as well.

6.1 Suggestions

- Enhance cash monitoring: The company may also apply the weekly cash flow monitoring or bi-weekly cash flow monitoring to strictly observe the changes and keep a closer control over the cash flows
- Improve the accuracy of the forecast: The company will be able to increase the accuracy of the future cash flow by combining historical sales trends, seasonal trends, and market data to achieve that.
- Establish an emergency cash fund: A buffer fund will assist the company to address unexpected costs or any unexpected cash inflows.
- Optimize the non-essential costs: The company will be able to perform a periodical analysis of overheads and minimize unnecessary expenditures in order to optimize net cash flow.
- Periodical revaluation of financing operations: Although financing activities are stable, it is possible to review financing operations annually and identify more appropriate ways of loans or timeline of repayment.
- Coordinate the departments better: The bilateral communication of the sales, procurement, and finance teams will help to create the appropriate cash flow planning and minimize inconsistencies.

- Implement periodical cash flow variance analysis: It will be beneficial to compare the projected cash flows and actual performances to identify gaps and enhance forecasting approaches.
- Make long-term cash flow predictions: While short-term projections are useful, long-term projections can be useful in planning strategy and making investments.

7.0 Conclusion

An analysis of the projected cash flow statement of SBOF Agrosmart Private Limited. indicates that the company has a well-structured and clear cash management system which is accurate in recording all the inflows and outflows of the operating, investing, and financing activities. The forecasts reveal that operating activities of the company continue to produce high cash flows, which represents the efficiency of its main business processes and sustainable meeting of the cash needs of the company day-to-day.

The analysis of net cash flow also indicates seasonality of the cash flows as some seasons have inflows in the cash flow, as a result of higher sales and receivables collections, and some seasons have outflows related to procurement and operational expenses. Although these have been fluctuating, the company has a good net cash position which means that the company has enough liquidity within the forecast period.

There is no excessive short-term borrowing and payment is on time which show good financial self-discipline. The outflows projected through purchasing of raw materials, salaries, utilities and loan payments are foreseeable and are planned out in order to aid the costly running of the company in terms of finances. The similarity in the projected figures and the trends of past cash flows is a sign that the SBOF Pvt. Ltd. uses sound forecasting methods, which results in proper financial planning. The cash flow performance of the company in general indicates that the company has good liquidity, financial stability and good cash management within the company. The existence of regular cash reserves allows them to reinvest and financial empowerment. By applying the proposed modifications e.g. the increase in forecasting precision, the improvement of digital cash tracking, and the effective application of the additional capital the company will be able to further streamline its cash flow management. Summing up, SBOF Pvt. Ltd. is in the right position to fulfil both its short-term and future commitments and achieve sustainable development in financial growth.

References

1. Chandra, P. (2022). Projects: Planning, analysis, selection, financing, implementation, and review, 10th ed., McGraw-Hill Education (India) Private Limited. ISBN: 978-93-329-0257-2

2. Gupta, S., & Agrawal, G. (2023). Comparative analysis of cash flow statements: A study of Tata Motors Ltd and Maruti Suzuki India Ltd. *IJIRMPs*, 11(1), 1–11. <https://www.ijirmps.org> (Paper ID: 230410; E-ISSN: 2349-7300; License: Creative Commons Attribution-ShareAlike 4.0 International).
3. Hymavathi, C., & Nikhila, K. N. (2021). Cash flow statement analysis. *Dogo Rangsang Research Journal*, 8(14, No. 02), 300–306. ISSN: 2347-7180.
4. Narendra, Y., & Haritha, K. (2022). A study on cash flow analysis in Vital Pvt Ltd, Tada. *International Journal of Research in Engineering and Science (IJRES)*, 10(9), 552–556. www.ijres.org (ISSN Online: 2320-9364; ISSN Print: 2320-9356).
5. Nasreen Begum, S., & Narender, S. (2023). A study on cash flow statements at Kotak Mahindra Bank. *International Journal of Marketing Management*, 11(3), 33–45. www.ijmm.net (ISSN: 2454-5007).
6. Etim, E. O., Daferighe, E. E., Enang, E. R., & Nyong, M. B. (2022). Cash flow management and financial performance of selected listed companies in Nigeria. *Indo-Asian Journal of Finance and Accounting*, 3(1), 27–46. <https://doi.org/10.47509/IAJFA.2022.v03i01.03>
7. Ihenyen, C. J., & Iganran, W. (2023). Management of cash flow and financial success of listed Nigerian oil and gas companies. *Federal University Otuoke Journal of Management Sciences*, 7(1), 95–100.
8. Kasaniak, P., Miroga, J., & Makokha, E. N. (2025). Cash flow management on financial performance of commercial banks in Eldoret City County, Kenya. *International Journal of Recent Research in Commerce Economics and Management (IJRRCEM)*, 12(3), 54–69. <https://doi.org/10.5281/zenodo.17194700> (ISSN: 2349-7807).
9. Maheshwari, A. (2018). Cash flow statements of Punjab National Bank and ICICI Bank: A comparative analysis. *International Journal of Science and Management Studies (IJSMS)*, 1(4), 6–13. www.ijmsjournal.org (E-ISSN: 2581-5946).
10. Mohd Ali, M., Mohamed Ali, K., Bashatweh, A. D., & Hasnan, S. (2022). Historical earnings, accrual accounting, and future cash flows: A Malaysian perspective. *The Economics and Finance Letters*, 9(2), 125–138. <https://doi.org/10.18488/29.v9i2.3056> (ISSN(e): 2312-430X; ISSN(p): 2312-6310).
11. Chandra Mouli, R., & Suganthi, A. (2024). A study on cash flow statement analysis with special reference to Neycer India Limited. *International Journal of Research and Analytical Reviews (IJRAR)*, 11(2), 821–824. www.ijrar.org (E-ISSN: 2348-1269; P-ISSN: 2349-5138).

Table 8: Comparative and Common Size Balance Sheet Comparative Statement

Particulars	SBOF Pvt.Ltd.																	
	Comparitive and Common Size Balance Sheet (in lakhs)																	
	Set 01					Set 02					Set 03					Common Size		
	Comparative				Common Size	Comparative				Common Size	Comparative				Common Size	Common Size		
Years	2023-2024	2024-2025	Abolute	%	2023-2024	2024-2025	2022-2023	2023-2024	Abolute	Percentage	2022-2023	2023-2024	2021-2022	2022-2023	Abolute	%	2021-2022	2022-2023
Liabilities																		
Equity Share Capital	350.00	350.00	-	0%	38%	36%	350.00	350.00	-	0%	40%	38%	350.00	350.00	-	0%	42%	40%
Reserves	202.28	232.62	30.34	15%	22%	24%	175.89	202.28	26.38	15%	20%	22%	152.95	175.89	22.94	15%	18%	20%
Borrowings	211.59	219.00	7.41	4%	23%	23%	204.43	211.59	7.16	4%	23%	23%	197.52	204.43	6.91	4%	24%	23%
Other Liabilities	154.58	166.17	11.59	8%	17%	17%	143.79	154.58	10.78	8%	16%	17%	133.76	143.79	10.03	7%	16%	16%
Total Liabilities	918.45	967.79	49.34	5%	100%	100%	874.12	918.45	44.32	5%	100%	100%	834.23	874.12	39.89	5%	100%	100%
ASSETS																		
Capital Work in Progress	25.63	25.70	0.06	0%	3%	3%	25.57	25.63	0.06	0%	3%	3%	25.50	25.57	0.06	0.25%	3%	3%
Investments	555.60	561.49	5.89	1%	60%	58%	549.77	555.60	5.83	1%	63%	60%	544.01	549.77	5.77	1.06%	65%	63%
Other Assets	339.46	383.59	44.13	13%	37%	40%	300.40	339.46	39.05	13%	34%	37%	265.84	300.40	34.56	13.00%	32%	34%
Total Assets	920.69	970.77	50.08	5%	100%	100%	875.75	920.69	44.94	5%	100%	100%	835.36	875.75	40.39	4.84%	100%	100%

In financial accounting, a comparative statement refers to a financial report that presents financial information for multiple periods side by side (like 2 or more years). This helps in comparing how figures have changed over time. Comparative financial statements show the financial performance of a company over two or more periods.

Common Size Statement: A common size statement in financial accounting is a financial statement it presents financial information as percentages, rather than actual figures. This makes it easier to compare different periods or companies of different sizes. Typically, the base figure used is either total assets for the balance sheet or net sales (revenue) for the income statement. Common size financial statements express each item as a percentage of a base figure.

Table 9: Reserves

Comparative (₹ in lakhs)				
Particular	2024-2025		2023-2024	
Reserves	232.62		202.28	
			175.89	
			152.95	

Figure 6: Reserves

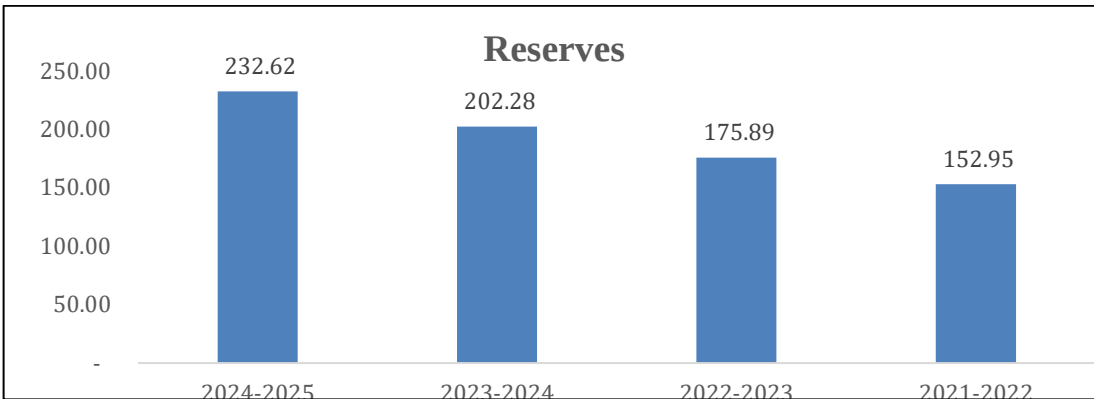


Table 10: Reserves

Common Size (₹ in lakhs)				
Particular	2024-2025	2023-2024	2022-2023	2021-2022
Reserves	24%	22%	20%	18%

Figure 7: Reserves

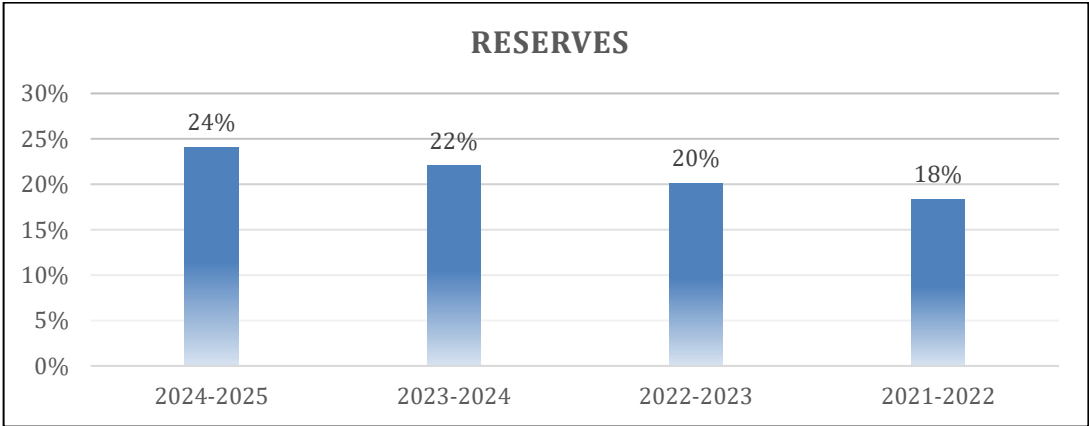


Table 11: Borrowings

Comparative (₹ in lakhs)				
Particular	2024-2025	2023-2024	2022-2023	2021-2022
Borrowings	219.00	211.59	204.43	197.52

Figure 8: Borrowings

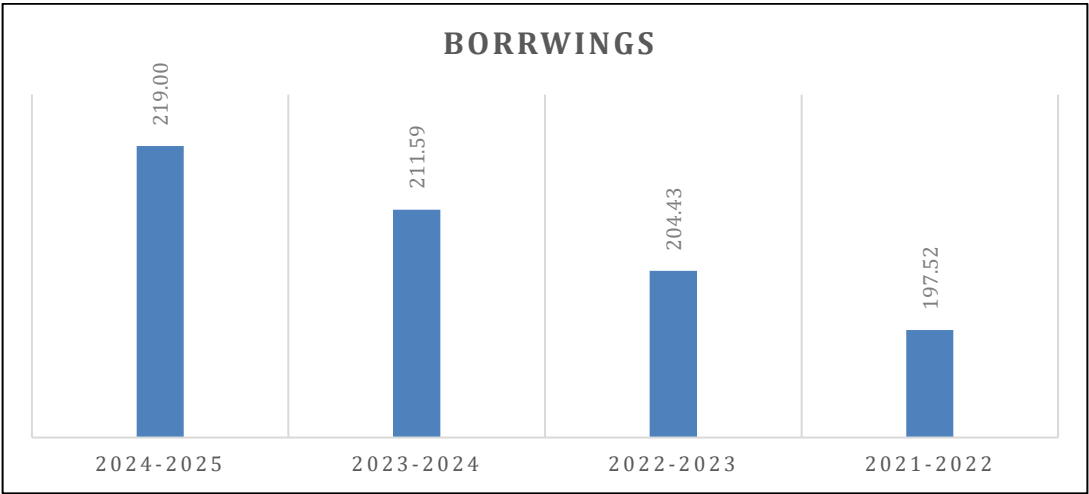


Table 12: Borrowings

Common Size (₹ in lakhs)				
Particular	2024-2025	2023-2024	2022-2023	2021-2022
Borrowings	23%	23%	23%	24%

Figure 9: Borrowings

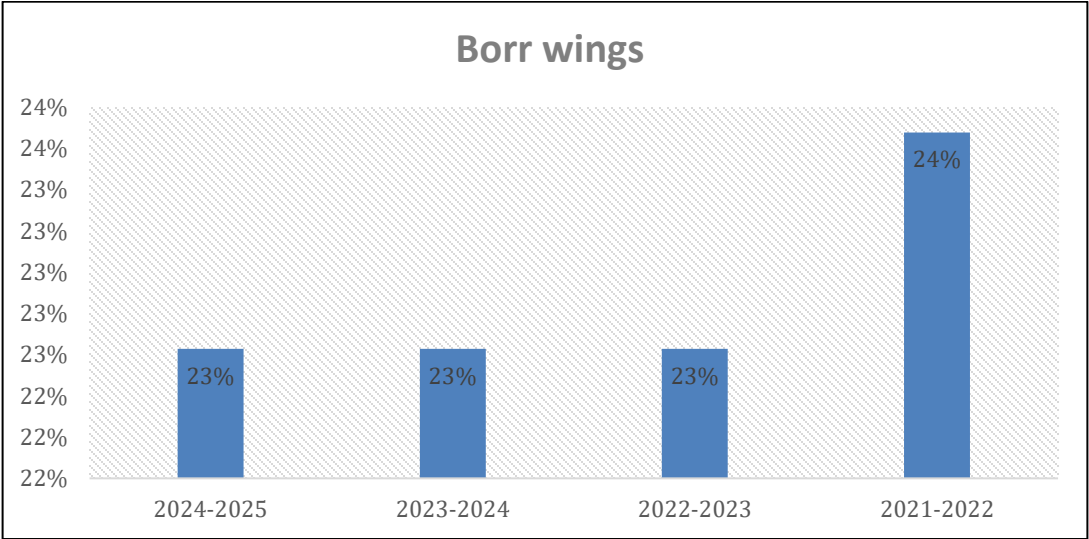


Table 13: Investments

Comparative (₹ in lakhs)				
Particular	2024-2025	2023-2024	2022-2023	2021-2022
Investments	561.49	555.60	549.77	544.01

Figure 10: Investments

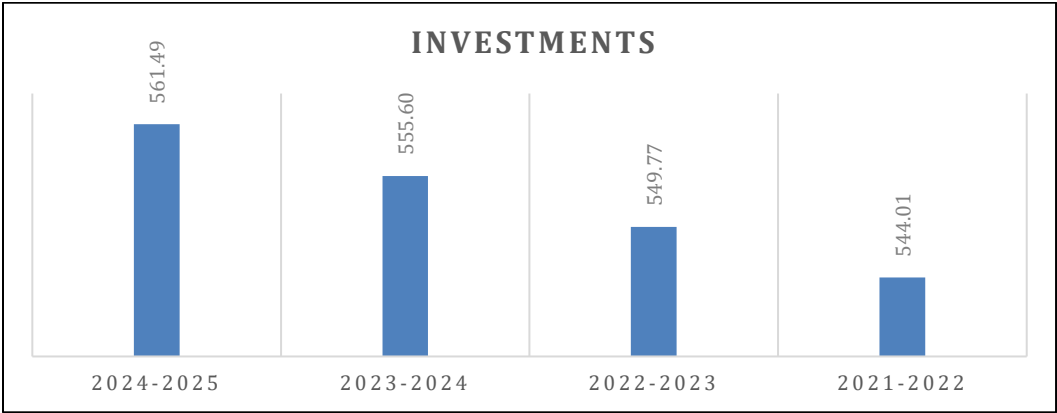
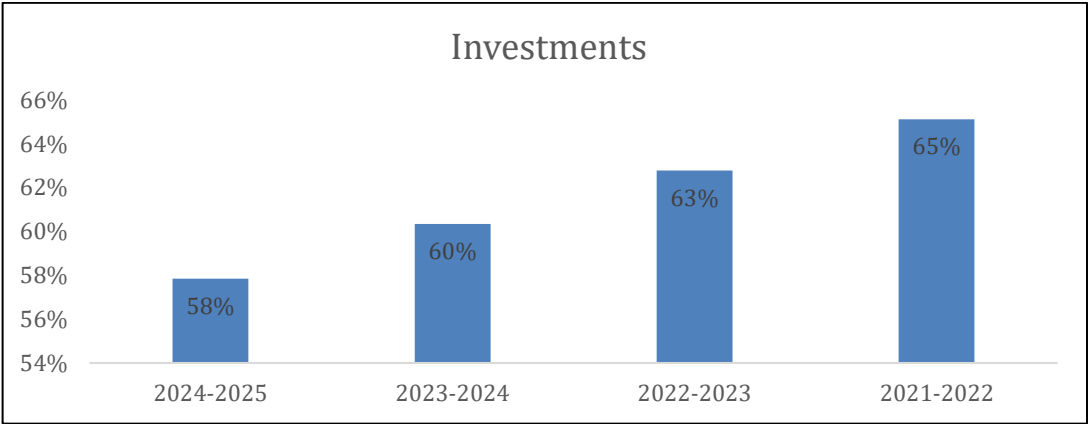


Table 14: Investments

Common Size (₹ in lakhs)				
Particular	2024-2025	2023-2024	2022-2023	2021-2022
Investments	58%	60%	63%	65%

Figure 11: Investment



CHAPTER 12

Bridging Tradition and Technology: AI Applications in Homoeopathic Materia Medica and Repertory Analysis - Narrative review

Shiwani Malai and Apeksha Kanago***

ABSTRACT

The Integration of Artificial Intelligence is transforming Modern Homoeopathic practice by enhancing accuracy, individualization and efficiency in clinical decision making. Homoeopathy relies on detailed case taking, careful observation of body language, extraction of characteristic symptoms, conversion of symptoms into precise rubrics and repertorisation according to Hahnemannian principles. As Repertorisation was introduced in homoeopathic system because of the expanding Materia Medica which is time consuming and complex, therefore the use of AI tools can expedite this process by swiftly analyzing symptom databases to suggesting relevant remedies and differentiating them. The advent of AI and advanced computing technologies in homeopathic medicine is paving the way for a future where traditional repertorisation may become obsolete. Well, its purpose should be to complement the expertise and judgement of well-trained homoeopaths, rather than a replacement for Professional Consultation and Diagnosis. This study provides Systematic overview of integration of AI into homoeopathic practice and assess its impact on patient care. Therefore, AI can quickly go through extensive repertories and prioritize remedies based on symptom similarity and can also assist in remedy relationship. AI homoeopathy integration offers efficiency, evidence-based practice and patient empowerment while following the Holistic principles of Homoeopathy.

Keywords: Homoeopathy; Artificial Intelligence; Repertorisation; Materia Medica; Integration.

1.0 Introduction

Homoeopathy is based on Holistic case taking, individualization, remedy selection on totality of symptoms. Classical Repertorisation emerged to manage expanding Materia medica but remains complex and time-intensive.

**Corresponding author; Assistant Professor, Gynaec and Obs, KLE Homoeopathic Medical College, Belagavi, Karnataka, India (E-mail: shivanism27@gmail.com)*

***Assistant Professor, Pathology, KLE Homoeopathic Medical College, Belagavi, Karnataka, India (E-mail: kanagoapeksha@gmail.com)*

In rapidly evolving healthcare Profession, recent advances in Artificial Intelligence have been offering various tools like machine learning^{2,7,8}, chatbot², NLP^{2,5,8}, Materiomics¹² which is capable of Repertorisation, analysing large symptom data, assisting in rubric formation, differentiating remedies and their relationship, understanding patient's constitution, behavioural patterns, cross referring Materia Medica, philosophical background, to maintain track of history and medical records etc aiding practitioners in evidence-based decision making. The integration of AI into Homoeopathic practice offers an opportunity to bridge traditional wisdom with modern computational tools. This narrative review synthesizes these contemporary studies to evaluate how AI supports Materia Medica understanding and Repertorial analysis, while reviewing the methodologies, strengths and limitations.

AI in Homoeopathy requires more of Empirical studies, but most of the reviewed articles are of conceptual dominance and involves heterogenicity of study designs. Thematic synthesis was done using framework analysis, grouping the findings into six themes by interpreting multiple research study to understand the depth and insights of each individual studies. Future research can be taken with more of clinical evidence-based study along with ethical concerns and larger datasets. Integrating AI with homoeopathy requires more of exploration and awareness of the tools, as to how it's been used how much accuracy, weightage etc is carried considering its strengths and limitations. However, AI can be useful for assisting a practitioner but not replace the Holistic-Healing of the patient's healthcare.

- *Research question:* Does AI Support and Enhance Homoeopathic Materia Medica and Repertory analysis?
- *Aim:* To explore the Application of AI in Homoeopathic Materia Medica and Repertorial analysis by critical review and synthesize existing literature to evaluate its role in enhancing clinical decision-making while preserving the holistic principles of homoeopathy.
- *Objectives:*
 - o To Explore recent developments in AI tools applied to homoeopathic Materia medica and Repertorisation.
 - o To Review the Advantages and Limitations of existing articles of AI assisted tools in homoeopathic practice.

3.0 Methodology

Study design: The purpose of this study is to conduct a narrative review of existing research on use of AI in repertorial analysis and homoeopathic Materia Medica. This approach was undertaken to enable conceptual synthesis and critical interpretation of

heterogenous study designs like analytical review, conceptual review, systematic review, technology-based evaluations.

Data sources: For this research, data was collected from various sources like:

1. PubMed
2. Scopus
3. Google Scholar
4. AYUSH research portal
5. ResearchGate
6. Research Rabbit

Search Strategy: Search terms included: “Artificial Intelligence”, “Machine Learning”, “Materia Medica”, “Repertorisation”, “Natural Language Processing”, “Homoeopathy”. Boolean operators (AND/OR) were applied.

3.1 Inclusion criteria

1. Published articles related to AI and homoeopathy: Review articles, analytical articles and conceptual framework.
2. Articles discussing AI, Machine learning, Chabot or digital tools applied to homoeopathy
3. Articles published in English.

3.2 Exclusion criteria

1. Articles unrelated to homoeopathy.

3.3 Thematic synthesis

Early work emphasizes on Expert Systems and Rule-based Algorithms for Remedy selection, while recent publications focus on machine learning, predictive analytics and conversational AI (e.g. ChatGPT). Most authors agree that AI enhances speed, accuracy and accessibility but cannot replace the physician’s intuition, empathy and individualisation central to Hahnemannian principles

4.0 Thematic Integration of Reviewed Articles

Theme 1: AI as a Supportive Adjunct in Homoeopathic Practice: Several authors consistently emphasize that AI should function as assistant rather than a replacement for the homoeopath. Bishwas et al. highlight that while AI enhances repertorisation, documentation and research efficiency, it lacks the capacity for empathy, intuition and individualization, which remain central to Hahnemannian practice. Ethical discussions across studies reinforce that professional judgement must remain paramount. Drawback is that there isn’t clinical outcome data.

Theme 2: AI in Repertorial Analysis and Remedy Selection: Early algorithm-based models and contemporary machine learning approaches demonstrate AI’s potential in rubric selection and remedy prioritization. Studies indicate that AI can rapidly process large repertories, identify symptom-remedy correlations and reduce manual errors. However, limitations related to data quality and dependence on accurate case input are repeatedly noted i.e limited datasets.

Theme 3: Digital repertories as a foundation for AI Integration: Reviews of repertory software illustrate the transition from manual to digital workflows in homoeopathy. These tools, while not fully autonomous AI systems, form the technological backbone for advanced AI applications with high clinical relevance. Authors report significant gains in efficiency and accessibility, though the interpretative responsibility remains with the clinicians. There is limited discussion of AI algorithms.

Theme 4: Conversational AI and Clinical Decision Support: Recent literature on ChatGPT and conversational AI suggest potential roles in symptom narration analysis, patient education, follow-up documentation and research assistance. While not homoeopathy-specific, these studies provide a conceptual framework for integrating NLP-based tools into homoeopathic case management, with caution regarding accuracy and ethical use.

Theme 5: AI in AYUSH and Sustainable Healthcare Systems: Systematic reviews across AYUSH disciplines position AI as a driver of sustainable healthcare innovation. Homoeopathy benefits from AI through scalable decision-support systems, research automation, and optimized resource utilization, aligning with sustainability and low-cost healthcare models.

Theme 6: Ethical and Philosophical Dimensions of AI in homoeopathy: Philosophical analyses underscore the epistemological limits of AI in healing sciences. Across articles, there is consensus that AI cannot capture the subjective, experiential, and relational dimensions of homoeopathic healing. Ethical frameworks are therefore essential to ensure responsible integration.

Author	Focus area	Methodology	Strengths /contribution	Limitations
Bishwas et al; 2025 ¹	AI homoeopathy: blessing or curse	Analytical review	Comprehensive overview of AI roles in repertorisation, patient management and education.	Dependence on data quality Validation gap: AI application remains experimental and lack robust clinical trials Complex case management: AI struggles with remedy aggravation, potency adjustments and nuanced follow-ups Conceptual, lacks empirical validation

Arya Manisha; 2024 ¹¹	Artificial Intelligence in Homoeopathy- The End or the Beginning?	Comprehensive review	Personalized Treatment plans based on patient symptoms and constitution. Symptom analysis and diagnosis using ML for accuracy Remedy selection with advanced algorithms and large remedy data Patient management Predictive analytics to forecast disease outbreaks and health trends Telemedicine and chatbots for remote guidance and patient education.	Validation gap: AI application remain experimental and lack robust clinical trials Ethical and professional concerns: patient privacy, data security and clinical responsibility. Conceptual, lacks empirical validation
Sai Lavanya Katari; 2025 ¹⁰	An Overview of Repertory Software Tools for Clinical Repertorisation in Homeopathy	Comprehensive	The article reviews repertory software tools used in clinical homoeopathy. Digital tools like RADAR Opus, Hompath Zomeo, MacRepertory, Complete Dynamics, ISIS, Vision, Cara etc. have transformed practice. These programs integrate multiple repertories, Materia medica, patient record, remedy comparison tools and analytical features. The study evaluated 50 different software tools, categorising them by functionality, repertory content, usability and target users. Findings show that digital repertory tools improve accuracy, speed and efficiency in case analysis, support education and enhance patient care. These tools are meant to assist practitioners not to replace to replace their expertise.	Dependence on software quality: accuracy varies depending on the repertory database and algorithms used. Some tools are complex and require significant training before use. Some of advanced software and tools can be expensive, limiting for access. Practitioners may depend too much, overlooking subtle patient cues. Outdated tools, not updated reducing their clinical relevance.
Doherty Rachel; 2025 ³	The application of AI in acute prescribing in homoeopathy	A comparative Retrospective study.	100 acute cases from a homoeopathy teaching clinic were analysed through an online available remedy finder. Researchers compared AI recommendation with practitioner-prescribed remedies. Data included symptoms, remedies, posology. AI tool covered 74 acute complaints; clinic cases represented 22 of these. Remedy overlap: Practitioner remedy appeared in AI results in 59% of cases. 37% it was among the top 3 suggestions. 17%, was top recommendation.	Low match rates: influenza (0%) AI tools lacked guidance on managing remedy response (e.g aggravations, potency) Can assist with acute, self-limiting complaints, but struggle with complex case management. AI tools may be risky and misused, especially with chronic or serious conditions. Reliance on case notes, small sample size, variability in complaints.

			High match rates: COVID-19(80%), ear infection (80%), kidney stones, nausea of pregnancy, sprains (100%)	Limited accuracy Weak case management, no guidance on remedy response, potency adjustments or handling aggravations.
Patil Aditya; 2025 ⁴	“Comparative Evaluation of Diagnostic and Treatment Accuracy: A Five-Level Scale Analysis of Generative AI and Homoeopathic Approaches”:	conceptual/ comparative study	Developed a five level evaluation scale level 1=poor, level 5=excellent) Comparative analysis General diagnostic: (fair-good) level 2-3. Standardized but less personalized; Generative AI: (level 1-5) Basic models weak (symptoms matching only) Advanced models strong (integrating genetics, lifestyle, clinical data). Homoeopathy: expert practitioner at level 4-5 with individualized, holistic care. Evaluates both technology (AI) and traditional (homoeopathy) Highlights Personalization whether via AI or homoeopathy. Suggests hybrid models integrating AI precision and Holistic approaches. Encourages collaboration between data scientists and homoeopaths for integrative healthcare innovation.	Non peer reviewed, findings are preliminary and needs empirical validation. Relies on descriptive rather than quantitative clinical trials. Focuses on diagnostic/ treatment accuracy but does not address cost-effectiveness or scalability in healthcare system.
Parajiya Tilak; 2022 ⁵	A Survey on Applications of AI in Homeopathy	Literature survey.	The article mentions some of applications of AI in homoeopathy: Expert systems: AI that replicate expert decision making. Remedy selection: - Fuzzy Expert systems: effective in handling unstructured patient data. - Decision Trees: less accurate compared to fuzzy systems. Glaucoma treatment (SEHO): Is an AI-powered expert system that helps homoeopaths and ophthalmologists select remedies for glaucoma by systematically analysing patient data and offering transparent, evidence-based recommendations. Expert System Development Uses Expert system development lifecycle (ESDLC): Assessment knowledge acquisition, design, testing, documentation, record maintenance.	Limited clinical trials Some conclusions are broad and not supported by detailed case studies or statistics. Even though The article focuses on Expert systems and fuzzy logic, it lacks to give insights on newer AI methods and its application (e.g. NLP)

D. Akhila; 2023 ²	“Homoeopathic Chatbot: A Simplified and Accurate Case-Receiving and Repertorising Application”:	Conceptual Study	Chatbots collect detailed complaints by NLP and ML to stimulate human interaction and provide precise symptom mapping. It is affordable, user friendly, scalable, and capable of collecting accurate patient data. Minimizes repetitive manual entry of Rubrics. Provides a judgement free environment where patients can disclose without any hesitation.	Chatbot is currently limited to “HEAD” chapter of BBCR. It doesn’t include clinical trials or patient outcome data. Uses Google firebase cloud storage, which may raise concerns about scalability, privacy.
Muthuperumal Prakash; 2024 ⁷	Status of artificial intelligence and machine learning in Indian traditional medicine systems.	A systematic review	This article aims at analysing how AI/ML have been applied in Ayush system. 54 studies were reviewed out of which majority i.e 36 studies were from India. Use of AI/ML shows >95% accuracy in tasks like drug identification, diagnosis, treatment support, personalized medicine.	Very limited study on homoeopathy. The research has no unified framework or large-scale clinical validation. Very limited datasets.
Mukta Nivedita Bera; 2025 ⁸	Homoeopathy meets Machine learning	Systematic review	Intersection of Homoeopathy and AI explores how ML techniques can be applied to homoeopathic practice, research and clinical decision making. ML can identify subtle symptoms pattern, supporting individualised remedy selection. It highlights Evidence Mapping where AI has been applied in homoeopathy (e.g. Expert systems, NLP, predictive modelling)	Lacks large, standardized and high-quality datasets, limiting ML model validation. ML models can be “Black Boxes” making it difficult to align outputs with homoeopathic principles. Ethical concerns.
Bhadoria Suraj; 2021 ⁹	‘Standardization of Homoeopathic Drugs’ by various tools	Systematic Review	The author analysed 25 studies published from Google Scholar between 2010-2021. On standardization of drugs using various analytical tools (like UV- Visible Spectroscopy, HPTLC, TLC etc.) it helped in assessing physiochemical properties, phytoconstituents, nanoparticles, molecular and structural changes in drugs including high dilutions. Tabulated form helped in comparison, clarity, readability of data. Emphasizes the importance of standardization.	Articles were collected only from Google Scholar. No PRISMA flow diagram. Limited clinical co-relation.

5.0 Discussion

Across the articles, AI is presented as a transformative tool for homoeopathy. Applications include chatbots for case taking, expert systems (like SEHO) for specific conditions, fuzzy logic and machine learning for remedy selection and digital repertory software for faster analysis. Coming to efficiency and accessibility AI systems and chatbots can save time, reduce workload and make homoeopathy more accessible. Expert systems and repertory software provide structured, consistent analysis, reducing practitioner bias. AI can help in record keeping, process large datasets and map symptoms systematically, improving remedy selection accuracy in straightforward cases. A recurring theme is that AI should support, not replace practitioners. The best outcomes emerge when AI handles preliminary data processing and repertory mapping while human practitioners provide final interpretation, empathy and nuanced judgement.

6.0 Limitations

1. Lack of randomized clinical trials in AI-assisted homoeopathy. There is no data quality dependence, no precise patient inputs given.
2. Predominance of conceptual and review-based literature.
3. Limited personalization, AI struggles to capture subtle, individualized symptoms that only experienced homoeopath notices. True personalization remains a human strength.
4. Current AI tools cannot manage remedy aggravations, potency adjustments or long-term case evolution.
5. Lack of robust clinical trials or standardization.
6. Loss of human touch: empathy, intuition etc cannot be replicated by machines
7. Proprietary software can be expensive
8. Patients or practitioners may depend too much on AI, potentially overlooking critical human judgement.
9. Ethical and privacy concerns, patient's data security and trust in automated systems are ongoing challenges.

7.0 Future Scope

Future scope should focus on:

1. Integration of AI with classical case-taking methods.
2. Development of validated AI models trained on authentic homoeopathic data.
3. Prospective clinical trials assessing patient outcome.
4. Ethical frameworks and regulatory guidelines for AI use I homoeopathy.

8.0 Conclusions

The Narrative synthesis indicates that AI serves as a powerful adjunct in homoeopathic Materia Medica and Repertorial analysis by improving efficiency, accuracy and educational outreach. However, AI cannot replace the holistic perception, empathy and clinical intuition of a trained homoeopath. Future research should focus on ethically designed, evidence-based clinical studies integrating AI while preserving homoeopathy's philosophical foundations.

References

1. Bishwas R, Shatru A, Dewansh DK, Srivastava SK, Bhutt D, Biswas R. Artificial intelligence in homoeopathy: A curse or blessing, AI can help the homoeopath, but it cannot replace – an analytical review. *Glob J Clin Med Med Res.* 2025;3(10):25–29. doi:10.5281/zenodo.17383629.
2. Akhila D, Anita SP, Sunita SD. a simplified and accurate case-receiving and repertorising application. *Indian J Psychol.* 2023;Book No.11:22.
3. Doherty R, Pracjek P, Luketic CD, Straiges D, Gray AC. The application of artificial intelligence in acute prescribing in homeopathy: a comparative retrospective study. *Healthcare (Basel).* 2025;13:1923. doi:10.3390/healthcare13151923.
4. Patil AD, Singh SR. Comparative evaluation of diagnostic and treatment accuracy: a five-level scale analysis of generative AI and homoeopathic approaches. *Preprints.org*; 2025 May 15. doi:10.20944/preprints202505.1204.v1.
5. Parajiya T, Farkunde T, Popat MK. A survey on applications of AI in homeopathy. *Int J Adv Res Sci Commun Technol.* 2022;2(3):275. doi:10.48175/568.
6. Singh SR, Patil AD. Bridging the gap between artificial intelligence and ancestral intelligence in conventional medicine and homoeopathy. *Indian J Integrated Medicine.* 2024;4(2):66. Vol 4 | Issue 2 | Apr - Jun 2024
7. Muthuperumal P, Karmegama D, Mappillairaju B. Status of artificial intelligence and machine learning in Indian traditional medicine systems: a systematic review. *J Med Pharm Chem Res.* 2024;6:1173–1187. doi:10.48309/JMPCR.2024.443836.1119.
8. Bera MN, Gupta A. Homoeopathy meets machine learning: a systematic review of pattern recognition in patient constitutional types. *Int J Homoeopath Sci.* 2025;9(1):195–199. doi:10.33545/26164485.2025.v9.i1c.1355.
9. Bhadoria SS, Patel S, Desai P. A systemic review on ‘Standardization of Homoeopathic Drugs’ by various tools. *Int J All Res Education Sci Methods.* 2021;9(11):881–82.

10. Katari Lavanya Sai, Kratika, Bhadoria SS. An overview of repertory software tools for clinical repertorisation in homeopathy. J Evid Based Homeopath [Internet]. 2025 [cited 2026 Jan 5];3(1):12-4. Available from: doi:10.5281/zenodo.17346078.
11. Arya M, Sharma DB, Aphale P, Shekhar H, Dokania S. Artificial Intelligence in Homoeopathy- The End or the Beginning? Afr J Biomed Res [Internet]. 2024 Nov [cited 2026 Jan 5];27(45):4409-13. Available from: doi.org
12. Nambisan, N. (2025, July 18). A new approach to repertorization leveraging artificial intelligence: Materiazation or materiomics. Hpathy.com. <https://hpathy.com/homeopathy-repertory/a-new-approach-to-repertorization-leveraging-artificial-intelligence-materiazation-or-materiomics/>
13. Hahnemann S. Organon of Medicine.6th ed. New Delhi: Indian Books and periodicals publishers; 2001.
14. Farrington EA. Farringtons Lectures on clinical materiamedica. Reprintedition. B Jain Publishers;2003;2004
15. Boericke W. Pocket manual of homeopathic Materia medica & repertory. 9th ed. New Delhi: B. Jain Publishers; 2001.
16. Kent JT. Repertory of the homeopathic Materia medica. 6th ed. New Delhi: B. Jain Publishers; 2004.

CHAPTER 13

Leveraging Artificial Intelligence to Support SDG 4

*Sonal Revankar**

ABSTRACT

This paper examines the transformative role of artificial intelligence (AI) in leveraging education, particularly with respect to the United Nations' Sustainable Development Goal 4 (SDG 4), which aims to ensure inclusive and equitable quality education for all by 2030. It highlights the potential of Artificial intelligence (AI) to dismantle barriers that inhibit access to quality education due to economic, geographic, and social disparities. By utilizing advanced technologies, such as natural language processing and machine learning, AI enhances personalized learning experiences and improves educational accessibility for diverse student groups across the globe. Furthermore, the study analyzes the implications of AI-driven educational innovations, addressing both the opportunities and challenges they present in achieving Sustainable Development Goal 4 of UNESCO. This exploration underscores the necessity of integrating AI in educational frameworks to foster an inclusive learning environment that promotes equity and quality in education worldwide. The paper also covers the challenges and ethical considerations involved with the development of AI.

Keywords: SDG4; Artificial Intelligence; Sustainability.

1.0 Introduction

Education is a tool that liberates the intellectual and imagination process. Accessibility to Education is a factor for economic development as it enables everyone to make positive contribution to a healthy and functioning economy. It also provides wealth of knowledge and greater opportunities for success. With the advancement of artificial intelligence there is a breakthrough transformation in education system. Traditional systems of education are being replaced by modern and integrated systems of education. Artificial Intelligence has led to a major disruption in the education system. It has paved way for more individualized and adaptable learning by enhancing the accessibility of education across various student groups with diverse needs.

**Corresponding author; Assistant Professor, Management Department, Government First Grade College, Khanapur, Uttar Kannada, Karnataka, India (E-mail: drsonalrevankar@gmail.com)*

AI has opened the doors for opportunities and challenges and has the potential to completely transform our education system. Hence there is a scope to examine the role of artificial intelligence towards achievement of sustainable Development Goal 4 of UNESCO. The main purpose of SDG 4 i.e., Sustainable Development Goal of the United Nations is to ensure inclusive and equitable quality education for all by 2030. Education is one of the global fundamental rights, yet millions of students lack access to quality education due to disparities in economy, location, gender, disabilities etc. This paper analyses the role played by AI in shaping the education system especially with reference to Sustainable Development Goal 4.

2.0 Artificial Intelligence and Sustainable Development Goal 4

Artificial intelligence (AI) refers to the development of computer systems capable of performing tasks that typically require human intelligence. These tasks include: Learning and problem-solving, Visual perception and speech recognition, Decision-making and language translation, Reasoning and planning. AI systems use algorithms, machine learning, and deep learning techniques to process large amounts of data, identify patterns, and make predictions or decisions. The field of AI encompasses various subfields, such as: Machine Learning: Algorithms that improve their performance through experience, Natural Language Processing: Enabling computers to understand and generate human language, Computer Vision: Allowing machines to interpret and analyze visual information, Robotics: Designing and programming machines to perform physical tasks.

AI applications are increasingly prevalent in various industries, including healthcare, finance, transportation, and entertainment. As the technology continues to advance, it has the potential to revolutionize many aspects of human life and work. Sustainable Development Goal (SDG) 4 aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all by 2030. This goal emphasizes the importance of providing equal access to education for all, particularly marginalized groups, to foster a more inclusive society. Achieving SDG 4 requires concerted efforts at both international and national levels to address barriers and create inclusive educational environments for all learners, especially those from vulnerable populations.

To effectively implement SDG 4, it is crucial to recognize that inclusive education extends beyond mere access; it also encompasses the quality of educational experiences provided to all students. This involves not only adapting curricula to meet diverse learning needs but also ensuring that teaching methods are inclusive and supportive of students with disabilities and other vulnerabilities. For instance, recent research highlights the importance of utilizing technology and innovative pedagogical strategies to create accessible learning environments that foster engagement and participation among all learners, particularly those

facing health challenges (Argyriadi et al., 2024) (Ceresnova et.al., 2017) Furthermore, systematic evaluations of existing educational policies are necessary to identify gaps and barriers that persist, thereby facilitating targeted interventions that can enhance educational equity and promote lifelong learning in accordance with the aspirations outlined in SDG 4 (Vindigni, 2024).

3.0 Role of Artificial Intelligence in achieving Sustainable Development Goal 4

AI applications help advance SDG 4 by addressing key challenges in education:

- **Personalized Learning:** AI-powered systems can analyze a student's learning patterns, strengths, and weaknesses to create a customized curriculum. This allows students to progress at their own pace, ensuring they fully grasp concepts before moving on. This is especially beneficial for students who may fall behind in a traditional classroom setting.
- **Enhanced Accessibility and Equity:** AI can help bridge the gap in education by providing access to high-quality resources for students in remote or underserved areas. AI tools can offer multimodal language support, like real-time translation and transcription, making content more accessible for students with diverse linguistic backgrounds or disabilities.
- **Teacher Support and Efficiency:** AI can automate time-consuming administrative tasks, such as grading quizzes and managing student records. This frees up teachers to focus on more meaningful interactions, providing personalized guidance and fostering deeper engagement with students.
- **Data-Driven Insights:** AI can analyze educational data to identify students at risk of falling behind or dropping out. This allows educators to intervene with timely and targeted support, improving student outcomes and reducing inequalities.
- **Lifelong Learning and Skill Development:** AI platforms can provide flexible, on-demand learning opportunities for adults and professionals, offering courses and resources to help them acquire new skills and adapt to a changing job market.

4.0 Challenges and Ethical Considerations

While AI offers immense potential, its implementation in education also comes with challenges that must be addressed to ensure its sustainable and equitable use:

- **The Digital Divide:** Without adequate investment in digital infrastructure and resources, particularly in developing regions, AI-driven education could exacerbate existing inequalities. Students without access to reliable internet, devices, and digital literacy training will be left behind.

- **Bias in Algorithms:** AI models are trained on data, and if that data is biased, the algorithms can perpetuate or even amplify existing social and cultural biases. This can lead to unfair or discriminatory outcomes, such as reinforcing stereotypes or providing inadequate support to certain student groups.
- **Data Privacy and Security:** The use of AI in education involves collecting vast amounts of student data, raising significant concerns about privacy and security. Robust policies and safeguards are essential to protect sensitive information from misuse or breaches.
- **Over-reliance and Dehumanization:** Over-reliance on AI could diminish critical thinking and problem-solving skills in students. It could also lead to a more isolated learning experience, as the technology cannot replicate the empathy and personal connection provided by human educators.

5.0 Conclusion

In conclusion, the integration of artificial intelligence in education holds significant promise for advancing the United Nations' Sustainable Development Goal 4 by enhancing accessibility, personalizing learning experiences, and supporting educators. However, to fully realize this potential, it is imperative to address the accompanying challenges, such as the digital divide and algorithmic bias, ensuring that AI serves as a tool for equity and inclusion in education for all.

References

1. Argyriadis, A., & Efstratopoulou, M. (2024). Caring for Mental Health of Vulnerable Minds. *Advances in Educational Marketing, Administration, and Leadership Book Series*. <https://doi.org/10.4018/979-8-3693-5325-7.ch006>
2. Camilleri, V., Dingli, A., & Montebello, M. (2019). *AI in education - a practical guide for teachers and young people*. <https://www.um.edu.mt/library/oar/handle/123456789/48256>
3. Motlagh, M. & Bonn Alliance for Sustainability Research. (2021). *Digitainable Thinkathon Digest*. https://www.bonnalliance-icb.de/wp-content/uploads/Thinkathon-digest_SDG-4.pdf
4. Nyhan, M., National University of Ireland - University College Cork, Marshall, K., & Microsoft Ireland. (2024). The ethical application of generative artificial intelligence in supporting education for sustainable development globally. In *Science-Policy Brief for the Multistakeholder Forum on Science, Technology and Innovation for the SDGs*. <https://sdgs.un.org/sites/default/files/2024->

5. Tahir, N. M., Hassan, N. F. D., & Shagoo, N. M. R. (2024). Role of artificial intelligence in education: A conceptual review. *World Journal of Advanced Research and Reviews*, 22(1), 1469–1475. <https://doi.org/10.30574/wjarr.2024.22.1.1217>
6. Vindigni, G. (2024). Overcoming Barriers to Inclusive and Equitable Education: A Systematic Review Towards Achieving Sustainable Development Goal 4 (SDG 4). [https://doi.org/10.59324/ejahss.2024.1\(5\).01](https://doi.org/10.59324/ejahss.2024.1(5).01)
7. <https://www.unesco.org/en/digital-education/artificial-intelligence>
8. <https://www.turnthebus.org/blog/how-can-artificial-intelligence-help-reach-the-sdg-for-education>
9. <https://ai-for-sdgs.academy/>
10. <https://unglobalcompact.org/compactjournal/artificial-intelligence-and-sustainable-development-goals-operationalizing>

CHAPTER 14

A Study on Implementation of CAPM on Nifty 50 Stocks

*Tanushree Sampgaonkar**

ABSTRACT

The Capital Asset Pricing Model (CAPM) is a fundamental financial model that explains the relationship between expected return and systematic risk of securities. It provides a theoretical framework for pricing risky assets by linking their expected returns to market risk, measured through beta. The NIFTY 50 index, representing the performance of 50 large-cap companies listed on the National Stock Exchange (NSE) of India, serves as a key benchmark for the Indian equity market. This study examines the implementation and applicability of the CAPM on selected NIFTY 50 stocks to analyze their risk–return dynamics and market valuation. The primary objectives of the study are to evaluate the effectiveness of CAPM in explaining the expected returns of NIFTY 50 stocks and to determine whether those stocks are undervalued or overvalued by comparing CAPM-based expected returns with actual market returns. The study also aims to assess the degree of systematic risk associated with the selected stocks. The research methodology is based on secondary data collected from reliable sources such as the National Stock Exchange, published financial databases, and official market reports. Monthly returns of selected NIFTY 50 stocks, NIFTY 50 index returns, and risk-free rates are used to estimate beta coefficients and expected returns under the CAPM framework. Statistical and comparative analyses are employed to interpret the results. The expected outcomes of the study suggest that CAPM provides meaningful insights into the risk–return relationship of NIFTY 50 stocks. The findings are anticipated to indicate whether the selected stocks are undervalued or overvalued, thereby offering practical implications for investors, portfolio managers, and academicians in portfolio selection and investment decision-making.

Keywords: Capital Asset Pricing Model (CAPM); NIFTY 50; Systematic Risk; Beta; Expected Return; Stock Valuation; Indian Stock Market.

1.0 Introduction

A Study on Implementation of CAPM on NIFTY 50 Stocks is an analytical and empirical research work that focuses on applying the Capital Asset Pricing Model (CAPM)

**MBA Finance, Chetan Business School, Hubballi, Karnataka, India
(E-mail: tanushreesampgaonkar@gmail.com)*

to selected companies listed under the NIFTY 50 index in order to examine the relationship between risk and return and to evaluate whether the returns generated by these stocks are in alignment with the theoretical expectations proposed by CAPM, which states that the expected return on a security is directly proportional to its systematic risk as measured by beta, and that investors are compensated only for market-related risk and not for unsystematic risk, which can be diversified away, making this study highly relevant in the context of modern portfolio theory and investment decision-making in the Indian capital market.

The study derives its importance from the fact that NIFTY 50 is India's benchmark index representing the top fifty large-capitalization companies across various sectors such as banking, information technology, pharmaceuticals, energy, FMCG, and manufacturing, thereby reflecting the overall performance and sentiment of the Indian stock market, and by implementing CAPM on these stocks, the research attempts to provide insights into how efficiently the Indian equity market prices risk and whether the theoretical assumptions of CAPM hold true in real market conditions characterized by volatility, macroeconomic changes, policy interventions, and investor behavior.

The title "A Study on Implementation of CAPM on NIFTY 50 Stocks" is carefully structured to communicate the scope, methodology, and relevance of the research, where the phrase "A Study" signifies a systematic, structured, and scholarly investigation, the term "Implementation" highlights the practical application of a financial model rather than a purely conceptual discussion, "CAPM" indicates the use of a widely accepted and foundational asset pricing model in finance, and "NIFTY 50 Stocks" specifies the sample universe and ensures that the findings are grounded in a credible, diversified, and representative market index, making the title appropriate for MBA finance projects, postgraduate dissertations, and academic research papers.

The primary objective of the study is to calculate the expected return of selected NIFTY 50 stocks using the CAPM formula and compare it with the actual return earned by these stocks over a specific period, thereby identifying whether the stocks are undervalued, overvalued, or fairly valued, while secondary objectives include measuring the beta of each stock, understanding the impact of market movements on individual stock returns, analyzing the risk-return trade-off, and providing investment insights based on CAPM scores.

The study is generally based on a secondary data research design, where historical stock price data of selected NIFTY 50 companies is collected from reliable sources such as NSE, Yahoo Finance, or financial databases, market return is calculated using NIFTY 50 index values, and the risk-free rate is obtained from government treasury bills or RBI-notified instruments, ensuring data reliability and consistency, while tools such as Excel, SPSS, or Power BI may be used for calculation and visualization purposes.

The Capital Asset Pricing Model forms the theoretical backbone of the study and is expressed through the formula Expected Return of a Stock equals Risk-Free Rate plus Beta multiplied by the difference between Market Return and Risk-Free Rate, where the risk-free rate represents the minimum guaranteed return available to investors, beta measures the sensitivity of a stock's return to market movements, and market return represents the overall return of the market index, and through this formula, CAPM establishes a linear relationship between expected return and systematic risk, emphasizing that higher risk should be compensated with higher expected returns.

Beta plays a crucial role in the study as it quantifies the level of systematic risk associated with each NIFTY 50 stock, where a beta greater than one indicates that the stock is more volatile than the market, a beta equal to one suggests that the stock moves in line with the market, a beta less than one implies lower volatility, and a negative beta indicates an inverse relationship with market movements, thereby allowing investors to classify stocks based on risk profile and align them with their risk tolerance and investment objectives.

The concept of the CAPM score or performance measure is central to the analysis, as it is calculated by comparing the actual return of a stock with its expected return derived from CAPM, and this difference serves as an indicator of valuation efficiency, where a positive CAPM score implies that the actual return exceeds the expected return, suggesting that the stock is undervalued and may offer buying opportunities, a negative CAPM score indicates that the actual return is lower than the expected return, suggesting overvaluation and potential selling or avoidance decisions, and a score close to zero reflects fair valuation, indicating that the stock is correctly priced according to market risk.

The study further evaluates how CAPM scores can be used as a decision-making tool for investors and portfolio managers by enabling them to identify stocks that provide superior risk-adjusted returns, optimize portfolio allocation, and manage exposure to market risk, while also highlighting the importance of diversification in reducing unsystematic risk, which CAPM assumes can be eliminated through proper portfolio construction.

From an academic perspective, the study contributes to existing finance literature by testing the applicability of CAPM in the Indian stock market context, which is often characterized by information asymmetry, regulatory changes, liquidity constraints, and behavioral biases, and by analyzing NIFTY 50 stocks, the research provides empirical evidence on whether CAPM assumptions such as efficient markets, rational investors, and homogeneous expectations hold true in a developing economy like India.

The findings of such a study typically reveal that while CAPM provides a useful framework for understanding the risk-return relationship, there may be deviations between expected and actual returns due to factors such as company-specific events, macroeconomic

shocks, interest rate changes, inflation, and investor sentiment, indicating that CAPM should be used as a guiding model rather than a definitive predictor of returns.

The practical implications of the study are significant, as it assists investors in identifying mispriced stocks, supports informed investment decisions, enhances portfolio performance evaluation, and aids financial analysts in risk assessment, while also helping academicians and students understand the real-world application of financial theories.

However, the study also acknowledges certain limitations, including reliance on historical data, assumption of market efficiency, exclusion of behavioral and macroeconomic variables, and sensitivity of results to the chosen time period, which may affect the generalizability of findings and suggest scope for future research using multi-factor models such as APT or Fama-French models.

A Study on Implementation of CAPM on NIFTY 50 Stocks provides a comprehensive analysis of how systematic risk influences stock returns in the Indian equity market, demonstrates the relevance and limitations of CAPM in practical investment analysis, and reinforces the importance of risk-adjusted performance evaluation in achieving optimal investment outcomes, making it a valuable contribution to finance education, research, and professional practice.

2.0 About CAPM

The Capital Asset Pricing Model (CAPM) is a quantitative financial model that is empirically applied using historical market data to estimate the expected return of securities based on their exposure to systematic market risk. In practical studies such as the implementation of CAPM on NIFTY 50 stocks, the model relies on secondary data including historical stock prices, market index values, and risk-free interest rates to compute returns and risk measures. The expected return under CAPM is calculated using the formula $\text{Expected Return} = \text{Risk-Free Rate} + \text{Beta} \times (\text{Market Return} - \text{Risk-Free Rate})$, where the risk-free rate is usually represented by Indian government treasury bills or RBI-notified securities, the market return is derived from NIFTY 50 index returns, and beta is estimated through regression analysis between individual stock returns and market returns.

From a data perspective, stock returns are calculated using periodic price changes, typically on a daily, monthly, or yearly basis, while market returns are computed using corresponding NIFTY 50 index values over the same time period to ensure consistency. Beta, which is the most critical variable in CAPM, is derived by measuring the covariance between stock returns and market returns divided by the variance of market returns, thereby indicating how sensitive a particular NIFTY 50 stock is to overall market movements. A beta value greater than one indicates that the stock is more volatile than the market, whereas a beta less

than one suggests lower volatility, and this beta coefficient directly influences the expected return calculated under CAPM.

When CAPM is applied to actual NIFTY 50 data, the expected return obtained from the model is compared with the actual return earned by the stock during the study period, and the difference between these two values forms the basis for evaluating stock performance. If the actual return exceeds the CAPM-expected return, the stock is considered undervalued according to the model, indicating that the investor is receiving higher returns for the level of systematic risk undertaken. Conversely, if the actual return is lower than the expected return, the stock is regarded as overvalued, suggesting inefficient pricing or lower compensation for risk. If both values are approximately equal, the stock is considered fairly valued.

Data-based CAPM analysis of NIFTY 50 stocks often reveals variation in expected returns across sectors due to differences in beta values, as cyclical sectors such as banking, automobiles, and metals typically exhibit higher beta values and higher expected returns, while defensive sectors like FMCG and pharmaceuticals show lower beta values and more stable expected returns. This sector-wise behavior highlights the importance of market sensitivity in CAPM calculations and demonstrates how beta reflects underlying economic and business risk captured through historical data.

Empirical results based on real market data also show that while CAPM effectively explains a portion of return variability through systematic risk, actual stock returns are influenced by additional factors such as company-specific news, macroeconomic conditions, interest rate changes, inflation, and investor sentiment, which are not directly captured by the model. As a result, deviations between actual and expected returns are commonly observed in CAPM-based studies using NIFTY 50 data, especially during periods of high market volatility. Overall, when evaluated using historical stock and index data, CAPM serves as a practical benchmark model that links risk and return in a measurable manner, supports valuation analysis, and aids investment decision-making, even though its explanatory power may be limited in capturing all real-world market dynamics. Thus, data-driven implementation of CAPM on NIFTY 50 stocks demonstrates both the usefulness and the limitations of the model in the Indian equity market.

3.0 Literature Review

Sharpe, W. F.

Title: Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk

Year: 1964

About: This study introduced the Capital Asset Pricing Model (CAPM) and explained the relationship between expected return and systematic risk measured by beta, forming the theoretical foundation for asset pricing studies.

Lintner, J.

Title: The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios

Year: 1965

About: Lintner validated CAPM by confirming that higher systematic risk leads to higher expected returns, supporting the use of beta as a key risk indicator.

Fama, E. F. & French, K. R.

Title: The Cross-Section of Expected Stock Returns

Year: 1992

About: This study criticized CAPM's ability to fully explain stock returns and suggested that factors beyond beta influence returns, highlighting limitations of CAPM.

Bhattacharya, B. & Mukherjee, J.

Title: An Empirical Study of the Capital Asset Pricing Model in India

Year: 2002

About: The authors tested CAPM in the Indian market and found mixed results, indicating partial applicability of CAPM due to market inefficiencies.

Rao, K. S. & Kumar, R.

Title: Risk and Return Analysis of Indian Equity Market Using CAPM

Year: 2010

About: This study applied CAPM to Indian stocks and concluded that beta explains returns to some extent but not completely, suggesting CAPM as a benchmark model.

Srivastava, A. & Mishra, P.

Title: Testing the Validity of CAPM in the Indian Stock Market

Year: 2018

About: The study found that CAPM works moderately well for NIFTY-based stocks but recommended additional factors for better return prediction.

4.0 Objective

To determine whether selected NIFTY 50 stocks are overvalued or undervalued by comparing their actual returns with the expected returns calculated using the Capital Asset Pricing Model (CAPM).

Explanation

- If Actual Return $>$ CAPM Expected Return $\rightarrow$ Stock is Undervalued
- If Actual Return $<$ CAPM Expected Return $\rightarrow$ Stock is Overvalued
- If Actual Return $\approx$ CAPM Expected Return $\rightarrow$ Stock is Fairly Valued

5.0 Research Methodology

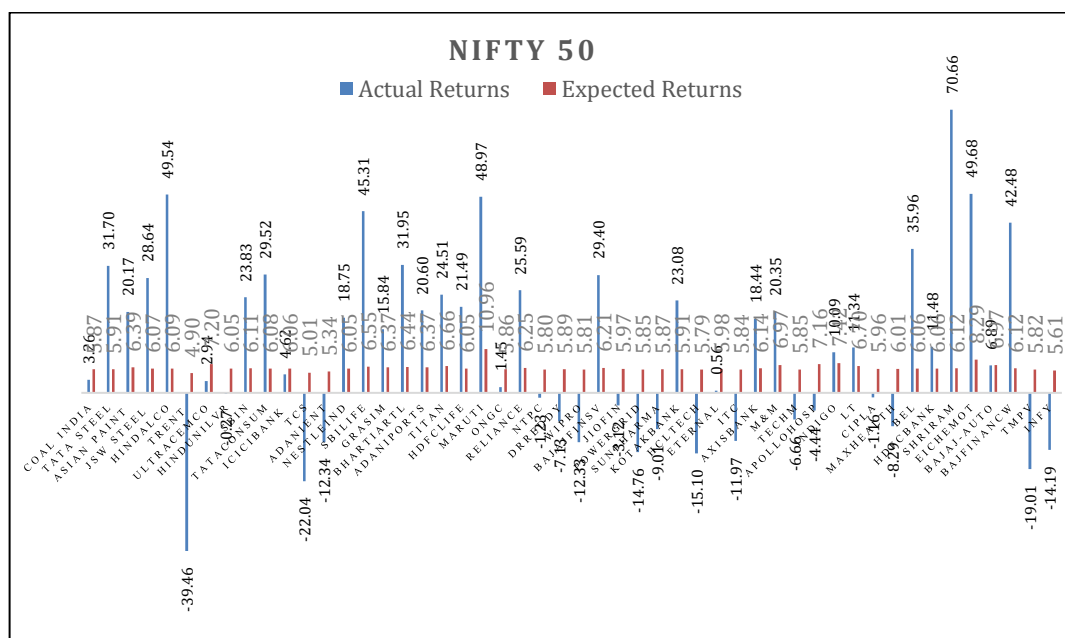
- **Research Design:** The study follows a descriptive and analytical research design, as it describes the behavior of stock returns and analytically examines the relationship between risk (beta) and return using the Capital Asset Pricing Model (CAPM) on NIFTY 50 stocks.
- **Nature of Data:** The study is based entirely on secondary data, as CAPM requires historical stock prices, index values, and interest rates, which are obtained from published and reliable financial sources.
- **Population of the Study:** The population includes all companies listed under the NIFTY 50 index, representing major sectors of the Indian economy and reflecting overall market performance.
- **Sample Selection:** The sample consists of selected NIFTY 50 stocks, chosen based on continuous availability of historical price data during the study period to ensure consistency and accuracy in analysis.
- **Period of the Study:** The study covers a specific and fixed time period (daily, monthly, or yearly), which allows comparison of stock and market returns under similar market conditions.
- **Sources of Data:** Data is collected from secondary sources such as the National Stock Exchange (NSE), Yahoo Finance, and other authenticated financial websites, while the risk-free rate is obtained from RBI publications or government treasury bill data.
- **Variables Used in the Study:** The study uses stock return as the dependent variable, market return as the independent variable, beta as the measure of systematic risk, and risk-free rate as a control variable in CAPM calculations.
- **Tools for Data Analysis:** Analytical tools such as Microsoft Excel and Power BI are used for return calculations, beta estimation, regression analysis, and graphical representation of results.
- **Method of Calculating Return:** Stock and market returns are calculated using historical closing prices by applying standard return formulas to measure periodic price changes accurately.
- **Measurement of Beta:** Beta is calculated by analyzing the relationship between individual stock returns and market returns using covariance and variance or regression methods, indicating the sensitivity of stock returns to market movements.
- **Application of CAPM:** CAPM is applied by computing the expected return of each stock using the risk-free rate, beta, and market risk premium to estimate theoretical returns.
- **Performance Evaluation:** The actual return of each stock is compared with its CAPM-expected return to evaluate whether the stock is undervalued, overvalued, or fairly valued.

- **Presentation of Results:** The findings are presented through tables, charts, and graphs, which help in easy interpretation and comparison of beta values and returns.
- **Limitations of the Study:** The study is limited by reliance on historical data, assumptions of market efficiency, exclusion of non-market risk factors, and sensitivity of results to the selected time period.

6.0 Data Analysis and Interpretation

S. No.	Company Name	Actual Returns	Expected Returns
1	COAL INDIA	3.26	5.87
2	TATA STEEL	31.70	5.91
3	ASIAN PAINT	20.17	6.39
4	JSW STEEL	28.64	6.07
5	HINDALCO	49.54	6.09
6	TRENT	-39.46	4.90
7	ULTRACEMCO	2.94	7.20
8	HINDUNILVR	-0.27	6.05
9	SBIN	23.83	6.11
10	TATACONSUM	29.52	6.08
11	ICICIBANK	4.62	6.06
12	TCS	-22.04	5.01
13	ADANIENT	-12.34	5.34
14	NESTLEIND	18.75	6.05
15	SBILIFE	45.31	6.55
16	GRASIM	15.84	6.37
17	BHARTIARTL	31.95	6.44
18	ADANIPTS	20.60	6.37
19	TITAN	24.51	6.66
20	HDFCLIFE	21.49	6.05
21	MARUTI	48.97	10.96
22	ONGC	1.45	5.86
23	RELIANCE	25.59	6.25
24	NTPC	-1.23	5.80
25	DRREDDY	-7.13	5.89
26	WIPRO	-12.33	5.81
27	BAJAJFINSV	29.40	6.21
28	JIOFIN	-3.12	5.97
29	POWERGRID	-14.76	5.85
30	SUNPHARMA	-9.01	5.87
31	KOTAKBANK	23.08	5.91
32	HCLTECH	-15.10	5.79
33	ETERNAL	0.56	5.98

34	ITC	-11.97	5.84
35	AXISBANK	18.44	6.14
36	M&M	20.35	6.97
37	TECHM	-6.66	5.85
38	APOLLOHOSP	-4.44	7.16
39	INDIGO	10.09	7.42
40	LT	11.34	6.70
41	CIPLA	-1.16	5.96
42	MAXHEALTH	-8.29	6.01
43	BEL	35.96	6.06
44	HDFCBANK	11.48	6.06
45	SHRIRAM	70.66	6.12
46	EICHEMOT	49.68	8.29
47	BAJAJ-AUTO	6.89	6.97
48	BAJFINANCW	42.48	6.12
49	TMPV	-19.01	5.82
50	INFY	-14.19	5.61



Source: Nifty 50

Interpretation: The CAPM analysis conducted on selected NIFTY 50 stocks compares the actual returns generated by the stocks with the expected returns estimated using the Capital Asset Pricing Model in order to evaluate their valuation and risk-adjusted

performance. The results indicate that several stocks such as Tata Steel, Asian Paints, JSW Steel, Hindalco, State Bank of India, Tata Consumer Products, Nestle India, SBI Life Insurance, Axis Bank, Mahindra & Mahindra, Bharat Electronics Limited, Shriram Finance, Eicher Motors, and Bajaj Finance have generated actual returns that are significantly higher than their expected returns, suggesting that these stocks were undervalued according to CAPM during the study period and provided higher compensation for the level of systematic risk undertaken by investors.

In contrast, stocks including Coal India, Trent, UltraTech Cement, Hindustan Unilever, ICICI Bank, TCS, Adani Enterprises, Tech Mahindra, Apollo Hospitals, Cipla, Max Healthcare, Tata Motors PV, and Infosys recorded actual returns lower than the CAPM-predicted returns, indicating that these stocks were overvalued and underperformed relative to their market risk. Some stocks such as Indigo, Larsen & Toubro, HDFC Bank, and Coal India exhibited only marginal differences between actual and expected returns, implying that they were fairly valued and closely aligned with CAPM expectations. The analysis further reveals that stocks from metal, banking, automobile, and financial services sectors largely outperformed CAPM predictions, whereas IT, FMCG, and healthcare sector stocks showed relatively weaker performance during the study period. The presence of significant deviations between actual and expected returns highlights the limitation of CAPM in fully explaining stock return behavior in the Indian equity market, as factors such as macroeconomic conditions, sectoral trends, and firm-specific developments also influence stock performance. Overall, the interpretation of the results suggests that while CAPM serves as a useful benchmark model for evaluating risk and return, it does not provide a complete explanation of stock price movements and therefore should be used in conjunction with other financial and fundamental analysis tools for effective investment decision-making.

7.0 Finding and Suggestion

7.1 Findings

1. The CAPM analysis partially explains the relationship between risk and return for NIFTY 50 stocks, as deviations between actual returns and expected returns are observed.
2. Stocks from banking, financial services, automobile, and metal sectors showed actual returns higher than CAPM-expected returns, indicating undervaluation and better risk-adjusted performance.
3. Stocks from IT, FMCG, and healthcare sectors recorded actual returns lower than expected returns, suggesting overvaluation during the study period.
4. Some stocks had minimal differences between actual and expected returns, indicating fair valuation and alignment with CAPM predictions.

5. Beta alone is insufficient to fully explain stock return behavior, as market anomalies, sectoral trends, and firm-specific factors also influence performance.
6. CAPM serves as a useful benchmark for evaluating systematic risk, but its predictive power in the Indian equity market is limited.

7.2 Suggestions

1. Investors should use CAPM as a preliminary tool for assessing risk and expected return, not as the sole basis for investment decisions.
2. CAPM analysis should be combined with fundamental analysis, technical indicators, and sectoral evaluation for better decision-making.
3. Portfolio managers should diversify across sectors to reduce unsystematic risk and improve overall portfolio performance.
4. Future research should incorporate multi-factor models such as the Fama–French model or Arbitrage Pricing Theory to enhance explanatory power.
5. Analysts should consider longer study periods and varying market conditions to increase the robustness of results.
6. Policymakers and academicians can use such studies to understand the behavior of asset pricing models in emerging markets like India.

8.0 Conclusion

The present study concludes that the Capital Asset Pricing Model (CAPM) provides a useful theoretical framework for understanding the relationship between systematic risk and expected return in the Indian equity market, particularly for NIFTY 50 stocks. By comparing actual returns with CAPM-based expected returns, the study identifies whether selected stocks are undervalued, overvalued, or fairly valued, thereby offering meaningful insights into stock valuation and risk-adjusted performance.

The analysis reveals that several stocks, especially from the banking, financial services, automobile, and metal sectors, generated actual returns higher than their CAPM-expected returns, indicating undervaluation and superior risk-adjusted performance during the study period. On the other hand, stocks from IT, FMCG, and healthcare sectors recorded actual returns lower than expected, suggesting overvaluation and weaker performance relative to their systematic risk. A few stocks showed close alignment between actual and expected returns, reflecting fair valuation as per CAPM.

The study also highlights that while beta is an important measure of market risk, CAPM alone is not sufficient to fully explain stock return behavior in the Indian stock market. Deviations between actual and expected returns indicate the influence of additional factors

such as macroeconomic conditions, sector-specific trends, company fundamentals, and investor sentiment, which are not captured by the model.

Overall, the study concludes that CAPM is an effective benchmark model for evaluating risk and return but should be used in combination with other analytical tools for sound investment decision-making. The findings emphasize the importance of diversification, comprehensive analysis, and cautious interpretation of CAPM results, making the study valuable for investors, portfolio managers, academicians, and future researchers in the field of finance.

About the Editors



Dr. Sanjay K. Deshpande is a management faculty resource with 18 years of experience in Teaching and consultancy, PhD in the area of evaluation of Soft Skills Training, MBA in HRM and a PGDELP from National Law University. He is also a certified trainer from NSDC and Skill India, BOSCH certified trainer for Nation Building, Certified HR Data Analyst. His areas of interest are Human Resources Management, Psychology, Learning & Development, Tiger Conservation, Outbound training, and Wildlife Management. He has conducted many training programs and offered consultancy programs to organizations like Gold's Gym, ACG Pharma Pack, LIC, SULA Wines, and others. Awarded as "Best Management Researcher" in the HR stream, and has secured the best research, with many milestones to his credit, and has authored a book with LAP Lambert Publishing Germany, with many Scopus indexed publications.



Dr. Vanishri R. Hundekar is an Associate Professor in the Department of MBA at KLS Gogte Institute of Technology. She brings over 16 years of experience in academia and research. She has PGDELP from National Law University. Her areas of expertise include finance and investment. She is a recognized Research Supervisor (Guide) at Visvesvaraya Technological University (VTU). Dr. Vanishri Hundekar has actively participated in several national and international conferences and is a recipient of Best Paper Awards. She has organized multiple research and case conferences and has also served as an organizer for ATAL Faculty Development Programmes (FDPs). She has an extensive publication record, with papers indexed in ABDC-listed journals, Scopus, and reputed quartile journals.



Dr. Rekha D. Birje is an Assistant Professor in the Department of MBA at KLS Gogte Institute of Technology, Belagavi, with over 18 years of combined academic, research and industry experience. She holds a Ph.D. in Commerce from Rani Channamma University and has qualified KSET. Her academic interests include Financial Management, Investment Management, Banking and Financial Services, and Personal Finance. She has actively contributed to research through publications and paper presentations at national and international conferences in the areas of finance, financial literacy, climate accounting, HR, and SME banking. She has participated in various Faculty Development Programmes and research-oriented workshops, reflecting her commitment to continuous learning and academic excellence. She has organized various workshops, research colloquium and national and international conferences. She is dedicated to fostering research culture, academic collaboration, industry-relevant learning among management students and scholars.



Journal Press India

Delhi, India

Mobile: +91 8826623730 / 32

Website: www.journalpressindia.com

E-mail: info@journalpressindia.com



Scan for
Online Version

ISBN 978-9-34-979052-0



9 789349 790520