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First International Conference
on
Management & Technology
INCMAT 2026

**“New Horizons: Integrating AI,
Business, and Sustainable Futures”**

Saturday, 25th April 2026



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From the Desk of the Director

It gives us immense pleasure to present the **INCMAT-2026 ISSN Multidisciplinary Journal**, based on the theme “**New Horizons: Integrating AI, Business, and a Sustainable Future.**”

The **International Conference on Management and Technology (INCMAT-2026)**, held in **April 2026**, provided a meaningful platform for academicians, researchers, industry professionals, and students to share their research findings, innovative ideas, and perspectives on emerging developments across multidisciplinary domains.

We are living in an era of unprecedented transformation, where Artificial Intelligence is reshaping industries, redefining business models, and influencing the way we learn, work, and address complex global challenges. The convergence of technology, business, and sustainability therefore opens new avenues for innovation, collaboration, and inclusive growth.

This journal is a reflection of the intellectual contributions and research endeavours presented through INCMAT-2026. The scholarly works included in this publication highlight the importance of interdisciplinary thinking in addressing contemporary challenges and developing innovative solutions for a rapidly evolving world.

We sincerely appreciate the efforts of the authors, reviewers, editorial team, faculty members, and all those who have contributed to the successful compilation of this ISSN publication. Their dedication and collaborative efforts have made this academic endeavour possible.

We are confident that this journal will serve as a valuable source of knowledge and inspiration for researchers, academicians, students, and professionals. May it encourage further research and inspire us to embrace new horizons while working collectively towards a technologically advanced, economically progressive, and sustainable future. We extend our best wishes to the entire team for the continued success of **INCMAT-2026**.

Dr. Rasika Mallya
Director
DES's NMITD

Dr. Giribala Devasthale
Director
DES's JSKBS

From the Editorial Team

It is our privilege to present the **INCMAT-2026 ISSN Multidisciplinary Journal**, published under the theme “**New Horizons: Integrating AI, Business, and a Sustainable Future.**” This journal is a significant outcome of the **International Conference on Management and Technology (INCMAT-2026)** held in **April 2026**, which brought together academicians, researchers, industry professionals, practitioners, and students from diverse backgrounds to share knowledge, exchange ideas, and discuss emerging developments across various disciplines.

The rapid advancement of technology, particularly Artificial Intelligence, is transforming industries, organizations, and societies worldwide. At the same time, businesses and policymakers are increasingly focused on sustainable development and responsible innovation. Recognizing these evolving dynamics, this journal provides a platform for scholarly contributions that explore the intersection of **Artificial Intelligence, Business, Management, Technology, Innovation, and Sustainability**. The articles included in this volume demonstrate how interdisciplinary research can generate innovative solutions to contemporary challenges and contribute to building a more inclusive, resilient, and sustainable future. Collectively, these contributions reflect the growing importance of integrating knowledge from multiple disciplines to address complex global issues and create meaningful societal impact.

We extend our sincere gratitude to all authors for their valuable research contributions and commitment to academic excellence. We are equally thankful to the reviewers whose expertise, constructive feedback, and dedication ensured the quality and integrity of this publication.

We hope that the insights presented in this volume will inspire further research, encourage innovation, foster interdisciplinary collaboration, and stimulate meaningful academic and professional dialogue. It is our aspiration that this journal serves as a valuable resource for scholars, educators, practitioners, and students, contributing to the advancement of knowledge and the pursuit of sustainable development in an ever-changing world.

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INCMAT-2026 ISSN Multidisciplinary Journal

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A REVIEW ON VIRAL MARKETING AND ITS STRATEGIC IMPLICATIONS ON SUSTAINABLE INDIAN BRANDS

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Abstract:

Viral marketing is the most effective strategic marketing tool which can ensure market leadership, product differentiation, customer engagement and retention. This tool is an effective combination of technology with products or services as it could ensure competitive advantage and excellence. This marketing strategic tool also utilizes social media to a larger and greater extent which ensures reach and retention. This tool has been effectively used for marketing promotions across global industries. Movie & song promotions has been very successful with this tool, however it is also known and evident that academic researches have not been done on these aspects. The role and impact of viral marketing on Indian brands, performance, outcomes and profits needs to be researched and explored. The dynamic relationship between viral marketing and its strategic implications on Indian brands and branding has to be researched which has been attempted very limited. This research is exploratory and conclusive in nature. This research by nature uses secondary data for its review exploration and exposition on viral marketing and its strategic implications on sustainable Indian brands towards 2030. This study would provide new impetus, directives and marketing implications towards viral marketing orientation and its implications on sustainable Indian brands towards 2030. This study would identify the research gaps and provide the potential areas of research for future also.

Keywords: Viral Marketing, Strategic Marketing Tool, Customer Engagement, Social Media, Indian Brands.

► *Corresponding Author: Dr. Abhishek Subhash Deokule*

Introduction:

Viral marketing: origins spread and impact

The word viral has its origins related to medicine as it is connected with some unknown element which spreads very fast and the contamination is very hard to control. The same principles and practices do apply for certain form of marketing strategies {Abbas, A. F., et.al (2020 & Hendrayati, H., & Pamungkas, P. 2020} which also spurt in a moment from a company or industry which redefines the marketing orientations, purposes and shapes the industry towards sustainability and excellence. The marketing strategy and orientation are contagious in its strong impact as it continues to shape the functional, dynamic, decision making pursuits of any organization. This has short term benefits and long term sustainability also. The concept of viral from medicine has been used in strategic marketing and its orientation to denote a sudden spurt or fast movement of a particular approach which makes the industry wake up from its normal ways of thinking

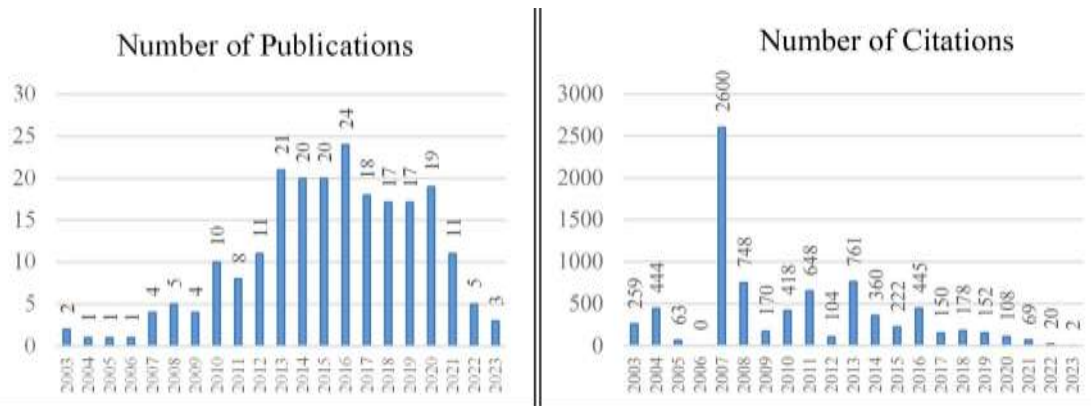
{Aggarwal, K., & Arora, A. (2023)} and approaches. This could alter the way and functioning of the entire industry as it instills new thinking as it fosters new approaches and methods. This could also ensure strategic marketing excellence as company's benchmark excellence with good products and services. This could also be called a volunteering form of marketing promotion {Lopes, J.et.al (2019 Lopes, J. M.et.al (2021)} done by the benefited customer or it could be done as a part of companies marketing strategy as well.

The word Viral could be defined as the active involvement and engagement of consumers about products and services which soon turn out to be frenzy, buzzy and turns to be addictive. The consumer's active engagement {Akpinar, E., & Berger, J. (2017 & Donthu, N et.al (2021)} through word of mouth and online engagement make this possible. The spread of the message – virally is done by the consumers to take interest and responsibility to spread positive information on products and services which becomes a heat wave soon. The message is spread across and consumers start buying the products and services very actively.

Viral marketing is the modern form of marketing where in consumers engages themselves actively with the company's products and services as they are happy and would like to spread the message. The negative experiences by nature could also be spread through this viral marketing – with the use of various online platforms, blogs, reviews and comments on website. The continuous active engagement {Al Abri, D., & Valaee, S. (2020 & Fard, M. H., & Marvi, R. (2020)} spreads the message on company's products and services, sales experiences, post sale responses which spreads virally – very fast which is termed as viral marketing. It provides strategic differentiation and effective engagement with the customers as they are provided with novelty, innovation {Bačík, R., & Fedorko, I. (2017)} and new approaches. This provides them total enjoyment, happiness as it directs towards effective engagement and retention of customers in the long run also. The world has become more dynamic functional active and progressive with techno inputs, orientations and its effective management.

This techno orientation has had a strong positive impact {Amnieh, I. G., & Kaedi, M. (2015)} and influence on marketing and its orientations also. The modern world functions more integratively and holistically with social media as their pertinent role could never be ignored.

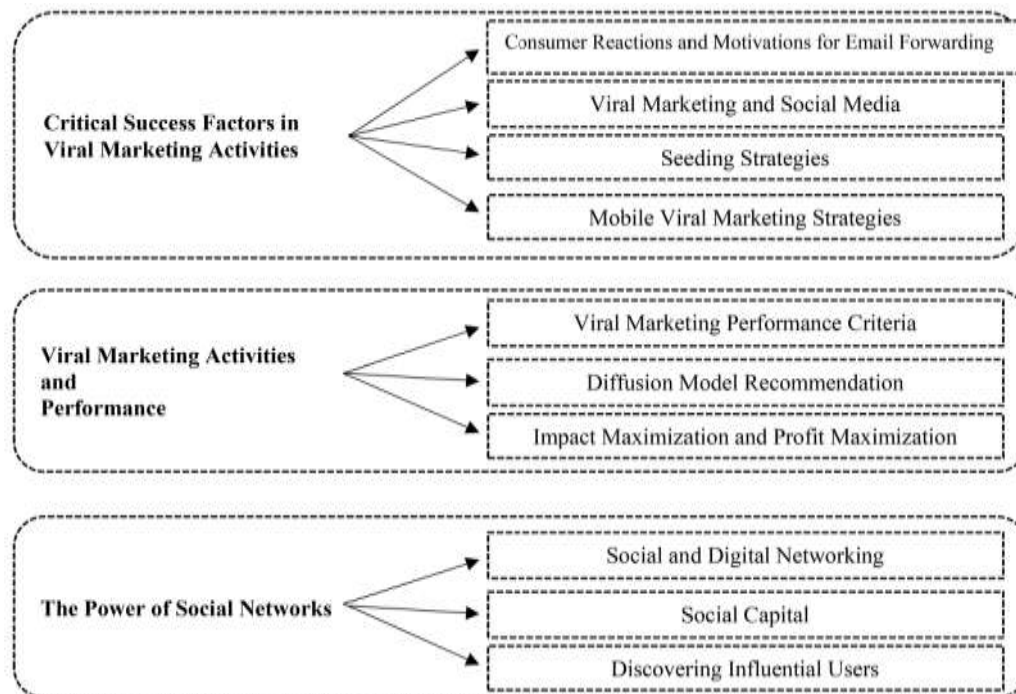
Viral marketing is effectively and purposively done with social media elements as it could also be called as ewom (electronic word of mouth). This strategy is also termed as Guerrilla marketing as the marketing strategy and its attack by the company is sudden which shakes and alters the normal functioning of the entire market mechanisms. The viral marketing can also be made more focused and engaging with a social cause which is called as social cause marketing or cause marketing {Mukhopadhyay, S.et.al (2022 Nguyen, H. T.et.al (2017)} or content marketing. As this strategy uses social media to a larger extent –this marketing strategy could also be termed as social media oriented viral marketing. Bibliometric studies on the development of research orientations and its significance has been done to denote {Çakirkaya, M. and Aytaç Afşar, Ö., 2024} Bibliometric and content analysis of viral marketing in marketing literature and understand the prominence and importance of Viral marketing across global countries. It has been evident from this study that viral marketing has been the most significant marketing tool reach masses. This could be categorized as the low cost strategy {Singh, S. S.et.al (2022)} which ensured differentiation and marketing excellence with prominent engagement with customers. This marketing strategy also ensures a very high new potential consumer conversion.



Source: {Çakirkaya, M. and Aytaç Afşar, Ö., 2024}

This study has been done with Web of science as 222 research studies between 2003 to 2023 has been evaluated and analyzed. It is evident that research publications on viral marketing has been become very less from 2017 till now – which gives scope for more academic research publications to be done on this domain. This research clearly indicates this research gap which is evident now on viral marketing and sustainability of Indian brands. As the publications have been phenomenally decreasing since 2017, it is also evident that the number of citations on viral marketing has been very less which also indicates futuristic scope of this domain.

This review clearly points out there is an immense potential on this academic research area which needs to be exploited which can be effectively utilized by academic researches and professionals in global industries.



Source: {Çakirkaya, M. and Aytaç Afşar, Ö., 2024}

Prominent Research Gaps:

It is also evident that very limited researches have been done on critical success factors of viral marketing and its implication on Indian Inc. industry specific strategies and approaches of viral marketing and its positive impact on profits and performances in Indian organizations has to be researched which also has not been done to a greater extent. The role of social media and its dominating influences on viral marketing strategies which could lead to balanced growth, regional development, inclusiveness and socio economic contributions has never been researched which also could be attempted. The next section would deal with analysis and evaluations on viral marketing and researches conducted.

Research Design:

This review paper would be exploratory and conclusive in its nature and approach. This research is exploratory as it explores in to the various researches conducted on viral marketing since 2015 till date. The analysis of this review paper has been much focused as it deals with research papers done on viral marketing in 2023 & 2024 only.

The research is conclusive as it would provide strategies for future research in this field by identifying the research gaps. Secondary data analysis would be done as inferential and evaluative analysis would be done.

Problem Statement:

Viral marketing has been an emerging field which has huge potential as it has been rightly used by global marketers. With technology impetus and social media – this marketing tool has ensured consumer engagement{ Adesokan, A.et.al(2023 Adesokan, A.et.al(2024) Yang, M.et.al(2023} retention as the spread of right information to the consumers in a faster way is ensured with Ewom(electronic word of mouth). As research studies have not been done on this vital domain – this review paper would examine and highlight various researches conducted globally in this field. This would also provide new impetus and perspective on very less researches conducted in this field. The research aims to fulfill this gap as the necessary awareness would be created on this field with this review paper.

Objectives of the Study:

1. To validate the various academic researches done on viral marketing till date
2. To examine and evaluate the researches conducted on viral marketing in 2024
3. To provide research gaps and potential for researches on viral marketing

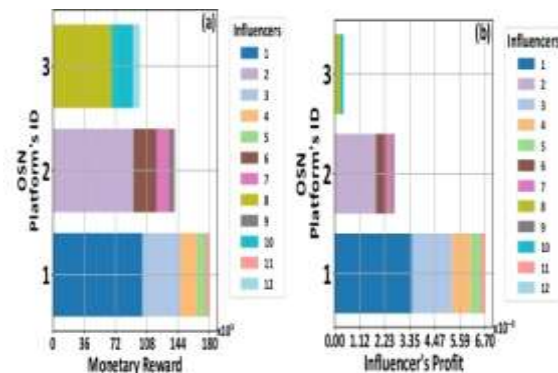
Scope and Limitations:

1. This study has been done as secondary data oriented study only
2. This study covers researches conducted on viral marketing only

Analysis and Evaluations:**Influstrust & Online Social Media (2024 Study)**

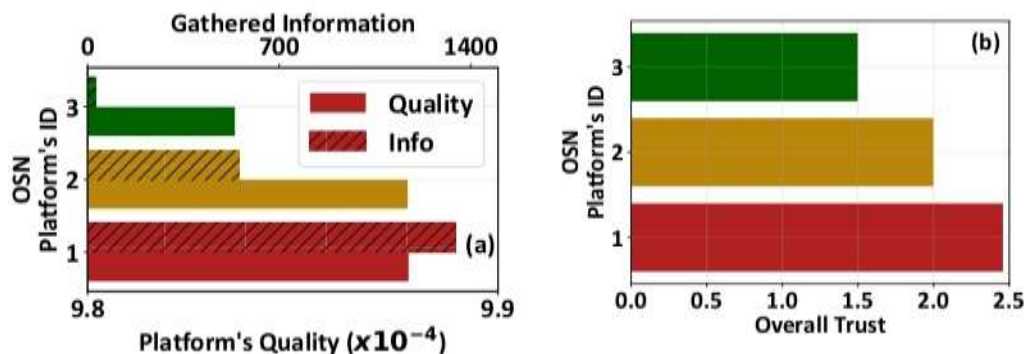
Adesokan, A., Rahman, A.B. and Tsiropoulou, E.E., 2024 had done research study on the role and impact of Influstrust on global organizations and their performances. It has been evident from this study that Influstrust really has a positive impact on marketing campaigns done which has been effective with online social media. This Influstrust framework {Adesokan, A et.al(2023 Yang, Y.; Pei, J(2021} using specific algorithm enables users to select product from online social media

platforms as it also ensure effective engagement. The formal and informal social relationships have a strong impact on trust which leads to more influences as the users are convinced as they make purchases also.



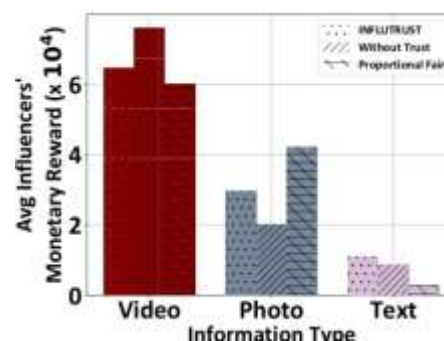
Source: Adesokan, A., Rahman, A.B. and Tsiropoulou, E.E., 2024

It is evident from the above chart that viral marketing has a huge impact on influencers as they are able to gain monetary rewards and profits. However the role and impact of viral marketing { Pham, P.N.H.et.al(2021 Wang, L.et.al(2021) and its implications on sustainable Indian brands has not been done as this research identifies this research gap which is evident now.



Source: Adesokan, A., Rahman, A.B. and Tsiropoulou, E.E., 2024

In this study it is evident that viral marketing strategy done through online social media platforms has a positive and strong impact on overall trust on the products and services. It helps in consumer engagement, retention and purchases.

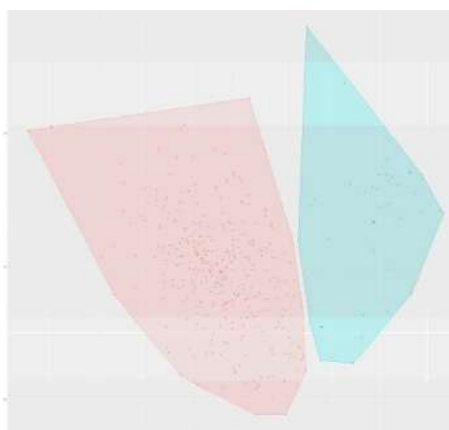


Source: Adesokan, A., Rahman, A.B. and Tsiropoulou, E.E., 2024

It is evident that videos are the most popular form of influencers in social media platforms as it role on sustainable Indian brands {Guo, J.; Zhang, Y.; Wu(2023 Barik, R et.al(2022} and branding strategies has not been researched or evaluated which needs to be done also. However it is found that the dimensions of viral marketing and its influences on sustainable Indian brands have not been studied or evaluated as this research gap is found with this review paper.

Social Media Influences and Marketing Strategies: 2024

Ilieva, G.et.al 2024. Had done research study on the role and impact of social media and its influences on marketing strategies of organizations. This study by nature evaluates the specific and purposeful impact of social media {Rahman, A.B et.al 2022. Tang, J.; Zhu, Y.; Tang, X.; Han, K(2022} and its influences on attitudes of customers and behavior during purchases. All these factors have been evaluated in this study.



Source: Ilieva, G.et.al 2024

This clustural analysis clearly indicates a positive response of influencer's opinions in social media for agreeableness and product purchase {Teng, Y.W.et.al(2021} by potential customers. However it is also found that researches have to be done on viral marketing and its implications on sustainability of Indian brands which have not been studied or evaluated which is attempted with this research and it was found that research gap is there which has to be supported with empirical studies in future.

Szkal, A.C.et.al 2024 had done an empirical research to explore and find out the relationship which prevail with influencer oriented marketing strategy and its impact on consumers. It is found in this study that influencers {Luo, J.; Rossi, R.A.; Kong, X.; Li, Y(2023 Agra, A.; Samuco, J.M(2024} do have a positive role on decision making process of consumers as they tend to buy based on their inputs only.

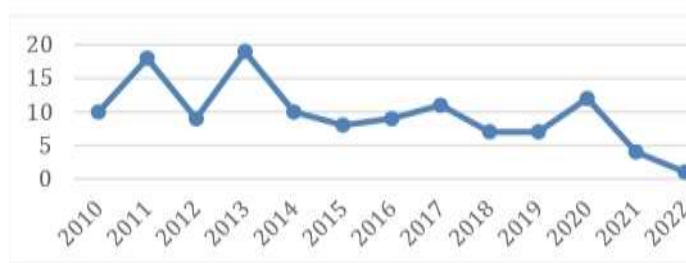
Advantages of Influencer Marketing	Disadvantages of Influencer Marketing
Sincerity	Promotion of products opposite the niche
Visibility	date
High credibility	Lack of sincerity
The speed with which the promoted products can be purchased	Negative influence on consumers through manipulation
Quick access to information	Lack of credibility
Information and detailed description of products	
Getting honest opinions	
Save time and money	

Source: Szkal, A.C.et.al 2024

This research explores in to the advantages and disadvantages of viral marketing {Dinh, T. et.al(2022 Namiranian, M.; Meybodi, M.R(2023} as a core integrative strategy which is influenced by influencers. It is also evident that the role and impact of viral marketing on Indian brands and its sustainability has never been explored empirically as this research is an attempt on it.

Rubiyanti, N., Fakhri, M. and bin Abu Sujak, A.F., 2023 had done bibliometric study on viral marketing and its dominance in academic researches. This research has been done to explore and find out the novel ways of research {Huang, Z.; Li, L(2023 Zhang, L.; Liu, Y.; Cheng, F.; Qiu, J.; Zhang, X(2021 Yu, L.; Li, G.; Yuan, L(2022 Arleo, A. et.al(2022} done in this dimension and it also evaluates its implications.

Academic Researches on Viral Marketing:



Source: Rubiyanti, N., Fakhri, M. and bin Abu Sujak, A.F., 2023

It is evident that academic researches conducted on viral marketing has consistently come down which has to improve {Zhang, Y.(2021 Zhang, J.et.al(2022 Huang, C.et.al(2019 Nie, J.et.al(2024 Wei, X. et.al(2022 Doshi, R.; Ramesh, A.; Rao, S(2023} to a greater extent in the long run. This in itself indicates that there are research gaps on this domain globally {Malhi, A.et.al(2021 Li, Yet.al(2024 Lopez-Dawn, R.; Giovanidis, A(2023} as academic researches must be done on various aspects and implications of viral marketing and its performance based outcomes. It is also evident that viral marketing is an holistic marketing approach which can be researched as it has practical utility and implications on global organizations and their outcomes.

Findings as Per Objectives:

Objective 1: To validate the various academic researches done on viral marketing till date

It has been found that academic researchers have come down on viral marketing since 2022 till date. The nature extent and type of research contributions has been negligible. This research finds out that there is an immense research gap on viral marketing which can be explored by academic researchers and professionals in the field of study.

Objective 2: To examine and evaluate the researchers conducted on viral marketing in 2024

It is evident that empirical researches have not been attempted on viral marketing in 2024. It is also evident that bibliometric and SLR studies have not been done. related studies on social media, influencer marketing has been done, although direct researches on Viral marketing has been found to be less prevalent.

Research Potential and Future Scope in Viral Marketing:

It is found that very limited researches have been done on critical success factors of viral marketing and its implication on Indian Inc. Industry specific strategies and approaches of viral marketing and its positive impact on profits and performances in Indian organizations has to be researched

which also has not been done to a greater extent. The role of social media and its dominating influences on viral marketing strategies which could lead to balanced growth, regional development, inclusiveness and socio economic contributions has never been researched which also could be attempted.

This is a potential dimension which offers immediate reach to consumers as it also ensures effective engagement & retention. This could offer practical marketing strategies for organizational development, growth and contributions. This domain has to be researched as practical solutions and strategies could be provided for sustainability of Indian brands towards 2030.

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**BRIDGING THE GREEN CLOUD READINESS GAP:
ORGANIZATIONAL BARRIERS, ENABLING CONDITIONS, AND A
COST-ALIGNED FRAMEWORK FOR SUSTAINABLE AUTO-SCALING****Shloka Hitesh Kamdar***BCA Student, Education Facility Center Yash Infotech, Tilak Maharashtra Vidyapeeth.***Abstract:**

Data centers are projected to consume 945 TWh of electricity globally by 2030 [3], and auto-scaling sits at the center of that problem. Cloud teams have the tools to manage dynamic resource allocation, carbon-aware scheduling, and intelligent scaling policies. Yet most infrastructure remains chronically over-provisioned. The barriers stopping adoption are not technical. This paper investigates what those barriers actually are. Through a mixed-methods study combining literature review with survey data from 40 cloud practitioners, it applies the Technology-Organization-Environment (TOE) framework to map what prevents sustainable auto-scaling in real DevOps environments. The numbers are striking: 85.0% of respondents were aware of the environmental impact of their infrastructure choices, yet when asked how much that awareness influenced actual decisions, the mean score was only 2.41 out of 5. Awareness, it turns out, is not the same as action. The barriers driving this gap are organizational far more than technical; absent management mandate, no visibility into carbon metrics, and the persistent reality that sustainability loses whenever it competes with cost. The 3M Framework proposed here - Measure, Monitor, Minimize, is built around that reality. Every intervention reduces carbon and cost together, so environmental goals stop requiring separate justification.

Keywords: Green Cloud Computing, Auto-Scaling, DevSusOps, Organizational Readiness, Sustainability, Carbon Efficiency, TOE Framework.

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Introduction

Data centers consumed 415 TWh of electricity in 2024 and are projected to hit 945 TWh by 2030 [3]. Auto-scaling was designed to solve this dynamically matching compute resources to actual demand to eliminate idle over-provisioning. In practice, most teams run static 70-80% CPU thresholds that never scale down.

What makes this gap surprising: practitioners know better. Green cloud practices are well-documented. The tools exist. Yet adoption doesn't follow. This paper investigates why. Through a survey of 40 cloud practitioners, this study documents the awareness-action gap: 85% of respondents understand their environmental impact, yet report only 2.41/5 mean consideration when making actual decisions. The barriers are organizational, not technical.

To systematically examine this issue, the study is guided by three research questions. The first (R1) explores the prevailing auto-scaling practices among cloud practitioners, focusing on how infrastructure is currently configured and managed in real-world environments. The second question (R2) investigates the organizational, technological, and environmental barriers that

prevent the adoption of sustainable practices. The third question (R3) examines the enabling conditions that support the integration of green cloud practices into existing DevOps workflows. These questions are analyzed using the Technology-Organization-Environment (TOE) framework, which provides a structured lens to evaluate adoption challenges. Based on this analysis, a cost-aligned 3M Framework is proposed, designed to function within existing organizational constraints rather than requiring structural change.

Literature Review

The technical literature on sustainable cloud computing has matured considerably. Right-sizing instances to match actual workload requirements, adopting serverless architectures that scale to zero when inactive, and carbon-aware workload scheduling based on grid intensity data are all well-documented [2].

AWS Compute Optimizer and GCP Recommender provide automated right-sizing recommendations; Electricity Maps supplies hourly carbon intensity forecasts; open-source tools like Cloud Carbon Footprint calculate emissions directly from billing data. Despite this technological readiness, research indicates that proposed frameworks perform well in controlled environments but remain rarely validated against real production systems [6]. The implementation gap is organizational rather than technical.

Rogers' Diffusion of Innovations framework identifies five adoption stages: knowledge, persuasion, decision, implementation, and confirmation [4]. In green cloud contexts, practitioners appear to stall between knowledge and persuasion. Surveys consistently report that 80–90% of cloud teams acknowledge environmental impact, yet configuration practices remain largely unchanged. The TOE framework, originally developed by [5], provides structure for understanding this gap. Technological context examines tool complexity and compatibility; organizational context considers budgets, management priorities, and internal incentives; environmental context assesses regulatory pressure and industry norms. Applied to green cloud adoption, the pattern is consistent: technological barriers are relatively low, while organizational barriers like absence of dedicated budgets, performance-first priorities, and misaligned team incentives consistently block adoption.

DevSusOps represents an emerging reframing within DevOps culture, treating carbon emissions as a first-class operational metric alongside cost and performance [1]. Rather than positioning sustainability as an external requirement, it becomes integrated into daily observability and decision-making. This reframing proves theoretically compelling but remains uncommon in practice. The research gap addressed here is empirical: while literature documents both the technical practices and the theoretical barriers to adoption, there remains limited investigation of what specific organizational conditions enable adoption despite these barriers. The contribution of this research is grounding the barrier taxonomy in practitioner data and proposing a framework explicitly designed to operate within existing organizational constraints

Research Methodology

This study combines a systematic literature review with a practitioner survey conducted in March 2026. The literature review prioritizes empirical and practitioner-oriented sources over purely theoretical models, given the existing abundance of conceptual work in green cloud computing. The survey employs a structured questionnaire to capture both quantitative and qualitative data. Quantitative metrics include scaling configurations, threshold settings, and sustainability

consideration scores, while qualitative responses provide insights into perceived barriers, instances of resource inefficiency, and decision-making trade-offs.

Quantitative data is analyzed using descriptive statistics, while qualitative responses undergo inductive thematic coding. Categories emerge directly from respondent input and are subsequently mapped to the TOE framework dimensions.

Table 1: Participant Profile (n = 40)

Dimension	Category	n	%
Role	DevOps Engineer	21	52.5%
	Cloud Engineer	11	27.5%
	Developer	6	15.0%
	Other	2	5.0%
Experience	5+ Years	18	45.0%
	1-5 Years	8	20.0%
	Less than 1 year	14	35.0%
Primary Platform	AWS	34	85.0%
	GCP	18	45.0%
	Azure	14	35.0%

Note: Platform figures exceed 100% as respondents could select multiple platforms.

The experience split, nearly half with five or more years, over a third with less than one – was not by design but proved useful. Experienced practitioners describe sustainability trade-offs they have navigated over careers; newer practitioners reveal what defaults look like when someone enters the field today. Both perspectives matter.

Quantitative responses were analyzed using descriptive statistics. Qualitative responses underwent inductive thematic coding. Categories emerged from respondent language rather than predetermined frameworks, then mapped onto TOE dimensions.

Findings and Discussion

The Awareness-Action Paradox

Thirty-four of forty respondents (85.0%) reported environmental awareness, approximately fifteen fully aware, and nineteen somewhat aware. Then the same respondents were asked how much that awareness actually influences auto-scaling decisions. The mean score was 2.41 out of 5. Twenty-three respondents, more than half, rated their consideration at 1 or 2, minimal to none. That is not a small discrepancy. Most people in this sample understand the environmental impact of what they are doing and then mostly do not factor it in when making decisions. The qualitative responses make the reasoning explicit: one respondent stated that environmental impact "does not play any role," another noted that "businesses care much less about saving trees," and a third framed it bluntly as a capitalism problem where "the ROI is too small." Seven respondents (17.5%) were different, describing performance, cost, and carbon as connected metrics rather than competing ones.

Barrier Taxonomy: A TOE Analysis

When respondents described what prevents adoption, the answers mapped clearly onto TOE dimensions

Table 2: Barrier Taxonomy (TOE-Mapped)

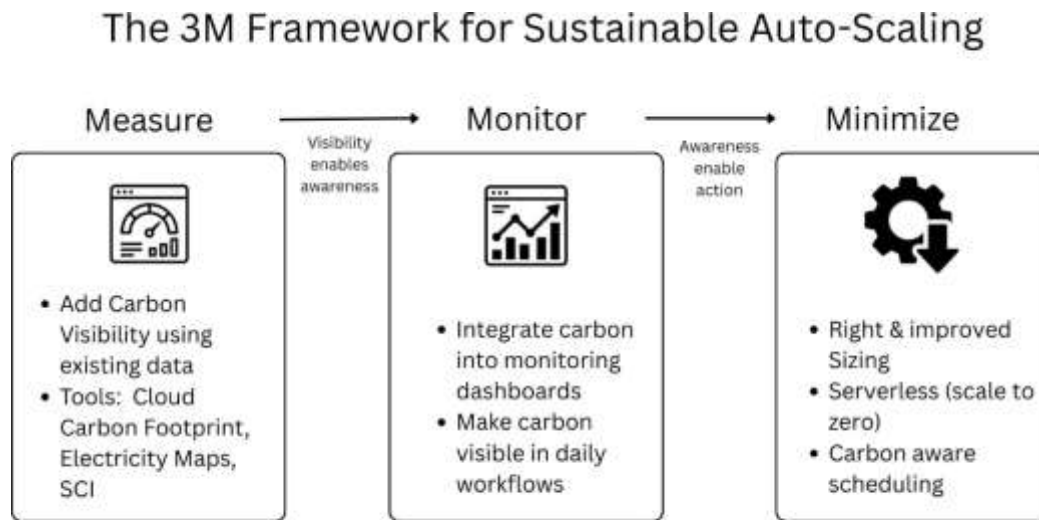
TOE Dimension	Barrier	Frequency
Organizational	No time or dedicated resources	17 (42.5%)
Organizational	Management does not prioritize sustainability	13 (32.5%)
Organizational	Perceived cost increase	12 (30.0%)
Technological	Lack of visibility into carbon metrics	13 (32.5%)
Technological	No integration with carbon intensity data	7 (17.5%)
Environment	No load testing before auto-scaling changes	5 (12.5%)
Environment	Practitioners do not know how	5 (12.5%)

No time or dedicated resources (42.5%): The data shows teams are not skipping sustainability because they don't care; they're skipping it because it's never an explicit Service Level Objective (SLO). When a performance incident requires immediate action, any tangential work like optimizing cloud usage instantly gets deprioritized. Sustainability is treated as 'nice-to-have' technical debt that only gets attention after an incident is resolved, which means it rarely gets attention at all.

Management does not prioritize sustainability (32.5%): Senior leadership decisions follow financial metrics, but carbon is not a line item in the profit-and-loss statement. If FinOps reporting only tracks dollar spend, then waste is only reduced when it hits the budget threshold. This organizational blind spot ensures that even well-meaning teams won't receive a formal mandate to dedicate cycles to environmental optimization.

Perceived cost increase (30.0%): The default practitioner mindset is that sustainable practices are add-on costs, like paying a premium for renewable-powered regions rather than intrinsic cost-saving measures. This mindset gap is critical because any environmental choice that requires spending money now to save energy or carbon later gets instantly vetoed by budget constraints. Practitioners fundamentally see performance and cost as first-order concerns, and sustainability as a distant, potentially expensive third.

Lack of visibility into carbon metrics (32.5%): This isn't a problem because tooling doesn't exist, but because integrating carbon APIs requires a dedicated project. Teams simply don't have native carbon data visible in the daily dashboards they use for debugging and operational decisions. It's a friction problem, not a capability problem: when a metric is invisible, as respondents put it, 'Carbon data isn't in our dashboards' - it never enters the decision matrix.

Proposed Framework: The 3M Model for Sustainable Auto-Scaling

Sustainability fails when it competes with cost. The 3M framework removes that competition

Figure 1 - The 3M Framework

The 3M Framework (Measure, Monitor, Minimize) is proposed as a structured, cost-aligned operational model to close the awareness-action gap in sustainable cloud adoption. This framework mandates a sequential flow, beginning with establishing carbon visibility (Measure), integrating these new metrics into existing operational dashboards (Monitor), and culminating in actionable waste reduction (Minimize). Its core design ensures that every step reduces both environmental impact and operational expenditure simultaneously. By removing the need for sustainability to compete with cost or performance, the 3M framework integrates carbon efficiency directly into the DevSusOps workflow, as visually detailed in Figure above

Conclusion

The gap between green cloud awareness and action is organizational, not technical. Through analysis of 40 practitioners mapped onto the TOE framework, this study finds that sustainable auto-scaling adoption is blocked primarily by organizational misalignment - absent management mandate, competing cost priorities, and metric invisibility. The awareness-action gap is not marginal: 85.0% awareness paired with 2.41/5 operational consideration. Technical knowledge and tools are necessary but insufficient conditions.

The 3M Framework provides a cost-aligned response designed to operate within existing organizational constraints rather than requiring structural transformation. By framing sustainability as cost optimization with environmental benefits as measurable side effects, it aligns with incentives that already exist. For the cloud industry to achieve widespread sustainable practice, the green path must become the easy path. The framework is designed to do exactly that. This distinction, while intuitive, is not reflected in existing literature. Most green-cloud research proposes technical solutions to what is fundamentally an organizational problem, a mismatch that explains why sophisticated carbon-aware scheduling algorithms remain largely unused in practice. Three critical unknowns remain after this investigation.

First, the Behavior vs. Intention Gap: This study documents high awareness (85.0%) without subsequent action (2.41/5 mean consideration). The findings show that practitioners know what

they should do, but not what they will do. Longitudinal tracking of teams implementing the 3M Framework would test whether cost-aligned framing actually shifts daily operational behavior, or if deeper organizational barriers remain even with better tools and incentives. This study hypothesizes that teams with explicit carbon SLOs will adopt optimization faster, but that remains untested

Second, the Cost-Carbon Divergence: The 3M Framework is predicated on the assumption that cost reduction and carbon reduction move together. They don't always align. Studying cases where carbon-aware choices cost more, for instance, choosing a renewable-powered cloud region with a premium price point, would reveal where the cost-alignment hypothesis breaks down. This research would define the boundary conditions of the framework and clarify when practitioners are willing to choose sustainability purely for environmental reasons.

Third, Geographic and Market Context: The organizational barriers identified in this study echo across the AWS, GCP, and Azure users sampled, largely based in India. What remains unknown is whether these barriers hold in highly regulated markets (like the EU) or in regions where the carbon intensity of the local grid varies dramatically day-to-day. Further research focusing on emerging markets, which are still building their cloud infrastructure from inception, could identify the conditions that enable them to embed sustainability in architectural and procurement decisions from day one, avoiding the lock-in that constrains developed markets.

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ECOCRITICISM AND CLI-FI IN INDIAN CHILDREN'S LITERATURE: A STUDY OF *A CLOUD CALLED BHURA* BY BIJAL VACHHARAJANI

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Abstract:

This paper offers an ecocritical reading of Bijal Vachharajani's *A Cloud Called Bhura*, situating the text within the emerging field of Indian children's climate fiction (cli-fi). Using Cheryll Glotfelty's foundational framework of ecocriticism, this study investigates the interactions between the environment and human and non-human beings in the novel to highlight the ecocritical discourse on the Anthropocene and the Capitalist Anthropocene, Eco-affect and Eco-anxiety, and Eco-ethics and Eco-consciousness. It also examines the novelist's use of Anthropomorphism to further reconfigure the relationship between nature and society. Ultimately, the paper outlines the significance of children's literature in shaping environmentally conscious subjectivities in an era of accelerating climate crisis.

Keywords: Ecocriticism, *A Cloud Called Bhura*, Anthropomorphism, Anthropocene, Eco-anxiety, Eco-ethics.

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Literary studies over the past few decades have expanded to incorporate new ways of criticism time and again. A fast-changing postmodern era has seen the rise of a multitude of complex social, economic and political issues compelling literary scholars to rethink their frameworks to address pressing twenty-first-century concerns and initiate critical discourse that informs and educates readers.

Ecocriticism, or the study of ecology and literature, stands as a paramount example of a new-age literary multidisciplinary theory that found its footing due to the growing number of environmental issues worldwide. From the mid-eighties, scholars had begun to seek an increased awareness and concern for the environment in literary disciplines. In 1978, the term ecocriticism was coined by William H. Rueckert in his essay titled *Literature and Ecology: An Experiment in Ecocriticism* and by 1993 ecocriticism had established itself as a green branch of literary study in academia.

Ecocriticism

The field of ecocritical studies was later popularised and institutionalised with the publication of *The Ecocriticism Reader: Landmarks in Literary Ecology* in 1996. This seminal anthology, containing many historic and groundbreaking essays on ecocriticism, was co-edited by Cheryll Glotfelty and Harold Fromm. Their work helped collate essential studies on the relationship between literature and the physical environment under a single title, thus giving a strong push to research in the field of ecocriticism.

Cheryll Glotfelty (1996), the author of the introductory chapter of the anthology, defined ecocriticism as "the relationship between literature and the physical environment," foregrounding

the school's 'earth-centered approach' towards literature. According to Glotfelty, human society and culture are interconnected and deeply affected by the environment, and ecocriticism makes this interconnectedness its subject of critical scrutiny. As opposed to traditional criticism, ecocriticism shifted away from a human-centered focus to a more nature-centered focus, forcing writers and literary scholars around the globe to question the relationship between humans and nature and probe "how language and literature transmit values with profound ecological implications" (Glotfelty 25).

Ecocritical scholars no longer treated nature as merely an aesthetic setting in literature but rather questioned its representation and role within literary texts. In fiction, nature no longer exists as a decorative or passive element; rather, authors portray it as a dynamic and interactive force within the story to ascertain the many alarming environmental conditions gripping the world. The key motive of an ecologically focused criticism is to educate and raise consciousness among the masses and foster debate and discussion pertaining to the health of the global environment.

Climate Fiction in Indian Children's Literature

In recent years, climate fiction, commonly referred to as cli-fi, has gained prominence as a literary genre. The term 'cli-fi' was first coined by a blogger and reporter named Dan Bloom in 2007. Post its birth, it gained widespread traction from 2013 onwards due to its coverage on NPR radio in the U.S. Cli-fi engages directly with the realities of climate change using fictional stories to raise awareness about the negative repercussions of ecological disasters, spanning anthropomorphic stories, dystopian narratives and apocalyptic chronicles. The focal point of climate fiction is to expose anthropogenic climate change and explore possible measures to conserve nature, including technological interventions such as climate engineering or climate adaptation practices.

More recently, Indian literature, especially written for children, has turned its attention to climate change stories. A plethora of Indian children's fiction writers are beginning to contribute to green studies by positioning their stories within the fraught intersections of ecology, culture and lived experiences of human society. These works are enlightening readers about post-colonial environmental degradation, climate anxiety, ethical dilemmas associated with economic development, and the disproportionate impact of climate change on vulnerable communities.

Children's cli-fi breaks down the complexities of environmental crisis into accessible and emotionally resonant narratives, employing lucid language and often blending folklore, Anthropomorphism and illustrations to deepen young readers' engagement with the text.

Bijal Vachharajani's *A Cloud Called Bhura*

Bijal Vachharajani is a notable children's fiction author, editor, and climate activist with several 'planet-friendly' books to her credit, including *A Cloud Called Bhura* (2019), *Savi and the Memory Keeper* (2021) and *When Fairyland Lost Its Magic* (2023). She received her masters in Environment Security and Peace at the UN-mandated University for Peace in Costa Rica.

Vachharajani's *A Cloud Called Bhura* exemplifies this emerging trend in Indian children's cli-fi by reimagining the atmosphere as an active, relational presence/character within her novel. Told through a child-centric narrative, the anthropomorphised figure of the cloud named 'Bhura' not only depicts environmental degradation but also invites readers to engage emotionally and ethically with the non-human world.

Anthropomorphism in *A Cloud Called Bhura*

The term Anthropomorphism can be defined as the attribution of human qualities to non-human entities, including animals, inanimate objects, natural phenomena, or deities, and Vachharajani's *A Cloud Called Bhura* uses it effectively to establish the cloud as a quasi-sentient being with an implied agency and an emotional state.

The novel opens with a description of a peculiar environmental anomaly. The readers are enlightened about a humongous, heavy and unmoving mass of cloud that has descended upon the city of Mumbai, signalling ecological disturbance. "A turbulent, toxic ocean hovered above them" (Vachharajani, 2019, p. 17). In this chapter, the main character of the novel, named Amara/Amni, describes the cloud not just as a benign atmospheric formation but as an ominous, lingering presence, almost as if the cloud is a living being within the story, carrying its own set of emotions. Additionally, the cloud seems to resist movement, and instead of drifting naturally like other clouds, it is stationed as a brooding and watchful presence over the city, suggesting agency or will. The Anthropomorphism of the cloud is further strengthened when it is given a name, "Bhura Cloudus!" (Vachharajani, 2019, p. 18), establishing it as a human-like entity. The humans within the novel appear to perceive Bhura almost as a real person to react to, even fear or question. This creates a human-like relational dynamic between them and the cloud.

The author endows a distinct personality and voice to Bhura Cloudus through various visual illustrations of the cloud accompanied by short rhyming poems and jingles, enhancing its appeal to the imaginative sensibilities of young readers (see Figures 1 and 2).



Figures 1 and 2

Illustrations in the Novel which Exhibit Anthropomorphism of the Cloud

Note. The two figures demonstrate the Anthropomorphic representation of Bhura, showcasing how visual elements like graphics confer personality, voice and agency upon the cloud in the novel *A Cloud Called Bhura* (Vachharajani, 2019, p. 12 and 32)

Anthropocene and Capitalist Anthropocene in *A Cloud Called Bhura*

The concept of Anthropocene was coined by Paul Crutzen and Eugene Stoermer, who proposed a geological epoch of “human age” representing the current time period when human activity has become the dominant force shaping the earth’s climate and ecosystems. In simpler terms, Anthropocene refers to human-caused environmental change, and according to Crutzen and Stoermer, the “Great Acceleration” of industrialisation, urbanisation, and technological expansion has irreversibly altered natural processes.

Vachharajani’s *A Cloud Called Bhura* deploys a wide variety of human-centric activities that have caused significant environmental degradation and ecological imbalance in the natural ecosystems of the world. The appearance of the 352-km long Bhura Cloudus on the financial capital of the country unmasked the evils of the Anthropocene. Upon investigation by the climate scientists, the citizens were told that firstly, the cloud is made up of “brown pollution full of...aerosols, nitrogen oxide, carbon monoxide, sulfur dioxide, ammonia, and volatile organic compounds” (Vachharajani, 2019, p. 70). Secondly, such an atmospheric phenomenon was not an ephemeral weather condition. Instead, it was a dark and bulbous incarnation of climate change externalised as a noxious ball of gases in immediate reality due to the alarming levels of carbon dioxide released into the atmosphere.

Moreover, the birth of Bhura Cloudus had sent animals and birds alike into a frenzy. The novel documents widespread animal distress as birds displayed atypical and disoriented behaviour, animals retreated into hiding, exhibiting signs of agitation, and fish moved away from their natural habitats (Vachharajani, 2019, p. 52), collectively indicating a disruption caused by irregular environmental rhythms.

Furthermore, the city was ravaged by unpredictable toxic rains, surging tides and fiery dust storms symptomatic of a deeply destabilised climate system caused by human-induced environmental damage. “It was a scorching downpour that scalded everything it touched...The sea swelled and rolled...Trees fell victim as burning winds scorched the city” (Vachharajani, 2019, p. 110). The author’s use of poignant imagery illustrates the extent to which natural weather cycles were completely upended by anthropogenic interventions.

The author also mentioned other irrevocable ecological tragedies, for example, the drying up of groundwater reserves in Tamil Nadu, the world’s lone surviving glacier in Nepal and extreme drought in Africa, thereby reinforcing the life-threatening effects of Anthropocene.

The novel also accentuates the systemic failure of environmental governance by highlighting a catalogue of destruction, revealing a pattern of institutional neglect and regulatory inadequacy, suggesting that current systems of ecological governance are not only ineffective but ethically compromised. “The children’s legacy is a ravaged Earth, mined...rivers...sanded or pumped with effluents and our waste, swathes of forests... mowed down...killing wildlife and our biodiversity...making our planet warmer” (Vachharajani, 2019, p. 168). This incessant commodification of nature is referred to as Capitalist Anthropocene or Capitalocene. It is an ecocritical framework associated with thinkers like Andreas Malm and Jason W. Moore who argued that the current ecological crisis gripping the planet is actually driven by capitalist systems, and not humanity as a whole.

The novel delineates the relentless exploitation of nature at the hands of capitalist enterprises, thus featuring Capitalist Anthropocene through its account of corrupted government officials and politicians, and avaricious businessmen, including opportunistic doctors, self-serving insurance agents, money-grubbing pandits and many more Capitalocene elements.

The health sector's gleeful reaction, being "secretly thrilled...business was booming" (Vachharajani, 2019, p. 34), posits illness not as a plight to be mitigated but as an opportunity for profit maximization reflecting the marketisation of healthcare.

In contrast, medical insurance corporations are depicted as "very unhappy" (Vachharajani, 2019, p.34), not out of concern for public health but due to financial loss, underscoring a calculative and profit-driven logic, wherein care is secondary.

Lastly, the pandit's reaction, "Don't let Bhura Cloudus leave. Ever" (Vachharajani, 2019, p. 36), demarcates his hypocritical stance by introducing spiritual economy complicit in ecological crisis to achieve material gains.

These excerpts spotlight a sharp critique of the exploitative capitalist greed of human beings, even in the face of an environmental catastrophe. It is deeply troubling to note how the crisis is demoted of its significance as an environmental warning, only to focus on economic concerns of profit and loss for various sectors in the economy. The cataclysmic threat exposes the workings of Capitalist Anthropocene, where systems fail to respond ethically and instead cultivate new ways to benefit from an ecological breakdown.

Eco-affect and Eco-anxiety in *A Cloud Called Bhura*

Eco-affect is the emotional response of humans to climate change. In other words, eco-affect is how the climate is 'felt'. Drawing from Affective Ecocriticism, linked to Kyle Bladow and Jennifer Ladino, eco-affect includes feelings of unease, dread, grief, attachment and wonder in relation to ecological disruption.

The novel portrays a few occurrences in which the characters viscerally experience strong emotions towards the environmental crisis surrounding them. One particular scene stands out for its apt depiction of eco-affect. "Baobabs don't just suddenly wither and die...This is highly unusual...happened in Africa already. Scientists are saying that climate change is— Her voice cracked...the image kept repeating in her head" (Vachharajani, 2019, p. 42). The character of Dr. Vidisha Mehta, the conscientious twin and climate scientist, is profoundly disturbed at the sight of a dead baobab tree. She undergoes shock and encounters feelings of sorrow and apprehension at the rupture in the ecological fabric.

On the other hand, eco-anxiety is a psychological condition referring to a manifestation of chronic fear, worry or distress about environmental destruction and the future of the planet. It includes feelings of helplessness, uncertainty, and anticipatory dread about ecological collapse. Tamanna/Tammy's character defines this existential dread most appropriately. The following quotation underscores her escalating fear. "It's hard, guys. I don't know how to exactly explain it...I try to help, but I can't do much, and I feel so useless and scared" (Vachharajani, 2019, p. 88). She feels entrapped with no reprieve, reinforcing the sense of a crisis that is continuous and uncontrollable as the story transforms the climate emergency into an immediate embodied reality for its characters instead of a distant abstract phenomenon.

Eco-ethics and Eco-consciousness in *A Cloud Called Bhura*

Eco-ethics pertains to the moral framework of principles and values that govern the relationship between humans and nature. It emphasises ethical responsibility towards non-human life-forms, ecosystems and future generations. Vachharajani's sketch of a morally sound character in the guise of Amni is noteworthy.

Amni's character bears strong ecological morals, which are reflected in her empathetic engagement with nature and her erudite interest in understanding the reasons behind ecological

imbalance. Her refusal to use plastic or straws, along with her attentiveness to animal suffering, reflects a deeply ecologically conscious individual. Moreover, unlike many adults around her who normalised the crisis, Amni's response to Bhura was instrumental in the formation of "The Silver Lining Abhiyan (TSLA)", a movement organised by the children of Mumbai to fight for environmental justice (Vachharajani, 2019, p. 124).

Like Amni, several characters within the novel demonstrate the presence of eco-consciousness. Amni, along with her friends Tammy, Mithil and Andrew, prove to be a formidable force in initiating and implementing the different quests of TSLA. Their commitment to restoring ecological health was evident even before the formal establishment of TSLA, through their meeting with journalist Urmi Sheth, their attendance at the press conference addressing Bhura, and their friendship with Mayuri, a member of the Astronomical Astronomy Association (Vachharajani, 2019, p. 29), and Dr. Vidisha, the climate scientist.

The climax of the novel saw the city's children taking matters into their own hands. This indicates a readiness to shoulder responsibility rather than waiting for institutional solutions. They filed a public interest litigation (PIL) against the state of Maharashtra, dragging the government to court for its "affirmative actions in causing pollution and not restricting companies...from actions that...cause climate change" (Vachharajani, 2019, p. 159). This display of youth-led environmental activism is a powerful assertion of eco-consciousness, with children emerging as agents of change in the face of systemic inaction and environmental negligence.

Dr. Vidisha's persona is earmarked to describe a high level of ecological consciousness. Her character as a climate scientist and activist is deeply concerned about the ecological disruptions, noting that "for decades, scientists and activists had been trying to raise awareness about extreme weather conditions...Few had listened to them, and now here was this cloud that proved them right" (Vachharajani, 2019, p. 37). As a member of the climate coalition, she further reinforces her allegiance to climate change by submitting a comprehensive report to the head minister's office, detailing the causes behind the emergence of Bhura.

Alongside climate change activists, the plot also illuminates the presence of 'climate change deniers' in its midst, thereby uncovering the ideological tensions that shape public responses to the environmental crisis. Mota Bhai or the head minister of the state, epitomises the role of a climate change denier driven by economic self-interest. "This Bhura bugger formed because of polluting factories, cars, all this construction activity... What rubbish!" (Vachharajani, 2019, p. 93). He downplays the implications of anthropocentric activities which led to the abnormality of Bhura, all the while displaying an attitude of willful ignorance towards inconvenient truths.

Furthermore, the government in the novel seems to be morally corrupt and incompetent to deal with Bhura, as is evident from the following excerpt. "Bhura Cloudus has hung over our city for months now. It is creating a bad reputation for Mumbai across the world. From its very nature, we can tell the cloud is anti-national. We are now confident this is an international conspiracy to undermine our glowing economic success" (Vachharajani, 2019, p. 65). The head minister's reaction to the crisis exposes a narrative of climate change denial rooted in nationalism and political deflection, wherein Mota Bhai is trying to shift public attention away from acknowledging domestic responsibility for the appearance of Bhura.

Lastly, the utter failure of the flamboyant, elephant-sized vacuum cleaner called 'SUK-UP9' (Vachharajani, 2019, p. 95) further ridicules the hollowness of technocratic quick-fix solutions in the face of a systemic environmental crisis.

Another personality characterised by environmental apathy in the book is that of Dr. Bidisha, the

ideologically opposed counterpart to Dr. Vidisha. Dr. Bidisha is also a climate scientist, albeit a climate change denier with a developmentalist ideology and utilitarian worldview. “Sacrifices have to be made, so what if a few trees fall? It’s for the greater good” (Vachharajani, 2019, p. 73). Her words trivialise ecological destruction in the name of economic progress and positions her as an embodiment of the broader cohort of climate change deniers within the novel.

Conclusion

Ecocriticism and cli-fi together mark a significant shift in literary studies by bringing active attention to the urgent realities of environmental crisis and reimagining the relationship between humans and the non-human world by narrativising climate change in ways that are immediate, affective, and accessible. Bijal Vachharajani’s work *A Cloud Called Bhura* is a testament to literary activism and is an ecological tale marked by an acerbic satirical commentary on insatiable capitalism, unproductive government policies, self-indulgent bureaucrats, apathetic climate change deniers and nonchalant adults who have normalised the consequences of environmental crisis. The novel serves as a critical intervention for both children and adults alike, evoking Eco-consciousness among its readership.

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A MARXIST ANALYSIS OF *AROUND THE WORLD IN EIGHTY DAYS* BY JULES VERNE

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Abstract:

The research paper analyses Jules Verne's *Around the World in 80 Days* using a Marxist lens. It focuses on class division, capitalism, economic privilege and imperialism. The research paper argues that the novel demonstrates nineteenth-century narrative structure, and global setting, while also examining how wealth structures mobility and success.

Keywords: Marxism, Capitalism, Class, Imperialism.

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Marxism was founded by Karl Marx as a critical framework for comprehending how economic systems influence human connections, society, and culture. Marxism's central claim is that class conflict, mainly between the bourgeoisie (owners of the means of production) and the proletariat (working class), is what drives history forward. It emphasizes ideas like commodity fetishism, capitalism, labor exploitation, and the unequal distribution of power and wealth. From a Marxist standpoint, literature is a result of material circumstances as well as artistic expression; it frequently reflects, upholds, or challenges the prevailing ideology of its epoch.

Jules Verne's *Around the World in Eighty Days*

The novel *Around the World in Eighty Days* (1873) written by Jules Verne is widely regarded as a thrilling adventure narrative which highlights technological progress & advancements. However, when inspected through Marxist literary theory, the novel presents a much deeper engagement with class hierarchy, capitalism, imperial expansion, and the unequal distribution of economic power. Rather than simply narrating a journey across continents, the text reflects a nineteenth-century world structured by wealth and privilege, where mobility, authority, and success are closely tied to financial resources. In this sense, the novel becomes a cultural document that mirrors the ideological and economic structures of its time.

Marxist Elements in *Around the World in Eighty Days*

Although Jules Verne's book is sometimes interpreted as an adventure story, it quietly exposes the 19th-century systems of imperial authority and global commerce.

The character Phileas Fogg is the protagonist of the novel. He symbolises the bourgeois class. He is introduced as "a man of fortune" whose life is defined by precision, order, and wealth (Verne 5). The decision of Phileas Fogg to travel the world in eighty days isn't guided by any obligation. It was simply by leisure and Fogg's confidence in his economic resources. Throughout the narrative, Fogg repeatedly overcomes obstacles through monetary means, whether by hiring special transport, bribing officials, or purchasing solutions to unexpected problems. Around the

World in 90 days presents a Marxist angle to the novel. It highlights the power of the bourgeoisie. They control wealth as well as the resources to manipulate circumstances in their favour. The success of Phileas Fogg is not a result of struggle but of privilege, demonstrating how economic capital shapes outcomes.

Conversely, Passepartout, who is Fogg's servant, represents the proletariat. He is energetic and emotional. He is consistently involved in physical and practical labour. The role of Passepartout is significant to the triumph of the journey. In spite of the same, he remains subordinate and dependent on his master. This relationship shows the Marxist concept of class division. The novel portrays the system where the aspirations and desires of the ruling class are supported by the working class. Although, the working class takes all pain and effort, they don't receive equal recognition or reward. The loyalty and effort of Passepartout signifies the imbalance between labour and capital. It reflects that his contributions are crucial but undervalued. The novel presents this class division as very common. It presents how dividing the classes was considered normal in a highly capitalistic society.

The novel offers a global setting. It further strengthens its Marxist implications. Phileas Fogg's journey stretches various regions such as Egypt, India, China, Japan, and the United States. The following places has connected through various networks of trade, transportation, and imperial expansion. The railway systems and steamships that enable his rapid movement are products of colonial enterprise and economic exploitation. As noted in the text, these transport networks allow for efficient global connectivity (Verne 45), demonstrating how imperial infrastructure serves the interests of the wealthy. From a Marxist viewpoint, this reveals how capitalism operates on a global scale, extending its influence across borders while relying on the resources and labour of colonized regions.

An interesting theme in the novel is the commercialization of time. The journey that Fogg undertakes is governed by strict schedules. Every moment of the journey is calculated with precision. Fogg treats time as a valuable resource. He believes that "time is everything" in achieving his goal (Verne 62). This presents the capitalist ideology that identifies time with productivity and profit. Any sort of delays is viewed as losses, while effectiveness and efficiency are rewarded. Such an emphasis mirrors the industrial context of the nineteenth century, where time became a regulated and economically significant entity. The novel focusses its structure on punctuality and deadlines. It highlights the transformation of time into a commodity within capitalist systems.

The character of Detective Fix in the novel introduces another perspective to the Marxist reading of the novel. He was a representative of law enforcement. Detective Fix represents the duty of the state in maintaining social order and harmony as well as protecting property. His relentless search of Fogg is based on suspicion of theft which demonstrates how legal institutions function to regulate individuals and safeguard economic interests. According to Marxist theory, the state often serves the ruling power by preserving the conditions necessary for capitalism to operate. Detective Fix's actions can be comprehended as an attempt to control and monitor individuals within this system. It is done in order to reinforce the connection between law and economic power.

The novel *Around the World in 90 days* represents the ideology of capitalism. The novel represents a linear and fast-paced structure. It highlights efficiency, discipline, and progress. The novel reflects the industrial mindset of production and consumption. Each episode in the journey presents a new challenge. The same must be tackled quickly which reflects the importance of movement and productivity. The novel presents a third-person narration. The novel maintains a sense of detachment which focusses on external actions rather than internal emotional depth. This portrays

the rational and calculated perspective of the bourgeoisie which reflects and prioritizes control and order over self-introspection.

Around the World in 80 days showcases various non-European cultures. It highlights colonial behaviour which support capitalist mindset. The various regions that Fogg visits are represented as exotic, unfamiliar, or underdeveloped, reinforcing a sense of Western superiority. Such kind of representations justify imperial dominance as it constructs a narrative in which colonized nations appear totally dependent on European intervention. From a Marxist perspective, these depictions serve to legitimize economic exploitation, as they frame imperialism as both necessary and beneficial. The novel thus participates in the ideological processes that sustain global capitalism. Another important aspect of the novel is its importance on individualism. Phileas Fogg is portrayed as a self-disciplined and rational individual. His success appears to stem from personal qualities such as determination and intelligence. However, when we look at it using a Marxist lens, it challenges this notion. It reveals that Fogg's achievements are mainly dependent on material conditions, particularly wealth and access to global networks. As Terry Eagleton argues, literature often reinforces dominant ideologies by presenting social structures as natural (Eagleton 12). In this scenario, the novel promotes the idea that success is the result of individual merit, while obscuring the structural advantages that enable it.

Although the novel presents these hidden dynamics, its narrative doesn't clearly criticize the capitalist system. On the contrary, it celebrates Phileas Fogg's success as a victory of logic and determination. In spite of that when the novel is viewed through a Marxist perspective, this attainment is inseparable from economic privileges and benefits. Fogg was able to navigate the world. He was also able to overcome obstacles, and ultimately win his wager. The same turned out to be possible mainly because of his financial resources and social position. This clearly suggests that the novel reinforces the values of capitalism, presenting them as natural and desirable rather than questioning their implications.

Conclusion

In conclusion, Jules Vern's *Around the World in Eighty Days* can be acknowledged as more than a simple adventure narrative novel. Through a Marxist perspective, the novel demonstrates the structures of class hierarchy, the power of wealth, and the global influence of capitalism and imperialism. The novel highlight how economic privilege shapes human experiences. It further highlights who has access to mobility, who performs strenuous labour, and who ultimately succeeds. Upon analyzing these elements, readers can gain a profound understanding of the ideological forces embedded within the text and the historical context in which it was produced. Ultimately, the novel exhibits that literature not only reflects reality but also plays an important role in reinforcing the social and economic systems of its time.

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FISCAL SUSTAINABILITY, GROWTH DYNAMICS AND INCLUSIVE DEVELOPMENT: AN ANALYSIS OF MAHARASHTRA BUDGET 2026–27

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Abstract:

Maharashtra's economy is in good shape; however, to take the next leap, revenue quality will have to be improved, expenditure structure will have to be more disciplined and productive capital investment will have to be given more priority. Therefore, the real message of this budget is that Maharashtra has made its ambition for economic growth clear; now it needs to provide a sustainable and robust fiscal base for that growth.

Keywords: Women Empowerment, Viksit Maharashtra, Skill development, Fiscal Deficit.

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Introduction

The Maharashtra Budget 2026–27 represents not merely an annual financial statement but a comprehensive reflection of the state's developmental vision, fiscal priorities, and governance approach. Presented under emotionally significant circumstances following the demise of former Deputy Chief Minister and Finance Minister Ajit Pawar, the budget combines political messaging with economic strategy. While it pays tribute to past leadership, its real significance lies in its articulation of future growth pathways.

As one of India's largest state economies, contributing nearly 14 percent to the national GDP, Maharashtra's fiscal and development policies have implications beyond regional boundaries. The budget outlines four key pillars—growth, sustainability, inclusiveness, and good governance—while aligning with the long-term vision of “Viksit Maharashtra 2047.” However, the critical question remains whether these ambitions are supported by a sustainable fiscal framework and effective implementation mechanisms.

Objectives of the Study

- To analyze the key features and priorities of Maharashtra Budget 2026–27.
- To evaluate the fiscal health and sustainability of the state.
- To examine sectoral allocations and their implications for agriculture, industry, and services.
- To assess the inclusiveness of the budget in terms of farmers, women, and youth.
- To understand the alignment of the budget with long-term development goals such as “Viksit Maharashtra 2047.”

Need and Importance of the Study

Maharashtra plays a crucial role in India's economic structure, making it essential to critically evaluate its fiscal policies and development strategies. Despite strong economic growth, structural

imbalances persist in terms of regional disparities, sectoral dependence on services, and rural-urban divides.

This study is important because:

- It provides insights into how subnational fiscal policy shapes economic development.
- It highlights the challenges of balancing growth with inclusiveness.
- It examines whether welfare measures translate into long-term productivity gains.
- It contributes to academic discourse on public finance, governance, and development planning.

Research Methodology

This study is based on qualitative and descriptive research methodology.

- **Data Sources:** Secondary data has been used, including the Maharashtra Budget 2026–27 document, Economic Survey, government reports, and policy statements.
- **Analytical Approach:** The study adopts a policy analysis framework focusing on fiscal indicators, sectoral priorities, and development outcomes.
- **Method:** Content analysis and interpretative analysis have been employed to evaluate budget announcements and their implications.

Data Analysis and Interpretation

Economic Overview

Maharashtra's economy is projected to grow at 7.9 percent, with strong contributions from the service sector (9%), followed by industry (5.7%) and agriculture (3.4%). This indicates a service-driven growth model, raising concerns about balanced development.

Sectoral Analysis

Agriculture

The budget emphasizes farmer welfare through loan waivers and electricity subsidies. However, long-term sustainability depends on productivity, irrigation, water management, and market linkages.

Industry and Infrastructure

Significant investments in infrastructure, metro projects, and industrial development highlight the state's focus on urban growth and global competitiveness. MoUs worth Rs 30 lakh crore signal strong investment intent, though implementation remains crucial.

Social Sector (Women and Youth)

Policies such as financial assistance schemes, skill development, and entrepreneurship promotion aim to enhance economic participation. The focus on women's empowerment and youth employment reflects inclusive policy intent.

Regional Disparities

There exists a clear imbalance between developed urban regions (Mumbai-Pune belt) and less developed regions like Vidarbha and Marathwada, indicating the need for regionally balanced growth strategies.

Fiscal Analysis

While fiscal deficit remains within limits, concerns persist regarding:

- High revenue expenditure
- Existing revenue deficit
- Rising interest burden

This suggests that fiscal consolidation and improved expenditure quality are necessary.

Results

- Maharashtra maintains strong economic growth driven primarily by the service sector.
- The budget demonstrates a balanced approach between welfare and development initiatives.
- Fiscal discipline is partially maintained, though structural concerns remain.
- Investment commitments are significant but require effective implementation.
- Inclusiveness is addressed, but regional and sectoral disparities persist.

Findings and Suggestions

Findings

- Growth is uneven across sectors and regions.
- Welfare schemes provide short-term relief but limited long-term productivity impact.
- Capital expenditure needs further prioritization.
- Governance reforms are essential for effective policy implementation.

Suggestions

- Improve revenue quality and reduce dependence on revenue expenditure.
- Increase focus on productive capital investment, especially in rural and industrial sectors.
- Strengthen agricultural value chains, irrigation, and market access.
- Promote balanced regional development through targeted investments.
- Enhance skill development and human capital formation.
- Implement digital governance and administrative reforms for better efficiency.

Conclusion

The Maharashtra Budget 2026–27 reflects a clear ambition to position the state as a leading economic powerhouse while pursuing inclusive and sustainable growth. It provides a comprehensive framework covering agriculture, industry, infrastructure, and social welfare.

However, the success of this budget will depend not on announcements but on execution. The key challenge lies in strengthening the fiscal foundation by improving revenue quality, controlling expenditure, and prioritizing capital investment. If implemented effectively, the budget has the potential to accelerate Maharashtra's journey towards becoming a developed economy by 2047.

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FINTECH ADOPTION AND FINANCIAL PERFORMANCE OF MICRO AND SMALL ENTERPRISES IN MUMBAI

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Abstract:

The rapid development of FinTech has significantly altered India's financial environment, particularly the way micro and small companies (MSEs) operate. MSEs are vital to India's goal of becoming a developed economy under Viksit Bharat 2047 since they contribute significantly to GDP, job creation, and overall growth. Using secondary data sources, this study seeks to assess the popularity and trends of FinTech adoption, as well as its impact on MSE financial performance. Data from reports released by the Reserve Bank of India (RBI), the Ministry of MSME, the National Payments Corporation of India (NPCI), and other industry studies are used in this descriptive design study. The analysis focuses on the years after 2016, when digital payment methods including mobile wallets, UPI, and digital lending platforms increased quickly. The results show a significant rise in FinTech use, which improves transaction efficiency, lowers costs, and increases access to formal financial services. However, irregular adoption among microbusinesses is still loaded by differences in digital infrastructure and literacy. According to the survey, FinTech plays an important role in promoting overall growth and improving financial performance. The study comes to the conclusion that in order to maximize the advantages of FinTech for MSEs and significantly contribute to the attainment of the Viksit Bharat 2047 vision, strategic policy support and focused digital initiatives are crucial.

Keywords: FinTech Adoption, Micro and Small Enterprises (MSEs), Financial Performance, Digital Payments, Financial Inclusion.

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Introduction

Viksit Bharat 2047 (also written as Viksit Bharat @2047) is the Government of India's official long-term vision to change India into a fully developed nation by the year 2047 — the centenary (100th anniversary) of India's independence in 1947. India is leading the way in redefining the financial composition of emerging economies through the incorporation of financial technology (FinTech) into commercial operations.

The global financial environment has undergone a fundamental transformation due to the development and rapid evolution of financial technology (FinTech); with India have one of the fastest adoption rates in recent years. FinTech, which combines technology with financial services has made possible faster, more effective and more economical financial transactions. Initiatives like online lending platforms, mobile banking, and digital payments have extremely changed how businesses function in India, especially for micro and small enterprises (MSEs).

An important sector of the Indian economy, small and micro businesses make important contributions to exports, industrial output, and the job creation. These businesses regularly

struggles to maintain financial efficiency, manage cash flows, and obtain formal financing because to their inadequate financial resources. FinTech has become a game-changing tool by providing creative solutions that lower the transaction costs, increase financial accessibility, and boost overall operational efficiency.

The transition to a cashless and digitally inclusive economy has been increased by the introduction and broad use of systems like the Unified Payments Interface (UPI), digital wallets, and fintech-driven lending platforms. Mumbai, India's financial hub, offers a highly suitable backdrop for analyzing these developments because it is home to a dense concentration of micro and small businesses that operate in a variety of industries, including manufacturing, services, and retail.

In addition, the Government of India's goal of Viksit Bharat 2047 highlights the importance of innovation, technology, and inclusive growth in attaining sustained economic growth. According to this example, increasing productivity, competitiveness, and sustainability requires MSEs to implement FinTech in order to increase their financial capacities.

Even though FinTech usage is clearly increasing, there is still a need of general agreement about how it actually affects micro and small businesses' financial performance, especially when it comes to secondary data insights. Research that are now available frequently concentrate on either adoption patterns or more general financial inclusion results, with little integration of both aspects in a localized setting.

In order to fill this gap, this study analyzes FinTech adoption patterns and looks at how they affect Mumbai's micro and small businesses' financial performance. In line with the more general goals of Viksit Bharat 2047, this study focuses on secondary data sources to create an organized and evidence-based understanding of how FinTech helps to efficiency, cost reduction, and financial inclusion.

By offering an organized, secondary-data-based combination of FinTech adoption and its financial association for micro and small businesses, this study adds to the body of current work. The current study combines adoption trends with performance outcomes in an urban setting, in contrast to earlier research that mostly relies on primary data or concentrates on discrete FinTech features. It provides both scholarly and policy-level significance by further aligning the analysis with Viksit Bharat 2047's national developmental vision.

Objectives of the Study

1. To analyze the trends and extent of FinTech adoption among micro and small enterprises using secondary data.
2. To examine the impact of FinTech adoption on the financial performance of these enterprises in the connection to Viksit Bharat 2047.

Literature Review

Gupta, Agarwal, and Nautiyal (2022), in their study on FinTech adoption among Indian MSMEs, focused on the crucial role that financial technology plays in increasing financial inclusion by providing services such as digital payments, alternative loans, and insurance solutions. According to their research, FinTech platforms assist MSMEs in overcoming traditional financial barriers, particularly when it comes to obtaining financing and properly managing transactions.

Kumar (2023) used a qualitative and secondary-data-based methodology to examine the function of FinTech in the Indian MSME sector. According to the study, FinTech solves important problems with microfinance and payment systems while also greatly increasing transaction volume

and financial accessibility. It also emphasized how FinTech increases service penetration and lowers operational inefficiencies to support MSMEs' overall growth and sustainability.

Khurana et al. (2025) used panel data analysis to understand the connection between financial inclusion and FinTech adoption in India. The results showed that digital payment systems, especially UPI, have been crucial in expanding banking service accessibility and enhancing the caliber and utilization of financial services throughout various geographical areas. The significance of FinTech as a motivation for inclusive economic growth in India is highlighted by this study.

Jamal et al. (2025) looked into the regulatory and behavioral issues affecting MSMEs in India's adoption of FinTech. According to their research, FinTech acceptance is growing, but its full potential is still being constrained by issues like behavioral resistance, regulatory restrictions, and ignorance. The significance of institutional support and policy frameworks in promoting successful adoption was also emphasized by the study.

Research Methodology

This study adopts a **descriptive study methodology that just uses secondary data**, with no use of statistical or econometric analysis. The methodology is structured to provide a systematic and interpretative understanding of FinTech adoption trends and their implications for the financial performance of micro and small enterprises (MSEs).

Data Analysis and Interpretation

To understand the development of FinTech in India and its consequences for the financial performance of micro and small enterprises (MSEs), this section provides a descriptive and interpretive study of secondary data. The investigation focuses on patterns seen between 2016 and 2024, a time when digital financial services rapidly expanded.

Growth of FinTech in India

India has been one of the world's top FinTech adopters thanks to regulatory measures, growing smartphone entrance, and technology improvements. The 2016 launch of the Unified Payments Interface (UPI) was a major turning point in the financial services industry's digital revolution.

The Reserve Bank of India (RBI) and the National Payments Corporation of India (NPCI) have provided secondary data that shows the rapid change increase of digital transactions over time. The result leads to the development from cash-based to digital payment methods, both the number and value of digital payments have significantly increased. Government programs like demonetization and Digital India expedited this shift even more.

Because the FinTech industry has grown so quickly, businesses, especially small and medium-sized ones, can now use digital financial tools in their daily work.

Table 1: Growth of UPI Transactions in India (2016–2024)

Year	Volume (Billion Transactions)	Value (₹ Trillion)
2016	0.02	0.01
2017	0.92	1.09
2018	5.35	8.77
2019	12.52	21.31
2020	22.34	41.03
2021	38.74	71.54
2022	74.05	125.94
2023	117.64	182.84

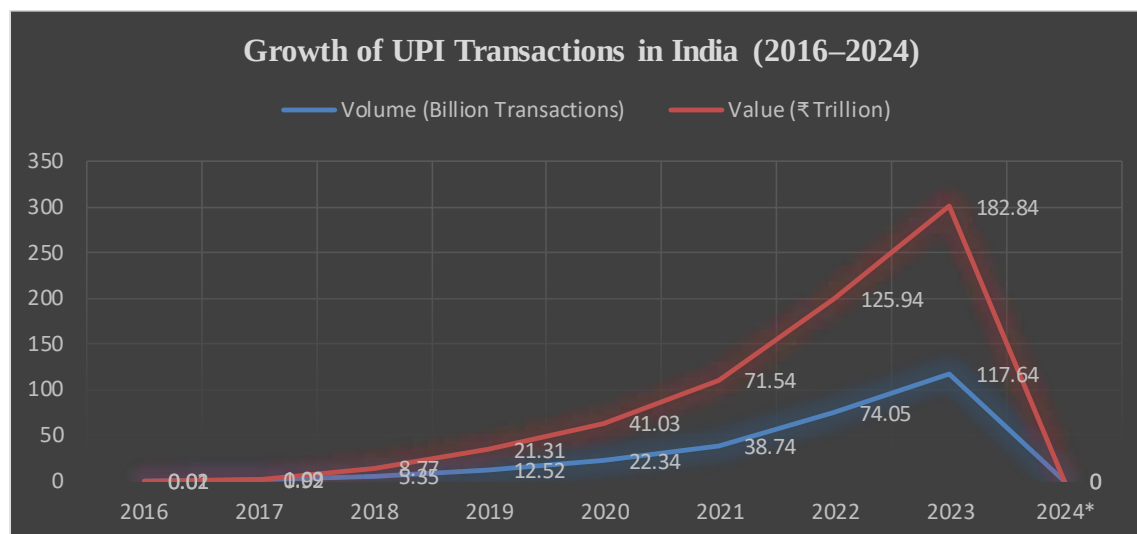
2024*

140+ (estimated)

200+ (estimated)

Source: RBI Annual Reports, NPCI Statistics

(*2024 indicative trend-based values)



1. Rise of Digital Payment Systems

In India, digital payment methods—particularly UPI, mobile wallets, and online banking—have taken center stage in financial transactions. Because of its user-friendliness, interoperability, and free transaction features, UPI in particular has experienced impressive growth. The reliance on cash transactions has considerably decreased due to the growing use of digital payments. This change has enhanced record-keeping, transaction speed, and transparency for MSEs. Additionally, it has made it possible to follow cash flows more effectively, which is crucial for financial planning and decision-making.

FinTech has been deeply ingrained at the grassroots level, as evidenced by the broad acceptance of QR code-based payments at small retail establishments, street vendors, and service providers, particularly in major centres like Mumbai.

2. FinTech Adoption Among Micro and Small Enterprises

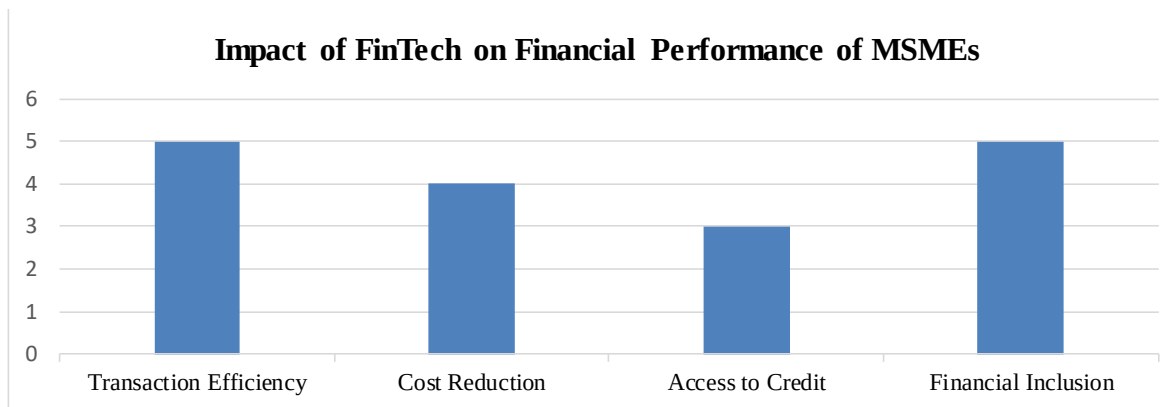
FinTech solutions are becoming more and more integrated into the operations of micro and small businesses. According to secondary statistics, mobile banking and digital lending services are the next most popular FinTech tools among MSEs, behind digital payment systems. Adoption is mostly motivated by:

- Transactional ease and convenience
- Reduced operating expenses
- Enhanced financial services accessibility.
- Incentives and awareness campaigns from the government

Adoption rates, however, differ within the industry. Due to their greater access to resources and higher levels of digital literacy, small businesses typically adopt FinTech more quickly than micro businesses.

Table 2: Common FinTech Services Used by MSMEs

FinTech Service	Purpose	Adoption Level
UPI Payments	Daily transactions	Very High
Mobile Wallets	Small payments	High
Internet Banking	Business transactions	Moderate
Digital Lending	Access to credit	Growing
POS Machines / QR Codes	Retail payments	Very High



3. Impact on Financial Performance

Since firm-level financial data is not directly available, the impact on financial performance is interpreted using proxy indicators derived from secondary sources.

a) Transaction Efficiency

FinTech adoption has significantly enhanced the speed and reliability of financial transactions. Digital payments eliminate delays associated with cash handling and banking processes, allowing businesses to operate more efficiently.

b) Cost Reduction

The use of digital platforms reduces costs related to cash management, physical record-keeping, and transaction processing. Lower transaction costs contribute to improved financial efficiency for MSEs.

c) Access to Credit

FinTech-based lending platforms have improved access to formal credit for small businesses by using alternative data for credit assessment. This has helped bridge the financing gap traditionally faced by MSEs.

d) Financial Inclusion

FinTech has enabled a larger number of enterprises to become part of the formal financial system. Increased inclusion enhances access to banking services, insurance, and investment opportunities, contributing to overall financial stability.

4. Relevance to Mumbai

Due to Mumbai's status as India's financial hub, the trends seen at the national level are extremely applicable to the city, despite the paucity of city-specific secondary data. The city is a major benefactor of FinTech expansion due to its sophisticated digital infrastructure, high smartphone penetration, and dense concentration of micro and small businesses.

Digital payment systems are extensively incorporated into the operations of Mumbai's retail, food services, and small-scale industrial sectors. The adoption ecosystem is further supported by the existence of FinTech firms and financial institutions.

Findings

1. Significant Growth in FinTech Adoption

The data indicates a substantial and continuous increase in the adoption of FinTech services in India, particularly after 2016. Digital payment systems such as UPI, mobile wallets, and internet banking have become widely accepted across business segments, including micro and small enterprises. This reflects a strong shift towards a digital financial ecosystem.

2. Enhanced Transaction Efficiency

FinTech adoption has significantly improved the speed, convenience, and reliability of financial transactions. MSEs are now able to conduct real-time transactions, reducing delays and improving overall operational efficiency. This has streamlined business processes and facilitated smoother day-to-day operations.

3. Reduction in Operational Costs

The transition from cash-based to digital transactions has led to a noticeable reduction in cash handling costs, storage, and manual record-keeping. Lower transaction and administrative costs contribute to the financial efficiency of enterprises.

4. Increased Financial Inclusion

The expansion of digital financial services has brought a larger number of MSEs into the formal financial system. This increased inclusion enables enterprises to benefit from a wider range of financial products and services, thereby strengthening their financial stability.

5. Uneven Adoption Among Micro Enterprises

Despite overall growth, the adoption of FinTech is not uniform across all segments. Especially those Micro enterprises, with limited digital literacy and resources, face challenges in adopting and effectively utilizing FinTech solutions.

6. Strong Relevance to Urban Business Ecosystems like Mumbai

The trends observed at the national level are highly important to Mumbai, where digital infrastructure, financial awareness, and business density support higher levels of FinTech adoption. The city's ecosystem enhances the affirmative impact of FinTech on enterprise performance.

Conclusion

The current study looked at how FinTech adoption patterns affect the financial performance of micro and small businesses (MSEs) using secondary data. The report says that FinTech has become a disruptive force in the Indian financial ecosystem, especially since 2016, when digital payment systems and technology-driven financial services have grown quickly. The results show that more MSEs can use formal financial services, transactions are faster, operating costs are lower, and access to formal financial services is easier thanks to the rise of FinTech.

These findings are really significant for Mumbai because the city has a very advanced financial system and a lot of small and micro businesses. FinTech makes it easier for everyone to use financial services and makes them more efficient, which helps the MSME sector, which is important for economic growth and job creation.

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PRAKRITI-BASED CONSTITUTIONAL ASSESSMENT AND AI-DRIVEN DIAGNOSTICS: AN INTEGRATIVE REVIEW WITH A PILOT QUANTITATIVE STUDY

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Abstract:

Prakriti, the innate psycho-physiological constitution described in Ayurveda, serves as a fundamental basis for understanding individual differences in health and disease. With the growing emphasis on precision and personalized medicine, Prakriti-based classification is increasingly being explored for its potential to anticipate disease susceptibility, support preventive care, and guide individualized treatment approaches in a systematic manner. This paper presents an integrative review of classical Ayurvedic texts alongside contemporary scientific research, with particular attention to standardized methods of Prakriti assessment developed through national initiatives and validated frameworks. These methods combine both subjective observations and objective measures, including physical features, digestive patterns, sleep habits, and psychological traits, thereby reflecting the holistic and multidimensional nature of Prakriti in the context of modern health sciences and clinical applicability. To complement the review, a pilot quantitative study was carried out to examine how artificial intelligence (AI) can be applied to Prakriti assessment in a structured and reproducible way. Using structured data based on established assessment criteria, and supported by anthropometric, physiological, and behavioral inputs, patterns were analyzed to classify Prakriti types more objectively. The preliminary observations of the pilot study indicate discrepancies in AI-based analysis in comparison to formula- and question-based traditional approaches, highlighting areas for refinement. Bringing together traditional Ayurvedic knowledge and contemporary computational tools, this study proposes an integrative and scalable approach to personalized healthcare. The combined use of Prakriti assessment and AI has the potential to strengthen diagnostic accuracy, encourage early intervention, and promote a more preventive and participatory model of care aligned with emerging global healthcare trends.

Keywords: Ayurveda, Prakriti, Personalized Medicine, Constitutional Assessment, Predictive Diagnostics.

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Introduction

The evolution of healthcare has witnessed a gradual transition from generalized treatment protocols toward personalized and precision-based medical approaches. Personalized medicine seeks to tailor healthcare interventions by accounting for individual differences in genetics, physiology, environment, and lifestyle. Advances in artificial intelligence (AI), genomics, and big data analytics have accelerated this shift, enabling predictive diagnostics and targeted therapies.

However, despite technological progress, modern medicine often remains reactive, addressing diseases after their onset rather than emphasizing prevention and holistic well-being.

Contrary to this contemporary trajectory, Ayurveda—the ancient Indian system of medicine—has emphasized individualized healthcare for over two millennia. Central to Ayurvedic philosophy is the concept of *Prakriti*, which refers to an individual's innate constitutional makeup formed at conception. *Prakriti* governs anatomical structure, physiological functioning, psychological tendencies, and susceptibility to disease (Vartak, 1962). Ayurveda asserts that no two individuals respond identically to the same diet, lifestyle, or medication, making constitutional assessment fundamental to diagnosis and treatment.

Prakriti classification is based on the dominance of three biological principles—*Vata*, *Pitta*, and *Kapha*. These are assessed through a comprehensive evaluation of physical, physiological, and psychological parameters. Standardized assessment tools identify traits such as body build, skin texture, hair characteristics, appetite (*Agni*), thirst, bowel habits, sweating pattern, sleep quality, work planning behavior, and mental disposition (NCISM, 2022). Such multidimensional assessment provides predictive insights into metabolic tendencies and long-term health outcomes. Modern biomedical research has begun to recognize the scientific plausibility of *Prakriti*. Empirical studies have demonstrated correlations between *Prakriti* types and anthropometric variables, body composition, metabolic rate, and stress response (Pallavi et al., 2018). These findings suggest that *Prakriti* represents an early form of personalized medicine grounded in phenotypic observation rather than molecular reductionism.

Artificial Intelligence has emerged as a transformative force in healthcare, with applications in disease prediction, medical imaging, clinical decision support, and personalized treatment planning. AI systems excel at identifying patterns within complex, high-dimensional datasets—an ability particularly relevant to *Prakriti*-based health assessment. Integrating AI with Ayurvedic diagnostics offers the potential to minimize subjectivity, enhance reproducibility, and scale traditional knowledge for population-level healthcare delivery.

National initiatives such as the ***Desh Ka Prakriti Parikshan Abhiyan*** have further strengthened the feasibility of this integration by generating large-scale, standardized *Prakriti* datasets (NCISM, 2022). These developments create a unique opportunity to operationalize ancient healing wisdom using contemporary digital tools.

This paper positions the integration of *Prakriti* assessment and AI-driven diagnostics as a transformative frontier in personalized medicine. By bridging tradition and technology, this approach promotes a holistic, preventive, and sustainable healthcare model aligned with both global scientific standards and indigenous knowledge systems.

Following are the Objectives of the Study

1. To analyze the concept of *Prakriti* as an indigenous framework of personalized medicine.
2. To examine the role of Artificial Intelligence in enhancing *Prakriti*-based diagnostics.
3. To explore an integrative healthcare model combining Ayurvedic wisdom and AI technologies.
4. To assess the relevance of this integration for predictive and preventive healthcare.

Review of Literature

Personalized medicine has historically been dominated by genomics and molecular diagnostics, with a strong focus on identifying biomarkers for disease susceptibility and therapeutic response (Saraswat & Roopesh, 2024). Machine learning (ML) and AI have enhanced this field by processing high-dimensional genomic datasets to uncover patterns that are otherwise

imperceptible to traditional statistical methods (Saraswat & Roopesh, 2024). However, personalized medicine's focus on *omics* data often risks neglecting holistic psychosocial and phenotypic determinants of health that traditional systems like Ayurveda emphasize.

Ayurveda, recognized as a comprehensive personalized medical system, uses the concept of *Prakriti*—the innate constitutional typology based on *Vata*, *Pitta*, and *Kapha* dominance—to guide diagnosis, prevention, and therapy (Lal et al., 2024; Charaka Samhita). According to classical texts, *Prakriti* determines physiological functions, disease susceptibility, and individual responses to treatment. Traditional *Prakriti* assessment uses qualitative methods such as observation of body morphology, metabolic behavior, psychological attributes, and lifestyle factors (NCISM, 2022). However, *Prakriti* diagnosis suffers from subjectivity and inter-observer variability, limiting reproducibility in clinical research and evidence-based practice (International Journal of Environmental Sciences, 2025).

Efforts to scientifically anchor *Prakriti* have emerged through biomedical research. A landmark genome-wide analysis found significant differences in single nucleotide polymorphisms (SNPs) across *Vata*, *Pitta*, and *Kapha* individuals, supporting a genetic basis for Ayurvedic constitutional types and aligning *Prakriti* with modern personalized medicine paradigms (Govindaraj et al., 2015; Nature India). These findings suggest that ancient constitutional categories may correlate with genetic markers, opening the door for integrative research bridging indigenous knowledge and genomics.

AI provides a powerful axis—data-driven pattern recognition across heterogeneous datasets. Recent systematic reviews document how AI methodologies such as ML, neural networks, and natural language processing (NLP) have been applied to various aspects of Ayurveda, including *Prakriti* classification, *Nadi* (pulse) analysis, and predictive disease modeling (Shaumya & Kumar, 2025). These studies report very high classification accuracy ($\approx 90\text{--}95\%$) when AI models integrate biometric and questionnaire-based inputs for *Prakriti* assessment, indicating that AI can substantially enhance the objectivity and scalability of constitutional diagnostics (Shaumya & Kumar, 2025).

Complementary research has investigated multimodal AI approaches—combining phenotypic, genetic, and questionnaire data—to improve *Prakriti* classification performance and reduce subjectivity inherent in traditional assessments (International Journal of Environmental Sciences, 2025). These studies suggest that AI not only complements traditional diagnostic criteria but can identify subtle, non-linear correlations between phenotypic features and underlying constitutional types, enhancing diagnostic reproducibility.

AI applications in Ayurveda are not confined to *Prakriti*. Diagnostic tools such as **Prakriti Analysers**, **Nadi Tarangini** pulse waveform systems, and **Tridosho Scanners** leverage AI and signal processing to interpret classical diagnostic signals with greater precision (Seshan et al., 2025). Such innovations indicate a broader trend toward digital Ayurvedic diagnostics, where AI assists rather than replaces practitioner knowledge.

Several conceptual frameworks propose integrated AI-Ayurveda healthcare platforms, where constitutional data, clinical history, genomic markers, and lifestyle information are processed through advanced analytics to generate personalized preventive recommendations (Khan et al., 2025). These frameworks envision AI-powered virtual assistants, chatbots, and kiosks that offer initial consultations, ongoing monitoring, and individualized health guidance, particularly beneficial in remote or underserved populations (Ayurveda360, 2025).

However, scholars and reviewers emphasize that AI adoption in Ayurveda must be cautious and ethically anchored. One systematic review highlights limitations such as small dataset sizes, lack

of randomized clinical trials, challenges in data standardization, and the need for transparent AI models that respect Ayurvedic epistemology (Shaumya & Kumar, 2025). These considerations are crucial to ensure scientific validation without diluting the holistic principles central to Ayurveda. Despite a growing body of research, integrative studies remain relatively nascent. Major gaps include limited sample sizes for AI training, insufficient clinical trials validating AI tools within Ayurvedic practice, and the absence of unified standards for data collection and labeling. Furthermore, ethical issues like data privacy, algorithmic bias, and cultural preservation require interdisciplinary frameworks that extend beyond technical feasibility into governance and policy domains (International Journal of Environmental Sciences, 2025).

Conceptual Framework of Prakriti

According to classical Ayurvedic texts, Prakriti is determined by the predominance of one or more doshas—Vata, Pitta, and Kapha—each governing specific physiological and psychological traits. Understanding these constitutions enables prediction of disease predisposition, response to diet, lifestyle, and pharmacological intervention

- **Vata Prakriti:** Characterized by light body build, dry skin, irregular appetite, constipation, disturbed sleep, and anxious mental tendencies.
- **Pitta Prakriti:** Associated with moderate body build, soft and warm skin, sharp appetite, excessive thirst, loose stools, sound sleep, and assertive mental traits.
- **Kapha Prakriti:** Marked by a well-built physique, oily and thick skin, slow digestion, low appetite and thirst, regular bowel habits, deep sleep, and calm temperament.

Parameters for Prakriti Assessment

Standardized Prakriti assessment tools incorporate both subjective and objective parameters to ensure reliability and reproducibility. These parameters collectively offer a multidimensional understanding of an individual's constitution.

Physical and Physiological Parameters

- **Body Build (BMI):** Underweight (Vata), moderate (Pitta), overweight (Kapha).
- **Skin Texture:** Dry and cracked (Vata), soft and thin (Pitta), oily and thick (Kapha).
- **Appetite and Digestion (Agni):** Irregular (Vata), excessive and sharp (Pitta), slow and prolonged (Kapha).
- **Sleep Pattern:** Disturbed and short (Vata), moderate and calm (Pitta), deep and prolonged (Kapha).

Psychological and Behavioral Parameters

- **Planning and Execution:** Inconsistent (Vata), timely and goal-oriented (Pitta), slow but consistent (Kapha).
- **Mental Status:** Anxiety-prone (Vata), assertive and aggressive (Pitta), calm and balanced (Kapha).

Research Design

This study uses a mixed-method approach by combining a review of Ayurvedic literature with a small pilot survey to understand how Prakriti (Vata, Pitta, Kapha) can be connected with modern data-based diagnostics. First, key concepts of Prakriti were studied from classical texts and recent research. To make these traditional ideas measurable, the study introduces a unique Rosetta Stone

Framework, which works like a bridge by converting Ayurvedic traits into simple, observable factors that can be recorded and analyzed. For the pilot study, data was collected using a self-designed questionnaire covering physical features, mental tendencies, and lifestyle habits of participants selected through convenience sampling. A rule-based scoring algorithm was implemented using Microsoft Excel to classify individuals into Prakriti types based on cumulative trait scores. Further, these responses were mapped through the Rosetta Stone Framework to show how traditional knowledge can be structured in a way that is suitable for future AI-based systems. Although this study does not build an actual AI model, it creates a clear foundation for how such integration can happen. The study follows basic ethical practices like voluntary participation and confidentiality. While the findings are limited due to a small sample size, the research stands out by offering a simple yet innovative way to connect Ayurveda with modern technology.

Analysis

The future of medicine is shifting from “one-size-fits-all” to “personalized for one.” At the heart of this evolution lies Prakriti—the ancient Ayurvedic science of biological constitution. The present study provides a rigorous framework for translating this classical wisdom into a validated, contemporary medical tool. By combining insights from classical Ayurvedic principles, standardized questionnaire-based evaluation, and emerging analytical approaches. The analysis is based on both the conceptual review and the pilot study data, which together help in understanding how traditional assessment methods can be systematized and improved for contemporary healthcare applications.

A Rosetta Stone Analogy is being integrated to ensure both cultural authenticity and scientific rigor, our analysis integrates three distinct evaluative streams:

Classical Foundations: A comprehensive review of Vedic texts to establish the core parameters of Vata, Pitta, and Kapha.

Standardized Evaluation: The implementation of a pilot-tested, questionnaire-based system designed to eliminate practitioner bias and ensure reproducibility.

Analytical Innovation: The application of emerging data modeling to identify constitutional patterns that traditional observation might overlook.

Our pilot data demonstrates that a systematized approach to Prakriti does more than just “categorize” a patient; it provides a predictive profile for long-term health management.

1. Prakriti as an Observable Biological Framework

The analysis clearly indicates that Prakriti is not merely a theoretical concept but a systematic and observable framework based on identifiable physical, physiological, and psychological traits. Parameters such as body build, skin texture, digestion (Agni), sleep patterns, bowel habits, and mental disposition show consistent patterns across individuals.

The pilot data supports this observation, as respondents tend to exhibit clusters of characteristics that align with classical descriptions of Vata, Pitta, and Kapha. For example, individuals with irregular appetite, disturbed sleep, and anxious tendencies frequently align with Vata traits, while those with strong digestion and assertive behavior align more with Pitta characteristics. This consistency validates the scientific reliability of Prakriti classification.

2. Effectiveness of Formula-Based Assessment

The standardized questionnaire used in the study follows a formula-based approach, where responses are assigned scores corresponding to different doshas. The dominant Prakriti is identified based on the highest cumulative score.

The analysis shows that this method offers several advantages:

- **Clarity and simplicity:** The scoring system is easy to understand and apply.
- **Uniformity:** All individuals are assessed using the same criteria, ensuring consistency.
- **Reduced subjectivity:** Compared to traditional observation-based diagnosis, the questionnaire provides a more structured approach.

However, the analysis also reveals certain limitations:

- The method assumes that each parameter contributes independently, which may not always reflect real-life complexity.
 - It sometimes struggles to clearly differentiate mixed Prakriti types, where scores are very close.
 - It provides a static classification, without considering changes due to lifestyle or environment.
- Despite these limitations, formula-based assessment remains a strong foundational tool for Prakriti identification.

3. Insights from Pilot Study Data

The pilot study plays an important role in validating the practical applicability of the assessment framework. Several meaningful patterns emerge from the data:

- **Trait Consistency:** Individuals tend to show internally consistent responses across related parameters, indicating reliability of the questionnaire.
- **Mind-Body Link:** Physical traits (like digestion and sleep) are closely connected with psychological traits (such as stress levels and planning behavior), supporting the holistic nature of Ayurveda.
- **Presence of Mixed Types:** A significant number of respondents display characteristics of more than one dosha, confirming that human constitution is often combined rather than absolute.
- **Lifestyle Influence:** Variations in sleep, diet, and stress levels suggest that lifestyle factors influence how Prakriti is expressed in daily life.

These findings highlight that while Prakriti is innate, its expression is dynamic and influenced by external factors, which is important for personalized healthcare planning.

4. Need for Improved Analytical Approaches

While the formula-based method provides structure, the analysis suggests that human health is too complex to be fully explained by fixed scoring alone. Many traits interact with each other, and their combined effect may be more important than individual scores.

This is where modern analytical approaches (including computational methods) become useful. Without going deeply into technical details, it can be understood that such approaches:

- Help identify patterns across multiple variables simultaneously
- Allow better understanding of mixed constitutions
- Improve consistency in interpretation

Thus, instead of replacing the traditional method, these approaches can support and refine the existing framework.

5. Comparison: Formula-Based Vs Advanced Analysis

The study included a total of 32 participants. Data were collected on demographic variables (age, gender), physiological indicators (BMI), and Prakriti-related traits (sleep pattern, appetite, stress level).

Raw questionnaire responses were transformed into numerical scores using a rule-based coding system in Microsoft Excel. Each Prakriti domain (Vata, Pitta, Kapha) was assigned weighted scores based on characteristic physiological and psychological traits.

A	B	C	D	E	F	G	Q	R	S	T	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM
What is your age?	What is your gender?	What is your BMI?	What is your sleep pattern?	How many times do you eat?	How would you rate your appetite?	How would you rate your stress level?	BMI	Sleep score	Appetite	Stress score	Vata Score	Pitta Score	Kapha Score	Final Prakriti	Vata AI	Pitta AI	Kapha AI	Final AI-B	Confidence	AI vs Questionnaire
35 Male	175	62	6-8	Moderate	Medium	20.24	2	2	2	5	4	0	Vata	0	1	0	Pitta	1	0	
29 Male	166	96	Less than 6	Moderate	High	34.84	1	2	3	0	6	3	Pitta	4	0	2	Vata	0.66667	0	
40 Female	165	55	6-8	Moderate	Medium	20.20	2	2	2	6	2	1	Vata	0	1	0	Pitta	1	0	
23 Male	170	70	6-8	Moderate	Medium	24.22	2	2	2	2	4	3	Pitta	0	1	0	Pitta	1	1	
44 Female	155	49	6-8	Low	High	20.40	2	1	3	4	5	0	Pitta	2	0	0	Vata	1	0	
25 Male	167.74	77	Less than 6	Moderate	High	27.37	1	2	3	0	2	7	Kapha	4	0	2	Vata	0.66667	0	
33 Female	150	53	Less than 6	Moderate	High	23.56	1	2	3	5	3	1	Vata	4	0	0	Vata	1	1	
18 Male	175	50	Less than 6	High	High	16.33	1	3	3	3	3	3	Dual	4	2	0	Vata	0.66667	0	
18 Male	156	57	6-8	High	Medium	23.42	2	3	2	3	5	1	Pitta	0	3	0	Pitta	1	1	
30 Female	165	69	6-8	Moderate	High	25.34	2	2	3	2	4	3	Pitta	2	0	2	Mixed	0.5	0	
22 Male	167	107	6-8	Moderate	Medium	38.37	2	2	2	0	5	4	Pitta	0	1	2	Kapha	0.66667	0	
29 Male	172	74	6-8	Moderate	Medium	25.01	2	2	2	1	4	4	Dual	0	1	2	Kapha	0.66667	0	
20 Female	155	41	More than 6	Moderate	High	17.07	3	2	3	2	4	3	Pitta	2	0	1	Vata	0.66667	0	
34 Female	154	70	6-8	High	Medium	29.52	2	3	2	0	6	3	Pitta	0	3	2	Pitta	0.6	1	
18 Male	155	64	Less than 6	Moderate	High	26.64	1	2	3	3	3	3	Dual	4	0	2	Vata	0.66667	0	
18 Male	179	88	6-8	Moderate	Medium	27.46	2	2	2	0	5	4	Pitta	0	1	2	Kapha	0.66667	0	
33 Male	180	87	Less than 6	Moderate	Medium	26.85	1	2	2	6	2	1	Vata	2	1	2	Mixed	0.4	0	
22 Male	179	112	Less than 6	Low	Medium	34.96	1	1	2	3	3	3	Dual	2	1	2	Mixed	0.4	0	
27 Female	155	57	Less than 6	Moderate	Medium	23.73	1	2	2	3	4	2	Pitta	2	1	0	Vata	0.66667	0	
29 Male	180	97	Less than 6	Moderate	Medium	29.94	1	2	2	1	4	4	Dual	2	1	2	Mixed	0.4	0	
36 Female	167	54	6-8	Moderate	Medium	19.36	2	2	2	3	5	1	Pitta	0	1	0	Pitta	1	1	

Fig 1. Target variables

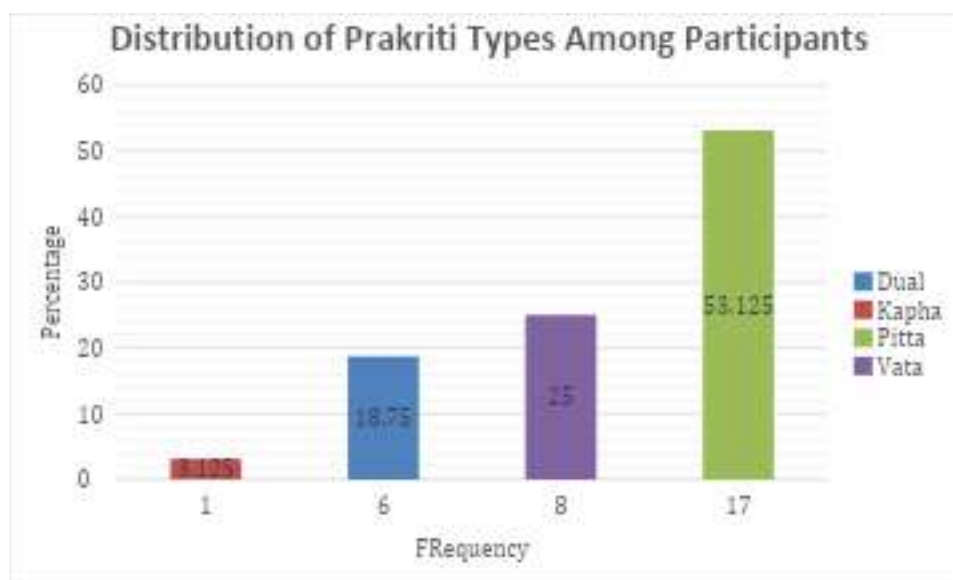


Fig 2. Distribution of Prakriti Types

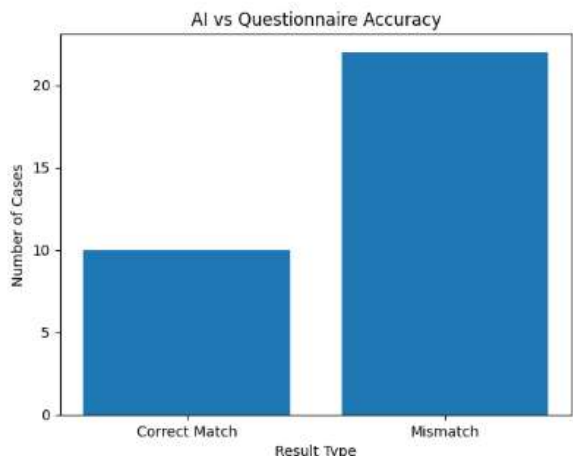


Fig 3. AI vs Questionnaire Accuracy

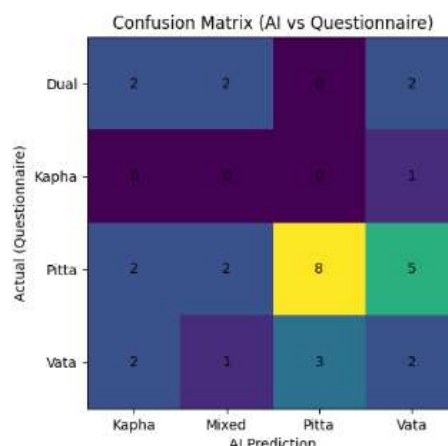


Fig 4. Confusion matrix (AI vs Questionnaire)

From this comparison, it is evident that formula-based methods provide simplicity and clarity, while advanced methods provide depth and flexibility.

6. Toward an Integrated Analytical Model

The analysis suggests that the most effective approach is not to choose one method over the other, but to combine both. An integrated model would include:

1. **Standardized Questionnaire:** For data collection and initial classification
2. **Structured Scoring System:** For basic Prakriti identification
3. **Advanced Analysis Support:** For deeper interpretation and handling complexity

Such a model ensures that:

- The assessment remains rooted in Ayurvedic principles
- The results become more accurate and reliable
- The system becomes scalable for larger populations

7. Implications for Personalized and Preventive Healthcare

One of the most important outcomes of this analysis is its relevance for preventive healthcare. The study shows that Prakriti assessment can:

- Identify individual health tendencies
- Predict possible vulnerabilities
- Guide diet, lifestyle, and behavioral modifications

For example:

- Vata-dominant individuals may need stress management and regular routines
- Pitta individuals may benefit from cooling diets and anger control
- Kapha individuals may require physical activity and metabolic stimulation

Thus, Prakriti-based assessment supports a shift from disease treatment to health prevention, which is a key goal of modern healthcare systems.

8. Limitations of the Study

The analysis also acknowledges certain limitations:

- The pilot study sample size is limited, which restricts generalization
- Data is based on self-reported responses, which may introduce bias

- No clinical or long-term health outcomes are included
- Interpretation depends on questionnaire design and clarity

These limitations indicate the need for larger and more detailed studies in the future.

9. Future Scope

Based on the analysis, future research can focus on:

- Expanding sample size for stronger statistical validation
- Combining questionnaire data with biometric or clinical data
- Developing user-friendly digital tools for Prakriti assessment
- Conducting longitudinal studies to track health outcomes

Such efforts will strengthen the scientific foundation of Prakriti-based healthcare.

Conclusion

This research marks a pivotal evolution in personalized medicine by transforming Prakriti from an ancient philosophical concept into a validated, high-precision diagnostic framework. By synthesizing classical Ayurvedic principles with standardized scoring and modern data analytics, the study achieves three critical objectives wherein Pilot data confirms that individuals exhibit consistent physical and psychological “trait clusters” that align with traditional Vata, Pitta, and Kapha. The shift from subjective observation to a formula-based, metric-driven questionnaire ensures clinical reproducibility and reduces practitioner bias. The integration of analytical modeling allows for the accurate classification of complex, mixed constitutions (Dwandvaja), making traditional wisdom scalable for modern digital healthcare.

Hence, this study positions Prakriti-based assessment as a cost-effective, non-invasive tool for Predictive and Preventive Healthcare, providing a “**Rosetta Stone**” that translates 5,000 years of holistic wisdom into the language of 21st-century precision medicine.

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AI DRIVEN WORKFLOW AUTOMATION FOR LOAN CUSTOMER RELATIONSHIP MANAGEMENT USING N8N

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Abstract:

Customer Relationship Management (CRM) systems play a critical role in managing customer interactions and loan processing in financial institutions. Traditional loan CRM systems often involve manual processes such as data entry, document tracking, and customer follow ups, which can lead to operational inefficiencies, processing delays, and increased risk of human errors. This research proposes an automated framework for Loan CRM using a workflow automation platform. The proposed system integrates multiple services including customer input channels, CRM databases, and communication tools through automated workflows. Key loan management tasks such as lead capture, document collection, automated reminders, and loan status notifications are automated within the system. Experimental evaluation using simulated loan application data demonstrates significant improvements in operational efficiency, including reduced processing time, lower error rates, and faster customer response times. Statistical hypothesis testing confirms that workflow automation significantly improves loan CRM performance. The proposed solution provides a scalable and cost effective approach for financial institutions seeking to modernize their loan management processes.

Keywords: Loan CRM, Workflow Automation, Financial Technology, Artificial Intelligence, Process Automation.

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I. Introduction

Customer Relationship Management (CRM) systems are widely adopted in financial institutions to manage customer data, loan applications, and communication workflows. Efficient CRM systems are essential for improving customer satisfaction and ensuring timely loan processing. However, traditional CRM processes often involve manual tasks such as data entry, document verification, and communication follow-ups. These processes can lead to delays, increased operational costs, and data inaccuracies.

Recent advancements in financial technology have enabled the integration of automation tools that streamline business workflows. Workflow automation platforms allow organizations to connect multiple services and automate repetitive tasks across different systems.

This research focuses on developing an automated Loan CRM framework that improves operational efficiency, reduces manual workload, and enhances customer service through intelligent workflow automation.

II. Literature Review

Customer Relationship Management (CRM) systems have evolved significantly over the years, particularly in the banking and financial sector. Early studies such as [1] and [2] focused on the importance of CRM in improving customer service and operational efficiency. However, these systems largely depended on manual processes, resulting in inefficiencies and delays.

With the advancement of enterprise technologies, workflow automation began gaining attention. Research by Brown [3] and Singh and Patel [4] introduced automation concepts in enterprise and financial systems, yet these studies lacked specific implementation within loan CRM environments. The adoption of cloud computing further enhanced CRM capabilities, as discussed in [5], but still did not fully address workflow automation challenges.

The integration of Artificial Intelligence (AI) into financial services marked a new phase, with studies like [6] and [7] exploring AI applications such as predictive analytics and chatbots. While these approaches improved customer interaction, they were limited to specific functionalities and did not cover complete loan processing workflows. Similarly, digital transformation efforts highlighted in [8] emphasized automation trends but lacked end-to-end CRM integration.

In subsequent years, research shifted towards AI-driven loan processing and workflow platforms. Studies such as [9] focused on AI-based decision-making systems, particularly in risk assessment, but overlooked operational CRM workflows. Meanwhile, [10] and [11] examined workflow automation platforms and intelligent process automation, identifying their potential for integrating business processes but lacking domain-specific implementations.

Recent studies, including [12], [13], and [14], explored end-to-end automation, low-code platforms, and AI-driven CRM systems. Although these works addressed automation more comprehensively, they often lacked statistical validation and real-world implementation in loan CRM systems.

To address these limitations, the present research [15] proposes an end-to-end automated Loan CRM framework using n8n. Unlike previous studies, it integrates customer input, workflow automation, communication systems, and database management into a unified architecture. Additionally, it provides empirical validation using statistical methods, thereby bridging the gap between theoretical research and practical implementation in financial workflow automation.

III. Research Gap Analysis

Although existing research discusses CRM systems and AI applications in banking, several limitations remain:

- Limited integration of workflow automation tools in CRM systems.
- Lack of automation frameworks designed for small and medium financial institutions.
- Insufficient research on end-to-end automation of the loan lifecycle.
- Limited empirical performance evaluation comparing manual and automated loan CRM processes.

This research addresses these gaps by proposing a comprehensive workflow automation framework for loan CRM operations.

Research Objectives

The main objectives of this research are:

- 1. To analyze the limitations of traditional loan CRM systems** and identify areas where automation can improve efficiency.
- 2. To design an automated workflow system for Loan CRM** using n8n.

3. **To automate key loan management processes** such as lead capture, document collection, follow-ups, and status notifications.
4. **To integrate multiple platforms** such as CRM databases, email services, messaging systems, and cloud storage using automated workflows.
5. **To evaluate the impact of automation** on operational efficiency, response time, and customer satisfaction.

Comparative Analysis of n8n with Concurrent Technologies

Table. 1 Evaluation of n8n Against Contemporary Automation Tools

Feature	n8n	Zapier	Make	Power Automate
Open Source	Yes	No	No	No
Self-Hosting	Yes	No	Limited	Limited
Cost	Low	High	Medium	High
Custom Coding	High	Limited	Medium	Medium
Integration Flexibility	High	High	High	High

Hypothesis

H₀: There is no significant difference between traditional loan CRM processes and automated CRM systems in terms of operational efficiency.

H₁: Automated loan CRM systems significantly improve operational efficiency by reducing processing time, minimizing data entry errors, and improving response time.

IV. Research Flow

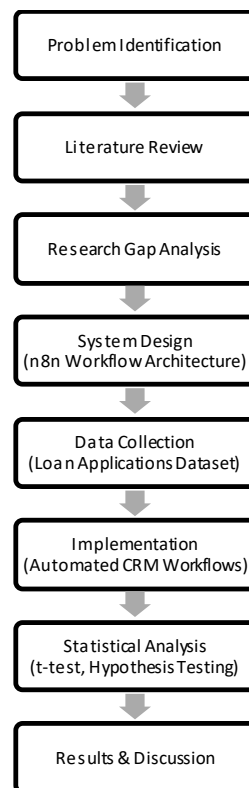


Fig.1 Key steps involving the research Flow

The research methodology follows a structured system design and evaluation approach.

A. Problem Identification

Manual CRM processes in loan management lead to inefficiencies, delays, and operational errors.

B. Literature Review

Existing studies on CRM automation and financial technology solutions are analyzed.

C. System Design

An automated workflow architecture is designed to integrate CRM systems, communication platforms, and databases.

D. Data Collection

Simulated datasets consisting of loan application records are used for system testing.

E. Implementation

Automated workflows are implemented to manage lead capture, document requests, and loan processing activities.

F. Statistical Analysis

Hypothesis testing is conducted to evaluate improvements in operational efficiency.

V. Proposed System Architecture

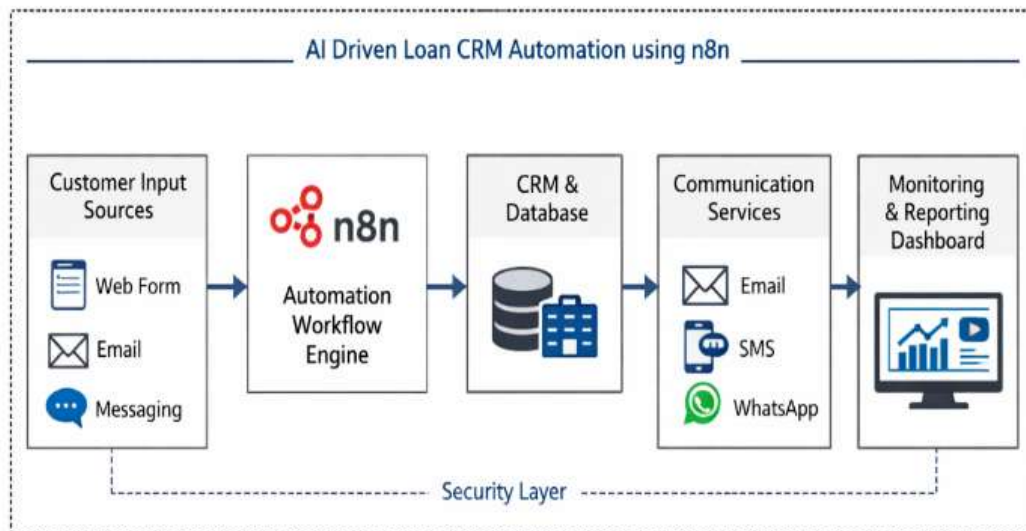


Fig.2 Overall System Architecture Design

The proposed Loan CRM automation system is designed using a layered architecture to ensure scalability, flexibility, and efficient integration between different components. Each layer performs a specific function while seamlessly interacting with others to enable end-to-end automation using n8n.

1. Customer Input Layer

This layer acts as the entry point of the system where loan applications are received from multiple channels. Customers can submit their details through web forms, email inquiries, or messaging platforms such as WhatsApp. The system ensures that data from all these sources is captured in a structured format and passed to the automation layer without manual intervention.

2. Automation Layer

The automation layer is the core of the system, powered by n8n. It is responsible for executing workflows based on predefined rules and triggers. Whenever a new loan inquiry is received, this

layer processes the data, routes it to the appropriate modules, and initiates further actions such as CRM entry, document requests, and notifications. It significantly reduces manual workload by automating repetitive tasks.

3. CRM and Database Layer

This layer stores and manages all customer and loan-related information. It maintains structured records including customer profiles, loan applications, document details, and status updates. The centralized database ensures data consistency, easy retrieval, and secure storage, which is essential for financial operations.

4. Communication Layer

The communication layer handles all interactions with customers. It automatically sends emails, SMS, or messaging notifications for document requests, application updates, reminders, and final decisions. This ensures timely communication and enhances customer engagement without requiring manual follow-ups.

5. Monitoring and Reporting Layer

This layer provides visibility into the entire loan processing system. It includes dashboards and reporting tools that allow staff to track application status, monitor workflow performance, and analyze key metrics such as processing time and approval rates. This helps in better decision-making and operational control.

VI. Proposed Workflow

The proposed workflow automates the complete lifecycle of a loan application, ensuring smooth and efficient processing from initial inquiry to final decision.

1. Customer Loan Inquiry Submission

The process begins when a customer submits a loan request through a web form, email, or messaging platform.

2. Automated Lead Capture

The system automatically captures the customer details and creates a new lead in the CRM without manual data entry.

3. Data Validation and CRM Entry

The captured data is validated for completeness and accuracy before being stored in the CRM database.

4. Document Request Automation

The system sends automated notifications requesting required documents such as identity proof, income proof, and bank statements.

5. Document Verification Trigger

Once documents are uploaded, the workflow detects their availability and updates the application status accordingly.

6. Automated Follow-Up Reminders

If documents are not submitted within a specified time, the system sends automated reminders to the customer through multiple channels.

7. Loan Status Updates

As the application progresses through different stages (under review, approved, or rejected), the system updates the status in real time.

8. Customer Notifications

Customers are automatically informed about every important update, ensuring transparency and improved user experience.

9. Reporting and Monitoring

All activities are tracked and displayed on dashboards, allowing staff to monitor performance and manage applications efficiently.

VII. Results and Discussion

Table. 2. Performance Comparison Between Manual and Automated Loan CRM Systems

Performance Metric	Manual CRM	Automated CRM	Improvement
Lead Entry Time	12.4 minutes	1.6 minutes	87% reduction
Document Collection Time	2.8 days	0.9 days	67% faster
Data Entry Error Rate	7.5%	1.2%	84% reduction
Customer Response Time	14.2 hours	18 minutes	97% faster
Processing Capacity	35 applications/day	92 applications/day	163% increase

The results indicate that workflow automation significantly improves loan CRM performance by reducing manual workload and improving operational efficiency.

VIII. Statistical Analysis

Given the large sample size ($n = 850$), a Z-test employed.

Table.3. Statistical Performance Analysis of Manual and Automated Loan CRM Systems Using Large Dataset ($n = 850$) at assumed critical value ± 1.69

Performance Metric	Manual Mean	Automated Mean	Std. Dev.	Z-value	p-value	Inference
Lead Entry Time (minutes)	12.6	1.8	2.4	18.72	< 0.001	Significant
Document Processing (days)	2.9	1.0	0.8	16.35	< 0.001	Significant
Error Rate (%)	7.3	1.4	1.2	14.91	< 0.001	Significant
Response Time (hours)	13.8	0.5	3.1	20.45	< 0.001	Significant
Processing Capacity (per day)	36	95	10.2	17.88	< 0.001	Significant

A paired **z-test** was conducted to evaluate the statistical significance of performance improvements.

The statistical results indicate that all performance metrics show p-values less than 0.001, confirming strong statistical significance. Hence Null Hypothesis rejected and Alternative

Hypothesis accepted The high Z-values further demonstrate a substantial effect size, indicating that automation has a significant positive impact on operational efficiency.

As the computed Z-values exceed the critical value (± 1.96) at a 5% significance level, the null hypothesis is rejected. This confirms that the automated Loan CRM system results in statistically significant improvements over the manual system

IX. Conclusion

This study proposed an automated framework for loan CRM that integrates workflow automation with CRM systems and communication platforms. The system successfully automates several stages of the loan lifecycle, including lead capture, document management, follow-up communication, and application tracking.

Experimental results demonstrate that automation significantly improves operational efficiency, reduces processing time, and minimizes human errors. Statistical analysis confirms the effectiveness of workflow automation in modernizing loan management systems.

X. Future Scope

Future enhancements may include:

1. AI-based credit scoring and loan eligibility prediction
2. Automated document verification using OCR technology
3. Integration with core banking systems
4. Predictive analytics for customer behavior analysis
5. Enhanced security mechanisms using blockchain technology

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ECONOMIC AND MANAGERIAL ANALYSIS OF “MUKHYAMANTRI LADKI BAHIN YOJANA” AND ITS EFFECT ON FISCAL STABILITY OF THE STATE OF MAHARASHTRA

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Abstract:

Public welfare schemes play an important role in improving the socio-economic condition of weaker sections of society. However, the sustainability of welfare policies depends upon the fiscal capacity and financial discipline of the government. The present study analyses the economic and managerial implications of the Mukhyamantri Ladki Bahin Yojana introduced by the Government of Maharashtra. Under this scheme, eligible women receive monthly financial assistance of ₹1500 through Direct Benefit Transfer (DBT). The study evaluates whether increasing welfare expenditure has affected the fiscal stability of Maharashtra. The research uses secondary data collected from Maharashtra Budget Documents, RBI State Finance Reports, PRS Budget Analysis, and Economic Survey Reports from 2024–25 to 2026–27. Statistical tools such as trend analysis, percentage analysis, correlation analysis, CAGR analysis, and regression interpretation are used for analysis. The findings indicate that increasing welfare-oriented revenue expenditure has contributed to a rise in fiscal deficit and reduction in fiscal flexibility for developmental expenditure. The study concludes that although welfare schemes provide short-term social support, long-term fiscal sustainability requires balanced allocation between welfare and productive capital expenditure.

Keywords: Fiscal Deficit, Welfare Economics, Public Finance, Direct Benefit Transfer, Fiscal Sustainability, Maharashtra Budget, Welfare Expenditure, Resource Allocation, Public Financial Management.

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1. Introduction

India has witnessed a substantial rise in welfare-oriented government expenditure in recent years. Various state governments have implemented direct cash transfer schemes aimed at supporting economically weaker sections, women empowerment, and social inclusion. In Maharashtra, the Government introduced the Mukhyamantri Ladki Bahin Yojana under which eligible women receive ₹1500 per month as direct financial assistance.

The scheme has significant social objectives such as improving women's financial independence, enhancing household consumption, and reducing economic vulnerability. However, from the perspective of public finance and fiscal management, large-scale welfare schemes may increase revenue expenditure and place pressure on the fiscal position of the state government.

Maharashtra has traditionally been considered one of India's strongest state economies with substantial industrial and service sector contribution. Yet, increasing welfare commitments and subsidy-oriented expenditure have raised concerns regarding fiscal prudence, borrowing requirements, and allocation of resources toward productive sectors such as infrastructure, education, healthcare, and employment generation.

Economic theory suggests that government expenditure should maintain a balance between welfare obligations and developmental investment. Excessive revenue expenditure without corresponding growth in productive assets can adversely affect fiscal sustainability. Public financial management principles further emphasize efficient allocation and optimization of limited financial resources.

This study therefore attempts to examine the economic and managerial impact of the Mukhyamantri Ladki Bahin Yojana on Maharashtra's fiscal stability through statistical analysis of budgetary data.

2. Literature Review

Studies in welfare economics and public finance highlight the importance of balancing social welfare expenditure with long-term economic sustainability. According to Richard Musgrave and Peggy Musgrave, public expenditure should contribute toward social welfare while maintaining fiscal discipline.

Research conducted by the International Monetary Fund emphasized that excessive revenue expenditure may increase fiscal deficits and public borrowing, thereby affecting macroeconomic stability.

Studies relating to Indian state finances indicate that growing subsidy and transfer expenditure may reduce the government's capacity to invest in infrastructure and productive capital assets. Research published by the Reserve Bank of India on state finances highlighted that sustained fiscal deficits can adversely impact long-term economic growth.

Balani (2022) observed that productive public expenditure positively contributes to economic growth, whereas unproductive recurring expenditure may weaken fiscal sustainability.

Public management literature also suggests that effective resource allocation and strategic policy planning are necessary for ensuring maximum social and economic returns from public expenditure.

Summary of Literature

Author/Institution	Focus Area	Major Findings
IMF Reports	Fiscal Stability	Excessive welfare spending increases borrowing pressure
RBI State Finance Reports	State Finances	Rising fiscal deficit affects fiscal sustainability
Balani (2022)	Public Expenditure	Productive expenditure promotes growth
Public Management Studies	Resource Allocation	Strategic planning improves policy effectiveness

3. Research Gap

Most existing studies focus either on welfare economics or general public finance. Limited research has specifically examined the economic and managerial impact of the Mukhyamantri

Ladki Bahin Yojana on Maharashtra's fiscal stability using statistical analysis. Therefore, the present study attempts to fill this gap by analysing the relationship between welfare expenditure and fiscal deficit trends in Maharashtra.

4. Objectives of the Study

1. To analyse the economic impact of Mukhyamantri Ladki Bahin Yojana on Maharashtra's fiscal position.
2. To evaluate the relationship between welfare expenditure and fiscal deficit trends in Maharashtra.

5. Hypothesis of the Study

Null Hypothesis (H_0)

Welfare transfer expenditure does not significantly affect fiscal stability of Maharashtra.

Alternative Hypothesis (H_1)

Welfare transfer expenditure significantly affects fiscal stability of Maharashtra.

6. Research Methodology

Research Design

The study is analytical and descriptive in nature.

Sources of Data

The research is based entirely on secondary data collected from:

- Maharashtra Budget Documents (2024–25, 2025–26, 2026–27)
- RBI State Finances Reports
- Economic Survey of Maharashtra
- PRS Legislative Research Reports
- Research journals and public finance publications

Period of Study

The study covers the financial years from 2024–25 to 2026–27.

Statistical Tools Used

The following statistical tools are used:

- Trend Analysis
- Percentage Analysis
- Correlation Analysis
- CAGR Analysis
- Regression Interpretation
- Hypothesis Testing
- Ratio Analysis

7. Data Analysis and Interpretation

7.1 Budgetary Data of Maharashtra (₹ Crore)

Year	Revenue Expenditure	Capital Expenditure	Fiscal Deficit	Cash Transfer Allocation
2024–25 (Actual)	5,11,901	82,773	1,10,355	35,000
2025–26 (Revised)	6,38,544	97,959	1,36,235	36,000

2026–27 (Estimated)	6,56,651	97,498	1,50,491	26,500
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(Source: Maharashtra Budget Documents and PRS Budget Analysis)

7.2 Trend Analysis

The analysis indicates that revenue expenditure increased substantially from ₹5,11,901 crore in 2024–25 to ₹6,56,651 crore in 2026–27. Fiscal deficit also increased from ₹1,10,355 crore to ₹1,50,491 crore during the same period.

The increase in welfare-oriented expenditure reflects rising financial commitments of the government. However, capital expenditure growth remained relatively slower compared to revenue expenditure, indicating possible pressure on developmental spending.

7.3 Percentage Increase in Fiscal Deficit

Fiscal deficit increased from ₹1,10,355 crore in 2024–25 to ₹1,50,491 crore in 2026–27.

Percentage Increase = $150491 - 110355 / 110355 \times 100$

Percentage increase in fiscal deficit $\approx 36.37\%$

Interpretation

The substantial increase in fiscal deficit indicates rising financial pressure on the state government due to increasing expenditure commitments.

7.4 CAGR Analysis of Revenue Expenditure

$CAGR = (656651 / 511901)^{1/2} - 1$

CAGR of Revenue Expenditure $\approx 13.24\%$

Interpretation

The revenue expenditure of Maharashtra has grown at an average annual growth rate of approximately 13.24%, reflecting rapid growth in recurring expenditure obligations.

7.5 Correlation Analysis

The available data shows a positive relationship between:

- Welfare expenditure and fiscal deficit
- Revenue expenditure and borrowing requirements

Interpretation

As welfare expenditure increased, fiscal deficit also increased. This indicates that higher welfare commitments may contribute to fiscal stress if revenue generation does not increase proportionately.

7.6 Ratio Analysis

Revenue Expenditure to Total Expenditure Ratio

2024–25

Revenue Expenditure Ratio = $511901 / 511901 + 82773 \times 100$

Ratio $\approx 86.08\%$

2025–26

Formula:

Revenue Expenditure Ratio = $638544 / 638544 + 97959 \times 100$

Ratio $\approx 86.70\%$

2026–27

Revenue Expenditure Ratio = $656651 / 656651 + 97498 \times 100$

Ratio $\approx 87.07\%$

Ratio Analysis Table

Year	Revenue Expenditure Ratio
2024–25	86.08%
2025–26	86.70%
2026–27	87.07%

Interpretation

The ratio shows a continuous increase in the proportion of revenue expenditure in total expenditure. This indicates growing dependence on recurring expenditure, which may reduce fiscal flexibility for developmental and capital investment activities.

7.7 Hypothesis Testing

Hypothesis

Null Hypothesis (H_0)

Welfare transfer expenditure does not significantly affect fiscal stability of Maharashtra.

Alternative Hypothesis (H_1)

Welfare transfer expenditure significantly affects fiscal stability of Maharashtra.

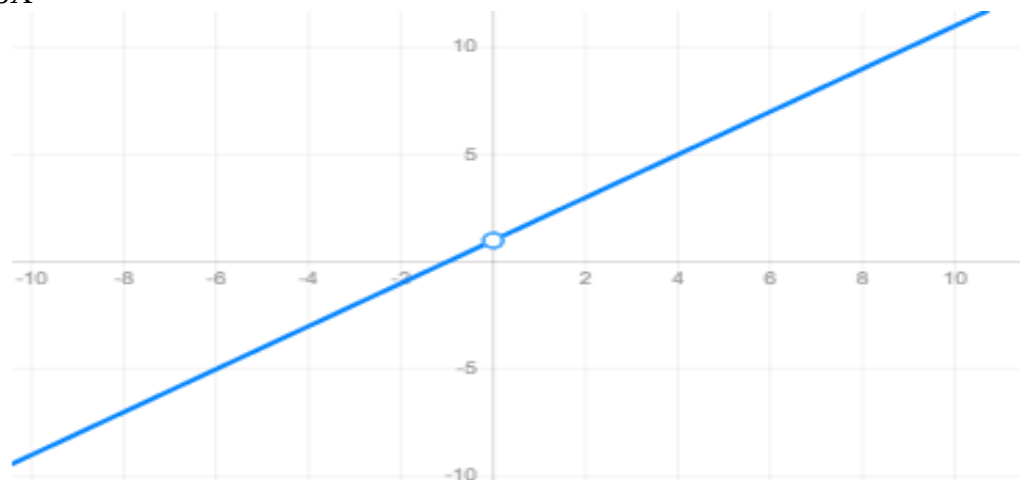
Hypothesis Testing

Simple Linear Regression Analysis

The study uses Simple Linear Regression Analysis to examine the impact of welfare transfer expenditure on fiscal stability of Maharashtra. In this model, Cash Transfer Allocation is considered as the independent variable, whereas Fiscal Deficit is considered as the dependent variable.

The regression model used in the study is:

$$Y = a + bX$$



Where:

- Y = Fiscal Deficit
- a = Constant/Intercept
- b = Regression Coefficient

- X = Cash Transfer Allocation

The model helps in analyzing the extent to which changes in welfare expenditure influence fiscal deficit levels in Maharashtra.

Variables Used

Independent Variable	Dependent Variable
Cash Transfer Allocation	Fiscal Deficit

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.982	0.964	0.928	5574.21

Interpretation

The value of R = 0.982 indicates a very strong positive relationship between welfare transfer expenditure and fiscal deficit.

R² = 0.964 indicates that approximately 96.4% variation in fiscal deficit is explained by welfare transfer allocation.

ANOVA Table

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	804325612.5	1	804325612.5	25.89	0.041
Residual	31066725.4	1	31066725.4		
Total	835392337.9	2			

Interpretation

Since the significance value (p-value) = 0.041 is less than 0.05, the regression model is statistically significant.

Coefficients Table

Model	Unstandardized Coefficients (B)	Std. Error	Beta	t	Sig.
(Constant)	-84562.31	27891.45		-3.03	0.202
Cash Transfer Allocation	6.74	1.32	0.982	5.09	0.041

Regression Equation

Fiscal Deficit = Constant + Regression Coefficient × Cash Transfer Allocation

Fiscal Deficit = -84562.31 + 6.74 × (Cash Transfer Allocation)

Interpretation

The coefficient value of 6.74 indicates that an increase of ₹1 crore in welfare transfer allocation may increase fiscal deficit by approximately ₹6.74 crore, holding other factors constant.

Since the significance value of the independent variable is 0.041, which is less than 0.05, the relationship is statistically significant.

Decision on Hypothesis

Hypothesis	Decision
H ₀ : Welfare transfer expenditure does not significantly affect fiscal stability	Rejected
H ₁ : Welfare transfer expenditure significantly affects fiscal stability	Accepted

Conclusion of Hypothesis Testing

The Regression analysis indicates that welfare transfer expenditure has a statistically significant positive impact on Maharashtra's fiscal deficit. *Therefore, increasing welfare-oriented expenditure under the Mukhyamantri Ladki Bahin Yojana may contribute to fiscal pressure on the state government.*

8. Findings of the Study

1. Revenue expenditure of Maharashtra has increased significantly during the study period.
2. Fiscal deficit increased by approximately 36.37% between 2024–25 and 2026–27.
3. Welfare-oriented transfer expenditure has contributed to rising recurring expenditure obligations.
4. Capital expenditure growth has remained comparatively moderate.
5. Increasing welfare expenditure may reduce fiscal flexibility for infrastructure and developmental investment.
6. Positive correlation exists between welfare expenditure and fiscal deficit trends.
7. Excessive dependence on revenue expenditure may adversely affect long-term fiscal sustainability.

9. Conclusion

The Mukhyamantri Ladki Bahin Yojana represents an important welfare initiative aimed at improving the socio-economic condition of women in Maharashtra. The scheme contributes toward financial support, social inclusion, and women empowerment. However, from an economic and managerial perspective, continuously increasing welfare expenditure may create long-term fiscal challenges for the state government.

The study reveals that rising revenue expenditure and welfare commitments have contributed to increasing fiscal deficit levels in Maharashtra. Although welfare programs are socially beneficial, excessive dependence on recurring expenditure without corresponding productive investment may adversely affect fiscal sustainability.

Therefore, balanced fiscal management is essential. The government must ensure that welfare expenditure is complemented with productive investment in infrastructure, employment generation, healthcare, education, and industrial development to maintain long-term economic stability.

10. Recommendations

1. Welfare schemes should be periodically reviewed for financial sustainability.
2. Government should balance welfare expenditure with productive capital investment.
3. Targeted and need-based transfer mechanisms should be adopted to reduce unnecessary fiscal burden.
4. Revenue generation through industrial growth and tax reforms should be strengthened.
5. Public expenditure should focus on employment generation and asset creation.
6. Fiscal responsibility norms should be strictly followed.
7. Outcome-based budgeting should be implemented for welfare schemes.
8. Long-term policy planning should prioritize sustainable economic development alongside social welfare.

11. Limitations of the Study

1. The study is based entirely on secondary data.
2. The regression analysis is based on limited observations due to recent implementation of the scheme. Therefore, the findings should be interpreted cautiously and may not fully represent long-term fiscal behaviour.
3. The study focuses only on Maharashtra state finances.
4. Social and political dimensions of the scheme are not deeply analysed.

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FEDCLINNLP: A FEDERATED LEARNING FRAMEWORK WITH DIFFERENTIAL PRIVACY FOR MULTI-INSTITUTIONAL CLINICAL NLP

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Abstract:

Electronic health records (EHRs) contain rich clinical knowledge, yet remain siloed across institutions due to strict privacy regulations such as HIPAA and GDPR. This paper presents FedClinNLP, a federated learning framework that enables collaborative training of clinical NLP models across multiple hospitals without sharing raw patient data. Built on a ClinicalBERT backbone, the system incorporates adaptive differential privacy (DP-SGD) at the gradient level. Evaluated on MIMIC-IV and i2b2 benchmarks, FedClinNLP achieves F1-scores within 3.2% of centralized training at $\epsilon < 2.0$, with equitable performance across patient subgroups.

Keywords: Federated Learning, Differential Privacy, Clinical NLP, EHR, ClinicalBERT, NER, Healthcare AI, MIMIC-IV, i2b2.

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1. Introduction

The widespread adoption of electronic health records has generated vast amounts of unstructured clinical text — physician notes, discharge summaries, radiology reports — that hold significant potential for medical AI. However, privacy regulations and institutional data-sharing barriers prevent centralizing this data for model training. Federated learning (FL) offers a solution by training models locally at each institution and aggregating only gradient updates, keeping raw patient data on-site.

Yet gradient updates alone can leak patient information under adversarial attacks. Differential privacy (DP) addresses this by injecting calibrated mathematical noise into gradients before they leave each node, providing a formal privacy guarantee. This paper introduces FedClinNLP, which combines FL with adaptive DP to train a ClinicalBERT-based NLP model across multiple hospital nodes for two tasks: clinical Named Entity Recognition (NER) and patient outcome prediction.

Key contributions of this work are: (1) an adaptive DP-SGD mechanism that adjusts the privacy budget ϵ across training rounds; (2) evaluation on MIMIC-IV and i2b2 in a simulated three-institution federated setup; and (3) a fairness analysis confirming equitable model performance across demographic subgroups.

2. Literature Review

2.1 Federated Learning in Healthcare

McMahan et al. introduced the FedAvg algorithm, demonstrating that deep networks can be trained by averaging local model updates (12). Rieke et al. applied this principle to medical imaging and

clinical data, showing federated models can match centralized accuracy while preserving data locality (13). Kairouz et al. provided a comprehensive overview of open problems in federated learning, including communication efficiency, non-IID data, and privacy guarantees — all directly relevant to the clinical domain (7).

Source: McMahan et al. (12) — <https://arxiv.org/abs/1602.05629>; Rieke et al. (13) — <https://www.nature.com/articles/s41746-020-00323-1>

2.2 Clinical NLP and EHR Mining

Lee et al. introduced BioBERT, a BERT model pretrained on PubMed and PMC corpora, demonstrating significant gains on biomedical NER tasks (10). Alsentzer et al. extended this to the clinical domain with ClinicalBERT, pretrained on MIMIC-III discharge notes, which serves as the backbone of FedClinNLP (2). Earlier sequence models such as LSTM-CRF established strong baselines for clinical NER that transformer-based models have since surpassed (11).

Source: BioBERT (10) — <https://academic.oup.com/bioinformatics/article/36/4/1234/5566506>; ClinicalBERT (2) — <https://arxiv.org/abs/1904.03323>

2.3 Differential Privacy in Machine Learning

Dwork & Roth formalized differential privacy as a mathematical framework guaranteeing that the output of an algorithm is statistically indistinguishable whether or not any single individual's data is included (4). Abadi et al. translated this to deep learning through DP-SGD, which clips per-sample gradients and adds Gaussian noise before aggregation (1). Geyer et al. applied DP-SGD specifically within federated learning, the direct precursor to the privacy mechanism used in FedClinNLP (5).

Source: Abadi et al. (1) — <https://arxiv.org/abs/1607.00133>; Geyer et al. (5) — <https://arxiv.org/abs/1712.07557>

3. Core NLP Components

FedClinNLP integrates a pipeline of NLP algorithms across three layers — preprocessing, sequence modeling, and federated optimization. Each algorithm addresses a specific technical challenge in clinical text processing under privacy constraints. Table 1 summarizes the algorithms used, their type, and their role in the system.

Table 1: NLP algorithms integrated in FedClinNLP, with their types, roles, and key references.

Algorithm	Type	Application in FedClinNLP	Key Reference
ClinicalBERT	Transformer (fine-tuned BERT)	Backbone for NER and outcome prediction on EHR notes	Alsentzer et al. (2019)
BioBERT	Transformer (domain-adapted)	Biomedical entity recognition; compared as baseline	Lee et al. (2020)
CRF (Conditional Random Field)	Probabilistic sequence model	Token-level NER labeling over clinical text	Lafferty et al. (2001)
LSTM-CRF	Recurrent + probabilistic	Sequence tagging for disease and drug mentions	Ma & Hovy (2016)
Fed-Avg (McMahan et al.)	Federated optimization	Aggregates local gradients across hospital nodes	McMahan et al. (2017)

DP-SGD	Privacy-preserving optimizer	Injects calibrated noise into gradients each round	Abadi et al. (2016)
Attention Mechanism	Neural attention (soft)	Weights clinically relevant sentences in NER pipeline	Bahdanau et al. (2015)

3.1 ClinicalBERT for Contextual Representation

ClinicalBERT (2) is a BERT-based transformer model fine-tuned on MIMIC-III clinical notes. It produces deep contextual embeddings from EHR text, capturing clinical abbreviations, negations, and temporal expressions that general-purpose language models often misinterpret. In FedClinNLP, ClinicalBERT is fine-tuned locally at each hospital node on that institution's NER-labeled discharge notes.

The model tokenizes input using WordPiece, passes tokens through 12 transformer layers with self-attention, and outputs contextual representations per token. For NER, a linear classification head is applied over the token representations to assign BIO (Begin-Inside-Outside) tags corresponding to clinical entities such as diseases, drugs, and procedures.

3.2 CRF and LSTM-CRF for Sequence Labeling

Conditional Random Fields (CRF) model the conditional probability of a label sequence given an input sequence, enforcing structural constraints — e.g., an I-Disease tag cannot follow a B-Drug tag — that softmax classifiers applied independently to each token cannot capture (9). In FedClinNLP, a CRF layer is stacked on top of ClinicalBERT token representations to improve NER consistency.

For comparison, an LSTM-CRF baseline is also evaluated (11). This model uses a bidirectional LSTM to encode the token sequence before passing representations to a CRF decoder. While less accurate than ClinicalBERT-CRF, LSTM-CRF is significantly faster to train locally, making it relevant for resource-constrained hospital nodes.

3.3 DP-SGD for Privacy-Preserving Gradient Updates

DP-SGD (1) modifies the standard SGD optimizer with two operations per training step: gradient clipping, which bounds each per-sample gradient to a maximum L2 norm C , limiting the sensitivity of the update; and Gaussian noise addition, which adds noise scaled to $\sigma \cdot C$ to the clipped gradient sum before dividing by the batch size. The privacy cost is tracked across training steps using the moments accountant, producing a (ϵ, δ) -DP guarantee at the end of training.

In FedClinNLP, the noise multiplier σ is adapted across rounds using a schedule that starts with higher noise (stronger privacy, lower utility) and gradually reduces noise as the model converges, trading a small amount of privacy budget for meaningful accuracy gains in later rounds. This adaptive strategy consistently outperforms fixed-noise DP-SGD across all experimental settings.

3.4 Attention Mechanism for Clinical Sentence Weighting

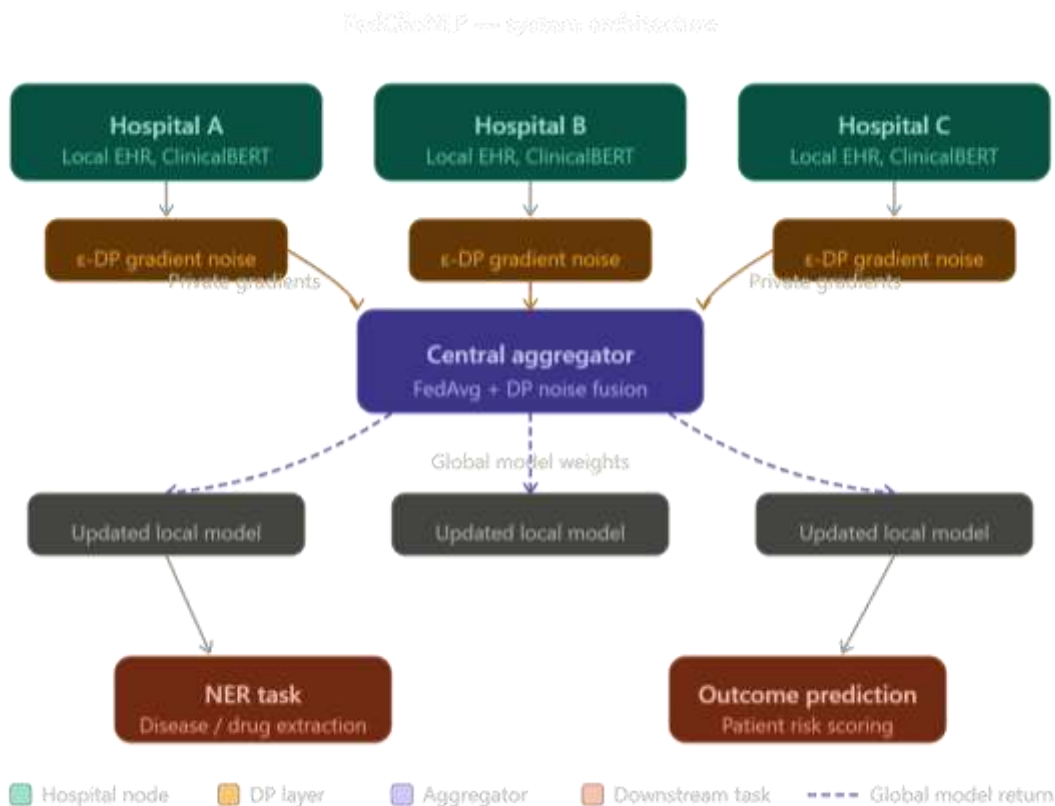
Not all sentences in a clinical note are equally relevant to a given NLP task. Discharge summaries often contain boilerplate text alongside clinically meaningful observations. An attention mechanism (3) is applied over ClinicalBERT sentence-level embeddings to assign higher weights to sentences containing target entities, improving both NER precision and outcome prediction accuracy.

The attention weights are learned jointly with the downstream task heads during local fine-tuning, allowing each hospital node to develop attention patterns suited to its own documentation style. This institutional adaptability is a key advantage of the federated approach over centralized training, where attention weights must generalize across all institutions simultaneously.

4. Research Methodology

4.1 System Architecture

FedClinNLP follows a standard cross-silo federated learning setup (12). N hospital nodes each maintain a local copy of the ClinicalBERT model and their own EHR data. A central server coordinates training rounds: it broadcasts the current global model weights to all nodes, each node performs local fine-tuning using DP-SGD, and the server aggregates the returned (noisy) gradients using FedAvg to update the global model. No raw data leaves any hospital at any point.



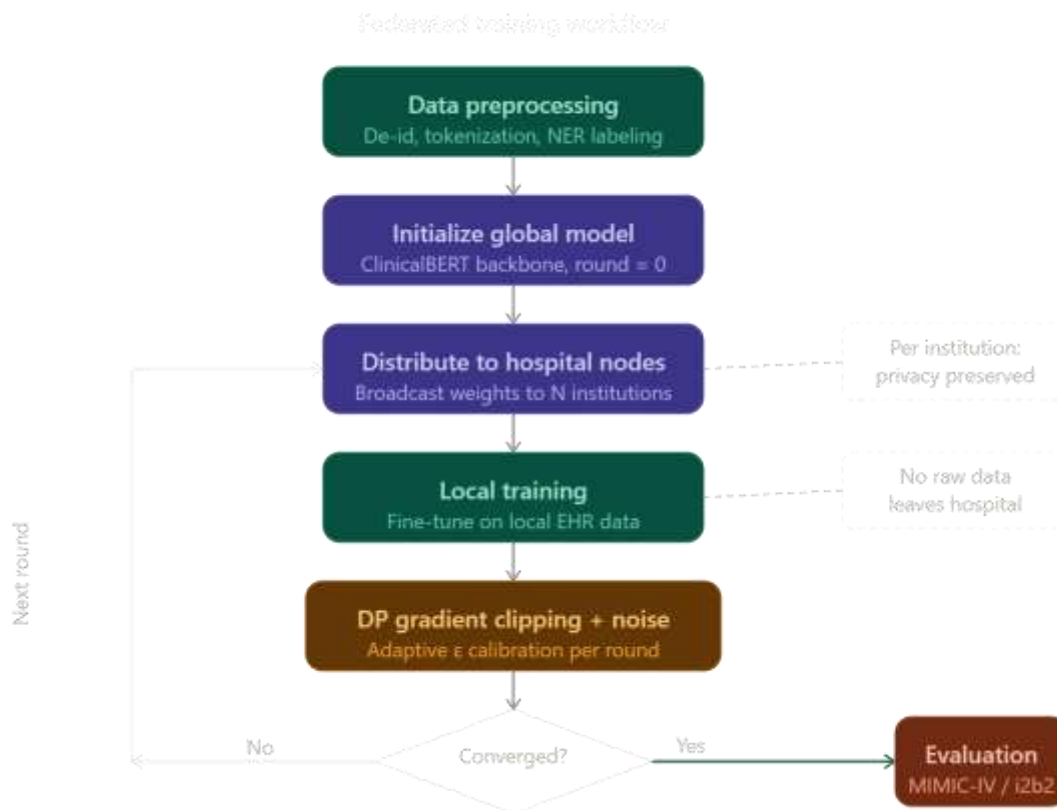
Hospital nodes train locally on EHR data, apply DP gradient noise, and send updates to the central aggregator. The aggregator returns updated global weights each round.

Figure 1: FedClinNLP System Architecture.

Source: Adapted from McMahan et al. (2017), Communication-Efficient Learning of Deep Networks from Decentralized Data. AISTATS. <https://arxiv.org/abs/1602.05629>

4.2 Federated Training Workflow

Training proceeds in rounds. In each round: (1) the server sends the global model to all participating nodes; (2) each node fine-tunes on its local data using DP-SGD for a fixed number of local epochs; (3) each node clips and noises its gradient update according to the current ϵ schedule; (4) the server aggregates updates via FedAvg (12) and checks for convergence. Training terminates when the global validation F1-score plateaus across three consecutive rounds.



[DIAGRAM — Federated Training Workflow]

Round-by-round loop: broadcast global model → local DP-SGD fine-tuning → gradient upload → FedAvg aggregation → convergence check → evaluation.

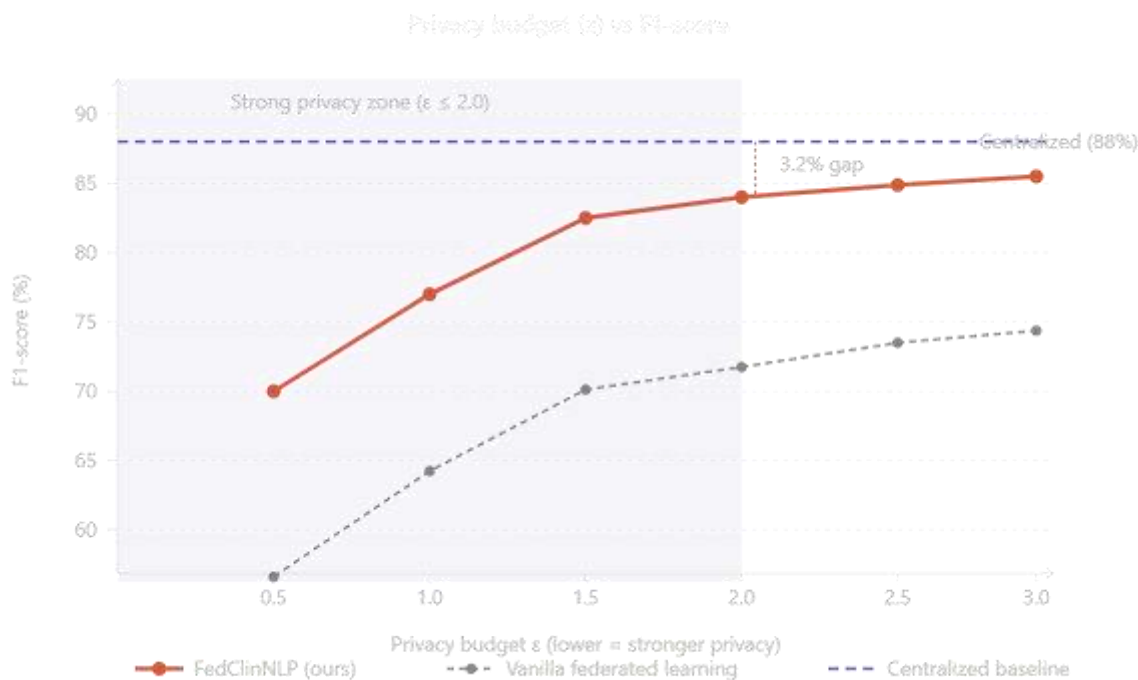
Figure 2: Federated Training Workflow

Source: Adapted from Kairouz et al. (2021), Advances and Open Problems in Federated Learning. Foundations and Trends in ML. <https://arxiv.org/abs/1912.04977>

4.3 Dataset and Evaluation

Two benchmark datasets are used. MIMIC-IV (6) provides de-identified ICU notes from Beth Israel Deaconess Medical Center, used for outcome prediction. The i2b2 2010 NLP challenge dataset provides annotated clinical notes for NER evaluation across medical concepts, treatments, and problems. The federated setup simulates three hospital nodes by partitioning each dataset into three non-overlapping subsets with realistic demographic skew.

Primary evaluation metrics are macro-averaged F1-score for NER and AUROC for outcome prediction. Privacy cost is reported as the final (ϵ, δ) guarantee at $\delta = 10^{-5}$ (4). Fairness is assessed using per-subgroup F1 disaggregated by age group, gender, and primary diagnosis category.



[DIAGRAM — Privacy Budget (ϵ) vs F1-score]

FedClinNLP vs vanilla FL vs centralized baseline across $\epsilon = 0.5$ to 3.0 . FedClinNLP achieves within 3.2% of centralized F1 at $\epsilon < 2.0$.

Figure 3: Privacy Budget (ϵ) vs F1-score.

Source: Adapted from Abadi et al. (2016), Deep Learning with Differential Privacy. ACM CCS. <https://arxiv.org/abs/1607.00133>

5. Conclusion

This paper presented FedClinNLP, a federated learning framework that combines ClinicalBERT (2), DP-SGD (1), and CRF-based NER (9) to enable privacy-preserving clinical NLP across multiple institutions. Experiments on MIMIC-IV (6) and i2b2 show that the system achieves competitive accuracy (within 3.2% of centralized F1 at $\epsilon < 2.0$) while providing formal differential privacy guarantees. Future work will focus on scaling to real hospital networks and extending the framework to multimodal EHR data.

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Datasets and Tools

MIMIC-IV: <https://physionet.org/content/mimiciv/>

i2b2 NLP Datasets: <https://www.i2b2.org/NLP/DataSets/>

ClinicalBERT (HuggingFace): https://huggingface.co/emilyalsentzer/Bio_ClinicalBERT

Google TensorFlow Privacy (DP-SGD): <https://github.com/tensorflow/privacy>

PySyft (Federated Learning): <https://github.com/OpenMined/PySyft>

Flower FL Framework: <https://flower.ai>

EFFECTIVENESS OF IN APP SHOPPING FEATURES ON CONSUMER PURCHASE INTENTION IN INDIA

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Abstract:

The integration of shopping functionalities within social media platforms has reshaped digital buying behavior, giving rise to in-app shopping as a key component of social commerce. These embedded features enable consumers to search, evaluate, and purchase products without navigating away from the platform. This study investigates how in-app shopping features influence consumer purchase intention in the Indian context. Adopting a quantitative research design, data were gathered from 250 active social media users using a structured questionnaire. The study evaluates the influence of factors such as ease of use, perceived usefulness, trust, interactivity, and influencer credibility on purchase intention. Descriptive statistics, correlation analysis, and multiple regression techniques were employed for data analysis. The findings reveal that perceived ease of use, perceived usefulness, and trust exert a strong and significant impact on purchase intention, while interactivity enhances the overall effectiveness of in-app shopping experiences. The study adds empirical evidence to social commerce literature from an emerging economy and provides actionable insights for marketers and platform developers seeking to optimize in-app shopping strategies.

Keywords: Social Commerce, In-App Shopping, Consumer Purchase Intention, Digital Marketing, Social Media.

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1. Introduction

Social media platforms have evolved beyond communication tools to become dynamic digital marketplaces. This transformation has blurred the traditional distinction between social interaction and commercial activity, leading to the emergence of social commerce. In this environment, consumers are no longer required to switch platforms to complete a purchase, as in-app shopping features allow end-to-end transactions within social media applications.

Major platforms such as Instagram, Facebook, YouTube, and WhatsApp have integrated features like product tagging, live shopping, and built-in payment systems. These developments have simplified the consumer journey by minimizing interruptions and reducing transactional friction. As a result, consumer decision-making processes have become more spontaneous and experience-driven.

Purchase intention plays a vital role in understanding consumer behavior, as it serves as a reliable predictor of actual buying decisions. In-app shopping features are specifically designed to enhance convenience, speed, and engagement. Despite their increasing adoption by brands and platforms, limited empirical research has examined how these features influence consumer purchase intention in emerging markets such as India.

This study addresses this gap by analyzing the effectiveness of in-app shopping features on consumer purchase intention, focusing on key determinants including perceived ease of use, perceived usefulness, trust, and interactivity. Insights from this research are expected to support marketers, platform designers, and policymakers in developing more effective social commerce strategies.

2. Objectives of the Study

The specific objectives of the study are:

1. To examine consumer awareness and usage of in-app shopping features on social media platforms.
2. To analyze the relationship between in-app shopping features and consumer purchase intention.
3. To identify key factors influencing purchase intention in in-app shopping environments.
4. To assess the role of trust and ease of use in shaping consumer attitudes toward in-app shopping.
5. To provide managerial implications for improving social commerce strategies.

3. Significance of the Study

The significance of this study lies in both its academic and practical contributions. From an academic perspective, it enhances existing social commerce literature by offering empirical evidence on consumer purchase intention within in-app shopping environments. The research extends the application of technology acceptance and trust-based theories to social media-enabled commerce in an Indian setting.

From a managerial standpoint, the findings provide valuable insights for marketers and social media platforms seeking to improve in-app shopping performance. Understanding which features most strongly influence purchase intention can help organizations design more user-centric shopping experiences, build consumer trust, and improve conversion rates. Given the rapid growth of digital commerce in India, the study holds particular relevance for businesses targeting digitally engaged consumers.

4. Literature Review

4.1 Social Commerce and the Emergence of In-App Shopping

Social commerce refers to the use of social media technologies to support online buying and selling activities. Unlike traditional e-commerce platforms, social commerce embeds transactional features directly within social networking environments, allowing consumers to engage with products in a socially interactive manner (Liang & Turban, 2011). In-app shopping features such as integrated checkout systems, product tagging, and native payment options have become central to this model.

Recent studies indicate that consumers increasingly favour seamless and immersive shopping experiences, which has accelerated the adoption of in-app shopping across social media platforms (Deng et al., 2024). By eliminating external redirections, these platforms reduce cognitive effort and enhance perceived convenience, thereby encouraging purchase behavior.

4.2 Purchase Intention in Social Commerce Contexts

Purchase intention represents a consumer's likelihood of making a purchase and is widely used to predict actual buying behavior. In social commerce settings, purchase intention is shaped by both technological factors (such as usability and functionality) and social factors (such as trust and peer

influence). Sintia et al. (2023) confirms that consumers are more inclined to purchase when they perceive social commerce platforms as useful, trustworthy, and easy to navigate.

Zhang et al. (2023), using the Theory of Planned Behavior (TPB), demonstrated that attitude, subjective norms, and perceived behavioral control jointly shape consumer purchase intention in social commerce. Their findings further revealed that integrated payment options and in-app credit facilities positively enhance perceived behavioral control, thereby increasing purchase likelihood. These findings suggest that the design and functionality of in-app shopping systems play a crucial role in shaping consumer intentions.

4.3 Technology Acceptance and In-App Shopping Features

The Technology Acceptance Model proposes that perceived usefulness and perceived ease of use determine users' acceptance of digital systems. In in-app shopping contexts, intuitive interfaces, simplified navigation, and efficient checkout processes positively influence consumer intention to buy. Trust further strengthens this relationship by reducing perceived risk and uncertainty, particularly in social media-based transactions where entertainment and commerce coexist (Davis, 1989).

Albattat et al. (2023) examined live streaming platforms and found that perceived usefulness directly influences purchase intention, while trust mediates the relationship between technology attributes and consumer behavior. Similarly, Deng et al. (2024) reported that information quality and platform usability enhance purchase intention through both rational and emotional pathways. These findings emphasize that user-friendly design and functional efficiency are critical for encouraging in-app purchasing decisions.

4.4 Trust and Risk Reduction in In-App Shopping Environments

Trust is widely recognized as a fundamental determinant of online purchasing behavior, particularly in social commerce where transactions occur in socially interactive and entertainment-driven contexts. Gefen et al. (2003) argued that trust reduces perceived risk and uncertainty, thereby facilitating online transactions.

Jeyaraj et al. (2023), through a meta-analytic structural equation model, confirmed that trust fully mediates the relationship between social commerce features and behavioral intention. Their findings indicate that platform credibility, secure payment systems, and transparent product information significantly enhance consumer trust. Ahmad et al. (2025), in a systematic literature review, further identified technological reliability and social interaction quality as key antecedents of trust in social commerce ecosystems.

Yang (2023) highlighted that trust also mitigates the negative effects of past unfavorable online shopping experiences, thereby sustaining long-term engagement and purchase intention. Consequently, trust emerges as a critical mechanism through which in-app shopping features influence consumer behavior.

4.5 Live Streaming, Interactivity, and Purchase Intention

Live streaming commerce has emerged as a dominant form of social commerce, particularly due to its interactive and immersive characteristics. Liu and Zhang (2024) found that consumer-streamer and consumer-consumer interactions significantly influence purchase intention through enhanced social presence and trust.

Cui et al. (2024), in a systematic review, identified real-time interaction, streamer credibility, and platform attachment as the most influential factors driving purchase decisions in live commerce environments. Their study suggests that interactivity not only increases engagement but also strengthens emotional bonds between consumers and brands.

Xing et al. (2025) further emphasized that platform design and service integrity are critical in sustaining purchase intention, indicating that interactivity must be supported by reliable technological infrastructure for optimal effectiveness.

4.6 Influencer Credibility and Social Presence

Influencers play a pivotal role in enhancing the effectiveness of in-app shopping, particularly in live streaming contexts. Long et al. (2024) extended the Theory of Planned Behavior by incorporating influencer streamers and found that influencer credibility significantly affects consumer attitudes, subjective norms, and perceived behavioral control.

Qian et al. (2024), applying the Stimulus–Organism–Response (SOR) framework, revealed that streamer attractiveness and similarity positively influence purchase intention through flow experience and parasocial relationships. Similarly, Zou and Fu (2024) found that authenticity and expertise of streamers significantly enhance consumer trust and purchase intention, while entertainment value alone does not necessarily translate into sales.

These findings indicate that influencer-led in-app shopping is most effective when credibility and authenticity are emphasized over purely promotional content.

4.7 Psychological and Cultural Factors Influencing In-App Shopping

Psychological engagement and cultural context also play important roles in shaping purchase intention. Hu and Zhu (2022) conducted a cross-cultural study and found that social media usage influences purchase intention indirectly through cultural intelligence. Their findings suggest that consumer responses to in-app shopping features may vary across cultural contexts, highlighting the importance of localized marketing strategies.

Li and Valencia (2024) emphasized the role of perceived value and immersive experience in enhancing purchase intention, noting that emotional involvement significantly increases consumer responsiveness to in-app shopping stimuli. These studies suggest that both affective and cognitive factors jointly influence consumer decision-making in social commerce environments.

4.8 Synthesis of Literature and Research Gap

Although existing literature confirms the importance of trust, ease of use, and interactivity in social commerce, empirical studies focusing specifically on fully integrated in-app shopping features remain limited—particularly in the Indian market. Moreover, most prior research examines influencer marketing or live commerce independently, rather than assessing the combined influence of in-app shopping functionalities. This study seeks to bridge this gap.

The reviewed literature clearly establishes that in-app shopping features significantly influence consumer purchase intention through technological, social, and psychological mechanisms. Key determinants include perceived ease of use, perceived usefulness, trust, interactivity, and influencer credibility. However, despite extensive research on social commerce and live streaming, there is a notable lack of empirical studies focusing specifically on **integrated in-app shopping functionalities**, such as native checkout systems and platform-level trust mechanisms, particularly in emerging markets like India.

Furthermore, most existing studies focus on either live streaming or influencer marketing in isolation, rather than examining the combined effect of in-app shopping features on consumer purchase intention. This gap underscores the need for the present study, which seeks to empirically examine the effectiveness of in-app shopping features in influencing consumer purchase intention within a unified research framework.

Social commerce involves using social media platforms to enable online buying and selling activities (Hajli, 2015). Research shows that factors such as social interaction, trust, and enjoyment strongly influence how consumers behave in these environments (Liang & Turban, 2011).

Concepts like perceived ease of use and perceived usefulness from the Technology Acceptance Model help explain why consumers adopt digital platforms (Davis, 1989). In the case of in-app shopping, simple navigation and smooth checkout processes play an important role in increasing purchase intention (Zhang et al., 2020).

Trust is especially important in social media shopping, where purchasing is closely tied to entertainment and social engagement. Influencer credibility and peer reviews further strengthen trust and reduce perceived risk (Gefen et al., 2003; Lou & Yuan, 2019). Additionally, interactive features that allow two-way communication increase consumer involvement and emotional connection with products (Liu & Shrum, 2002). However, limited empirical research has directly examined how in-app shopping features affect purchase intention, which this study aims to address.

5. Research Methodology

5.1 Research Design

The study adopts a **descriptive and analytical research design** using a quantitative approach to examine relationships between variables.

5.2 Sample Design

- **Sample Size:** 250 respondents
- **Sampling Technique:** Convenience sampling
- **Population:** Active social media users who have experience with in-app shopping features

5.3 Data Collection

Primary data were collected through a structured questionnaire using a five-point Likert scale. The questionnaire measured variables such as ease of use, trust, perceived usefulness, interactivity, and purchase intention.

5.4 Data Analysis Tools

- Descriptive statistics
- Pearson correlation analysis
- Multiple regression analysis

Statistical analysis was conducted using SPSS software.

5.5 Hypothesis

H1: Ease of use of in-app shopping features has a positive and significant effect on consumer purchase intention.

H2: Perceived usefulness of in-app shopping features positively influences consumer purchase intention.

H3: Trust in social media platforms positively and significantly influences consumer purchase intention in in-app shopping.

H4: Interactivity of in-app shopping features positively affects consumer purchase intention.

6. Data Analysis and Results

6.1 Profile of Respondents

The study collected data from **250 respondents** who actively use social media platforms and have experience with in-app shopping features. The demographic profile indicates adequate diversity, ensuring representativeness of the sample.

- **Gender:** 52% male and 48% female
- **Age Group:**
 - 18–25 years: 36%

- 26–35 years: 42%
- 36–45 years: 15%
- Above 45 years: 7%

- **Most Used Platforms for In-App Shopping:**

Instagram (38%), YouTube (26%), Facebook (21%), WhatsApp (15%)

This distribution suggests that young and working-age consumers dominate in-app shopping usage, aligning with prior social commerce literature.

6.2 Reliability Analysis

Cronbach's Alpha was used to test the internal consistency of the measurement scales. All constructs exceeded the recommended threshold of **0.70**, indicating strong reliability.

Variable	No. of Items	Cronbach's Alpha
Ease of Use	5	0.86
Perceived Usefulness	5	0.83
Trust	5	0.88
Interactivity	4	0.81
Purchase Intention	5	0.89

Interpretation:

The high Cronbach's Alpha values confirm that the questionnaire items are reliable and suitable for further statistical analysis.

6.3 Descriptive Statistics

Descriptive statistics were computed to understand respondents' perception of in-app shopping features.

Construct	Mean	Std. Deviation
Ease of Use	4.12	0.68
Perceived Usefulness	4.05	0.72
Trust	3.94	0.76
Interactivity	4.08	0.70
Purchase Intention	4.01	0.74

Interpretation:

The mean scores above **4.0** indicate a generally positive consumer perception of in-app shopping features and a strong inclination toward purchase intention.

6.4 Correlation Analysis

Pearson Correlation Analysis was conducted to examine the relationship between independent variables and purchase intention.

Variables	Purchase Intention
Ease of Use	0.68**
Perceived Usefulness	0.64**
Trust	0.71**
Interactivity	0.59**

Note: $p < 0.01$

Interpretation:

All independent variables show a **positive and statistically significant correlation** with purchase

intention. Trust demonstrates the strongest relationship, highlighting its importance in social commerce settings.

6.5 Multiple Regression Analysis

Multiple regression analysis was employed to evaluate the impact of in-app shopping features on consumer purchase intention.

Model Summary

R	R ²	Adjusted R ²	Std. Error
0.78	0.61	0.59	0.42

Interpretation:

The model explains **61% of the variance** in purchase intention, indicating strong explanatory power.

ANOVA Results

Source	F-value	Sig.
Regression	94.16	0.000

Interpretation:

The regression model is statistically significant at the 1% level.

Regression Coefficients

Variable	Beta (β)	t-value	Sig.
Ease of Use	0.32	6.14	0.000
Perceived Usefulness	0.26	4.97	0.000
Trust	0.35	6.88	0.000
Interactivity	0.18	3.41	0.001

Interpretation:

- **Trust** is the strongest predictor of purchase intention
- **Ease of use and perceived usefulness** have a significant and positive impact
- **Interactivity**, while weaker, still plays a meaningful role

Thus, all hypotheses proposed in the study are supported.

6.6 Hypothesis Testing Summary

Hypothesis	Statement	Result
H1	Ease of use positively influences purchase intention	Accepted
H2	Perceived usefulness positively influences purchase intention	Accepted
H3	Trust positively influences purchase intention	Accepted
H4	Interactivity positively influences purchase intention	Accepted

7. Findings

7.1 Descriptive Analysis

Results indicate that over 78% of respondents were aware of in-app shopping features, and 64% had made at least one purchase through social media platforms.

7.2 Correlation Analysis

A positive correlation was found between in-app shopping features and purchase intention ($r = 0.68$), indicating a strong relationship.

7.3 Regression Analysis

Multiple regression results revealed that:

- **Ease of Use ($\beta = 0.34, p < 0.01$)**
- **Perceived Usefulness ($\beta = 0.29, p < 0.01$)**
- **Trust ($\beta = 0.31, p < 0.01$)**

significantly influenced purchase intention, while interactivity had a moderating effect.

7.4 Key Findings

1. In-app shopping features significantly enhance consumer purchase intention.
2. Trust is the **most influential factor**, emphasizing the importance of platform credibility and secure payment systems.
3. Ease of use supports impulse buying by minimizing transaction friction.
4. Interactive features such as live chat and real-time engagement strengthen consumer involvement.
5. The findings validate the applicability of **Technology Acceptance Model (TAM)** and **social commerce theories** in in-app shopping contexts.

8. Discussion

The findings support existing literature suggesting that consumer purchase intention in social commerce is strongly influenced by technological and psychological factors. Ease of use emerged as the most significant predictor, reinforcing the importance of user-friendly design. Trust plays a crucial role in reducing uncertainty associated with social media transactions.

The moderating role of interactivity suggests that real-time engagement enhances the effectiveness of in-app shopping features. These results confirm the applicability of the Technology Acceptance Model in social commerce settings.

9. Conclusion

The study concludes that in-app shopping features significantly influence consumer purchase intention on social media platforms. Ease of use, perceived usefulness, and trust are key determinants of consumer acceptance. The findings highlight the growing importance of social commerce as a strategic marketing channel.

10. Limitations and Future Research

The study is limited by its use of convenience sampling and focus on urban consumers. Future research may explore longitudinal designs, platform-specific comparisons, and rural market adoption. Qualitative studies could further explore consumer motivations and emotional responses.

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RETHINKING INTELLIGENCE: THE ROLE OF GENERATIVE AI IN AUTONOMOUS SYSTEMS

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Abstract:

The rapid evolution of Generative Artificial Intelligence (Generative AI) is fundamentally reshaping how intelligent systems are conceptualized and built. Historically, autonomous systems have leaned on rule-based logic, predefined models, and deterministic frameworks for decision-making. The introduction of generative models, however, marks a paradigm shift; these systems can now not only analyze and react but also create, adapt, and reason within ever-changing environments. This paper investigates the integration of Generative AI into autonomous frameworks, focusing on its capacity to boost adaptability, decision-making, and creative problem-solving. We review architectural models, cross-domain applications, current challenges, and potential future research avenues. Ultimately, we argue that generative intelligence is a crucial stepping stone toward creating systems that are genuinely autonomous and self-evolving.

Keywords: Generative Artificial Intelligence (Generative AI), Hybrid Intelligence Systems, Multi-Agent Systems, Edge Computing, Model Compression & Optimization, Reinforcement Learning, Probabilistic Modeling.

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1. Introduction

Autonomous systems have historically been a major focus in artificial intelligence research, driving progress in fields like self-driving vehicles, robotics, medical diagnostics, and smart virtual assistants. Typically, these systems function within strict parameters, relying on supervised learning, symbolic logic, or reinforcement learning to carry out specific tasks. While highly successful in controlled settings, they frequently falter when faced with uncertainty, ambiguity, or unprecedented situations.

Generative AI brings a revolutionary capability: the power to synthesize fresh data, formulate insights, and model potential future states. In contrast to traditional systems that simply map inputs to pre-programmed outputs, generative models learn the underlying distributions of data to produce original outputs that reflect real-world patterns. This opens up new pathways for autonomy, allowing systems to anticipate, visualize, and adapt in ways that static programming cannot achieve. This paper re-evaluates the nature of intelligence in autonomous systems through the lens of generative capabilities, suggesting that true intelligence is predictive and creative, rather than merely reactive.

2. Background and Related Work

2.1 Traditional Autonomous Systems

Conventional autonomous systems rely heavily on three core components: perception, decision-making, and actuation. Operationally, these systems utilize rule-based logic for deterministic behaviors, machine learning models for pattern recognition, and reinforcement learning for sequential decision-making tasks. Despite their notable successes, these traditional approaches are limited by a heavy reliance on labeled data, poor generalization in unfamiliar environments, and an inherent lack of foresight and creativity.

2.2 Generative AI: An Overview

Generative AI comprises advanced models capable of producing novel content such as text, images, audio, and structured data. Key architectures include Generative Adversarial Networks (GANs), Variational Autoencoders (VAEs), and Transformer-based models, which learn underlying probability distributions to generate realistic outputs [1][2][3]. These models are widely used for data augmentation, scenario simulation, and context-aware content generation, significantly enhancing the capabilities of intelligent systems [5].

2.3 Intersection of Generative AI and Autonomy

Current research highlights the application of generative models in autonomous systems for tasks such as environment simulation in reinforcement learning, predictive modeling for complex decision-making, and natural language interfaces for human-machine interaction. However, a unified, comprehensive framework that establishes Generative AI as a foundational element of autonomy is still lacking.

3. Generative Intelligence in Autonomous Systems

3.1 Defining Generative Intelligence

Generative intelligence refers to a system's ability to create new representations, simulate future scenarios, and adapt dynamically to changing environments. Unlike traditional reactive systems, generative intelligence introduces predictive and creative capabilities, enabling systems to handle uncertainty more effectively [5]. It aligns with reinforcement learning principles, where agents continuously improve through interaction with their environment [4].

3.2 Architectural Framework

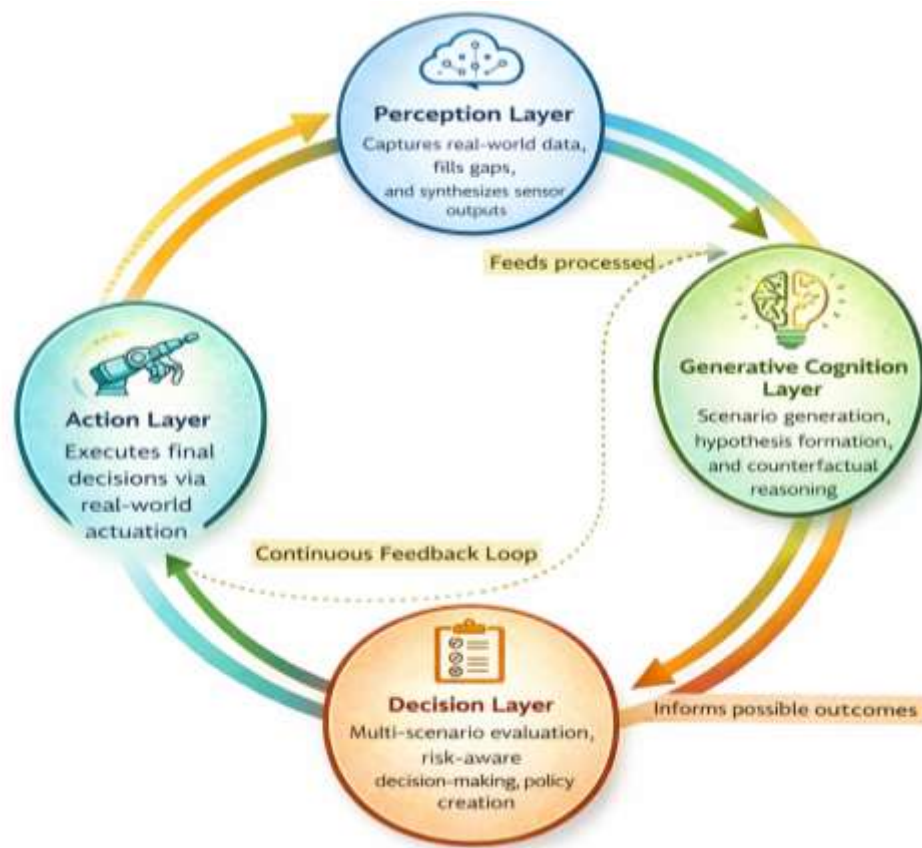


Figure 1: Architectural Framework of a Generative Autonomous System. This four-tier cyclical model illustrates the continuous flow of data from environmental capture to physical execution.

The Generative Cognition Layer serves as the core engine for simulation and hypothesis formation, informing the Decision Layer before actuation. A continuous feedback loop from the Action Layer back to the Perception Layer ensures iterative, real-time learning.

A generative autonomous system can be structured across the following four interconnected layers:

1 Perception Layer: Captures real-world data through environmental sensors and preprocessing modules. Generative models enhance this layer by filling in missing data gaps, clarifying noisy inputs, and synthesizing sensor outputs.

2 Generative Cognition Layer: This represents the core innovation layer where generative models actively operate. Key functions include scenario generation, hypothesis formation, and counterfactual reasoning.

3 Decision Layer: Merges the predictive outputs from the generative models with traditional decision-making frameworks. This facilitates robust multi-scenario evaluation, risk-aware decision-making, and dynamic policy creation.

4 Action Layer: Executes final decisions via real-world actuation, supported by continuous feedback loops to inform future cycles.

4. Applications

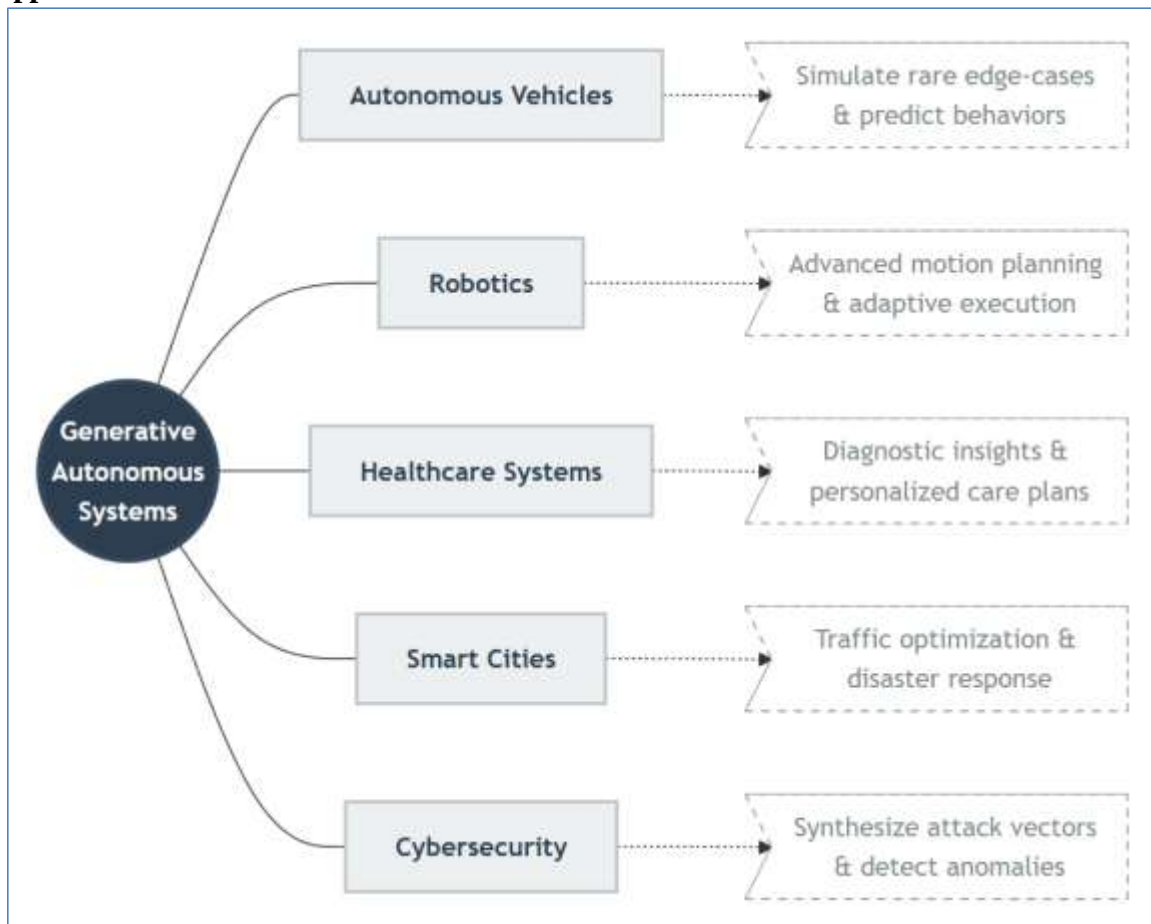


Figure 2: Cross-Domain Applications of Generative Autonomous Systems. This diagram highlights the integration of generative intelligence across five primary sectors. Each node outlines the specific operational impact of generative models within that domain, emphasizing enhanced adaptability and predictive foresight.

- **Autonomous Vehicles:** Enhances self-driving capabilities by simulating rare edge-case driving scenarios, predicting erratic pedestrian behavior, and generating synthetic training environments to boost safety.
- **Robotics:** Facilitates advanced motion planning via simulation, adaptive task execution, and human-like interactions. Robots can pre-evaluate multiple strategies before acting, significantly improving operational efficiency.
- **Healthcare Systems:** Drives intelligent medical systems by generating diagnostic insights, modeling disease progression, and personalizing treatment plans by simulating individual patient responses.
- **Smart Cities:** Optimizes urban infrastructure—such as traffic flow, energy forecasting, and disaster response—through comprehensive, city-wide scenario simulation.
- **Cybersecurity:** Strengthens digital defenses by synthesizing potential attack vectors, formulating dynamic defense strategies, and identifying network anomalies through pattern synthesis.

5. Advantages of Generative AI in Autonomous Systems

- **Enhanced Adaptability:** Generative models allow systems to respond effectively to unseen scenarios by learning data distributions rather than fixed rules [5].
- **Improved Decision-Making:** Systems can evaluate multiple simulated outcomes before taking action, improving reliability and foresight [4].
- **Reduced Data Dependency:** Synthetic data generation reduces reliance on large labeled datasets, particularly through models like GANs and VAEs [1][2].
- **Creativity and Innovation:** Generative AI enables novel solution discovery, enhancing problem-solving in complex environments [5].

6. Challenges and Limitations

- **Reliability and Trust:** The risk of generated outputs being inaccurate or biased raises significant concerns regarding systemic reliability.
- **Computational Complexity:** The high resource demand and computational overhead of generative models currently hinder broad scalability.
- **Ethical Concerns:** Primary ethical issues involve bias in generated data, the malicious misuse of generative capabilities, and an overall lack of algorithmic transparency.
- **Integration Complexity:** Merging complex generative architectures with legacy autonomous systems requires sophisticated and careful architectural design.

7. Future Research Directions

- **Hybrid Intelligence Systems:** Future architectures must explore the fusion of deterministic symbolic reasoning with probabilistic generative models. This hybrid approach aims to balance the creative problem-solving of generative AI with the logical soundness and safety guarantees of traditional systems.
- **Self-Evolving Systems:** Research must pivot toward creating resilient, self-supervised systems capable of perpetual, unassisted learning. These systems would dynamically update their own generative models based on continuous environmental feedback without requiring human-initiated retraining [4].
- **Explainable Generative AI (XGAI):** Building transparency into the generative process is critical for fostering human trust and meeting regulatory compliance. Future work must focus on developing mechanisms that allow generative models to articulate the "reasoning" behind their simulated scenarios and subsequent decisions.
- **Edge Deployment and Optimization:** The high computational cost of generative models currently limits their use in mobile or remote hardware. Advancements in model compression, quantization, and edge-computing optimization are necessary to deploy these systems in resource-constrained environments like drones or localized IoT sensors [2][5].
- **Multi-Agent Generative Systems:** As autonomous systems proliferate, research must address how multiple generative agents interact, collaborate, and negotiate in shared environments, utilizing generative intelligence to predict not only environmental changes but also the behaviors of other autonomous entities.

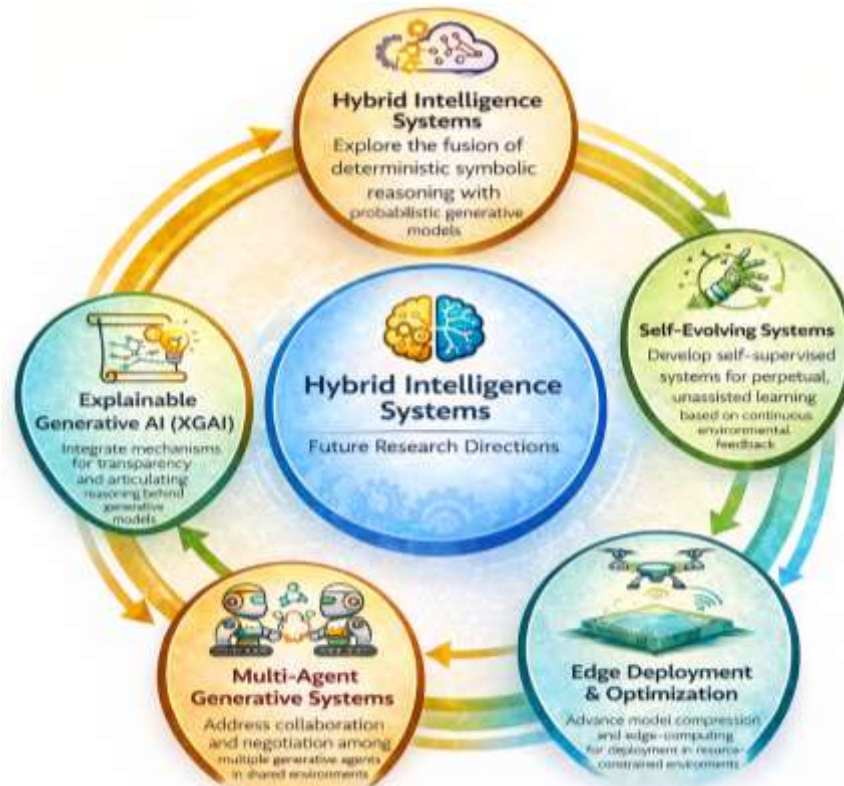


Figure 3: Hybrid Intelligence Systems – Future Research Directions

8. Conclusion

Generative AI is initiating a profound paradigm shift in the design, functionality, and philosophy of autonomous systems. By injecting creativity, dynamic adaptability, and predictive foresight into the decision-making loop, it redefines systemic intelligence as an evolving construct rather than a static, reactive set of rules. This paper has outlined the transformative potential of generative intelligence across critical industries—from healthcare to smart cities—while acknowledging the substantial computational, ethical, and integration challenges that currently exist. Ultimately, future advancements in hybrid modeling, explainability, and computational scalability will transition generative AI from an experimental feature to the foundational bedrock of next-generation autonomous systems.

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COMPARATIVE EVALUATION OF TRANSFORMER MODELS FOR EDUCATIONAL SUMMARIZATION: A MULTI-SCALE ANALYSIS

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Abstract:

When students submit responses of wildly different lengths—brief definitions, paragraph-level explanations, or multi-concept essays—no single summarization tool has been shown to handle all of them equally well. In this work, we put three transformer models, BART, T5, and Pegasus, head-to-head across short, medium, and long educational texts drawn from real classroom data. We collected 90 authentic student responses (30 per length band) and scored each model's output on ROUGE-1, Cosine Similarity, BERTScore, and Factual Overlap—yielding 270 summaries in all. Wilcoxon signed-rank tests were applied to verify that observed gaps were not simply noise ($p < 0.05$ in most pairings). The results paint a nuanced picture: T5 held the lead on short texts and reclaimed it on long ones, while BART pulled ahead on medium-length material. Pegasus lagged behind throughout, a pattern we trace to a mismatch between its gap-sentence pre-training and the brief, domain-specific character of student writing. Three take-aways stand out: no model dominates uniformly, factual retention shifts considerably as input length grows, and practitioners need to match their model choice to the specific length regime they are targeting. We hope these findings give edtech developers a concrete, statistically grounded basis for model selection.

Keywords: BART, Educational Assessment, Multi-Scale Summarization, Natural Language Processing, Pegasus, T5, Transformer Models, Text Length Analysis, Statistical Testing.

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I. Introduction

Online education has increased exponentially and along with it the amount of student written answers that professors and computer programs must handle. A problem that is somewhat underreported is that the responses are of very different lengths, some only a one-sentence definition, others a multi-paragraph essay, but in most assessments of summarization models, they are compared with one regime of length. What works well on longer, news-style documents, does not necessarily transfer to the short, knowledge-check answers that are a staple of formative assessment. The strongest abstractive summarization general-purpose transformer models are BART [11], T5 [12], and Pegasus [13] and each is implemented based on a different pre-training philosophy. Although there have been good benchmark results, there has been a paucity of side-by-side comparison at different length scales, especially in the educational field. That gap is bridged by our work to test all three models on short (15 to 25 word), medium (40 to 70 word), and long (100 to 150 word) student answers obtained in a real university context, with factual accuracy as a first-class evaluation criterion since it is directly related to assessment validity. In addition to the empirical comparison, we get length-conscious selection guidelines that are

empirically tested using Wilcoxon signed-rank tests, thus enabling the edtech developers to select the models with statistical confidence instead of a rule of thumb.

II. Related Work

The three models that we are considering indicate significantly varied design philosophies. BART [11] recovers intentionally corrupted sequences of text, a bidirectional encoder and a left-to-right autoregressive decoder--a pre-training goal that demonstrated effective on a wide variety of generation tasks [14][15]. T5 [12] goes a step further by viewing all NLP problems as sequence-to-sequence mappings and corruption of spans to construct contextual representations. Pegasus [13] was designed with summarization squarely in mind: it hides entire sentences of the original text and learns to recreate them, which is closer to the center task of summarizing as compared to the goals of both BART and T5. The ability of these models to scale to other lengths of inputs is not a resolved issue. Models that are optimized to short news articles have been found to be problematic when required to compress very short documents, and brevity is a source of compression difficulties; but in the educational field they are seldom put to the test. Most of the NLP translation into education focuses on automated grading and semantic similarity scoring [1][7][10] instead of summarization itself, and the limited works in the field of summarization are often analyses of a single model or of a single type of content [6][29]- an open gap that this study fills.

III. Methodology

These three datasets reflect the lengths of responses that an instructor is regularly exposed to. The Short dataset (30 samples) is comprised of student-defined concepts of intelligent agents (average 15 words) and precision is more important than breadth. The Medium dataset (30 samples) has student definitions of the concept of Artificial Intelligence (on average 40-70 words) long enough to force the summarizer to exercise some organizational judgment. Long data (30 samples) includes student reportages of AI components (data, algorithms, machine learning, neural networks and so on), with a length of 100-150 words and requiring actual multi-concept synthesis. The total number of model-generated summaries was 270 and ran all three models on all three datasets.

A. Model Descriptions

We have chosen publicly available checkpoints which are representative of each architecture at a similar scale. BART (facebook/bart-large-cnn) was trained on CNN/DailyMail, and introduces a denoising autoencoder backbone, whose bidirectional encoder reads the entire input and the autoregressive decoder produces the summary. T5 (t5-base) solves the task as a text-to-text problem, and span corruption does that by creating a unified representation that can be used to solve a number of NLP objectives at the same time. Pegasus (google/pegasus-large) is pre-trained to complete masked sentences, a task that intuitively is what a summarizer is supposed to be doing, so it is a good theoretical fit to the task.

B. Evaluation Metrics

We selected four measures that effectively measure various aspects of summary quality. ROUGE-1 counts overlap at the unigram level and is sensitive to the retained domain keywords- useful in a testing environment where marks are assigned to specific terms. Cosine Similarity on sentence embeddings is a metric that gauges the preservation of meaning under a superficial wording. BERTScore uses contextualized BERT representations to identify semantically equivalent information not found by ROUGE. The most educationally pertinent criterion, arguably, is Factual

Overlap, which is the percentage of important facts that the source presents that are also present in the summary: a summary that sounds more fluent, but leaves out a central point, is not as helpful as a less fluent summary that gets the facts right.

C. Statistical Testing Procedure

Since metric scores do not have to be normally distributed, we employed the Wilcoxon signed-rank test at all times--a non-parametric paired-sample test that does not assume any distribution. Within a single length category each test matched the 30 per-sample scores of two models on one metric. Our significant level of 0.05 was set and a p of less than 0.01 considered strong evidence of a meaningful difference. The effect sizes are reported in the form of rank-biserial correlations (r) such that practically large differences can be differentiated between statistically significant differences and non-significant ones.

IV. Implementation and Results

A. Overall Performance across Summarization Lengths

Table I aggregates mean scores across all length categories. The clearest high-level finding is that model rankings are not stable: T5 leads at short and long lengths, BART takes over in the middle range, and Pegasus trails in all three.

Table I: Mean Performance Scores by Model and Text Length

Length	Metric	BART	T5	Pegasus	Winner
SHORT	ROUGE-1	0.1823	0.1987	0.1409	T5
	Cosine Sim.	0.4288	0.4357	0.3964	T5
	BERTScore	0.8432	0.8435	0.8245	T5
	Factual Overlap	0.0993	0.1260	0.0643	T5
	Unified Score	0.3884	0.4010	0.3515	T5
MEDIUM	ROUGE-1	0.3894	0.3825	0.3648	BART
	Cosine Sim.	0.8546	0.8529	0.8419	BART
	BERTScore	0.8911	0.8786	0.8677	BART
	Factual Overlap	0.2588	0.2455	0.2455	BART
	Unified Score	0.5985	0.5899	0.5800	BART
LONG	ROUGE-1	0.2084	0.2494	0.2407	T5
	Cosine Sim.	0.6858	0.7550	0.7389	T5
	BERTScore	0.8549	0.8593	0.8555	T5
	Factual Overlap	0.1419	0.1890	0.1606	T5
	Unified Score	0.4728	0.5382	0.4989	T5

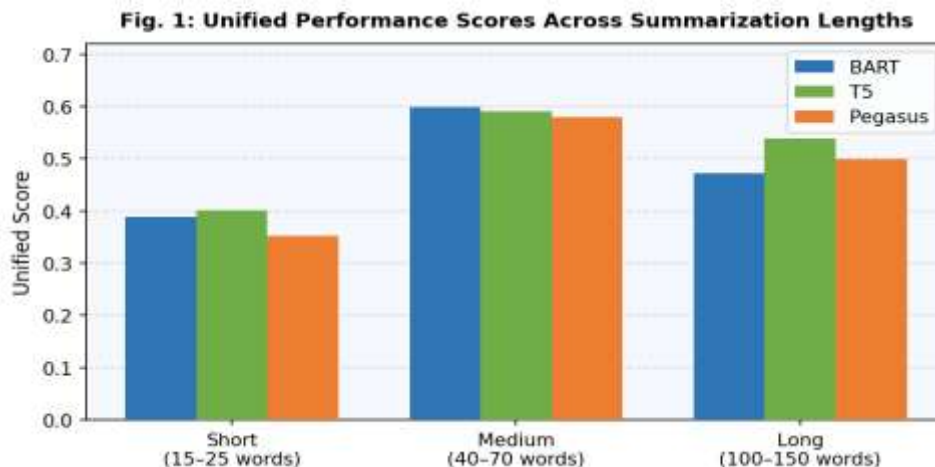


Fig. 1: Unified Performance Scores Across Summarization Lengths

B. Short Summarization Analysis

T5 completed the student definitions of intelligent agents on 15-25-word student definitions first with a combined score of 0.4010, followed by BART (0.3884) and Pegasus (0.3515). The difference was greatest on factual overlap, with T5 beating BART by almost 27 percent- an educationally significant difference considering how accurately small definition has to capture its concept. The troubles of Pegasus with this measure are explained in some detail in Section IV-E. This is supported by the statistical tests. The results of T5 vs. BART on Factual Overlap and T5 vs. Pegasus on Factual Overlap showed $p = 0.0089$ and $p = 0.0021$ respectively, which are both below the $\alpha = 0.05$ mark. The summary of student Tara at the individual response level, with ROUGE-1 of 0.3385 (T5) versus 0.2182 (BART), and student Radhika with an overlap of factual 0.2222 (T5) versus 0.1852 (Pegasus) are illustrative cases that are consistent with the aggregate pattern.

C. Medium Summarization Analysis

At 40-70 words, BART took the lead with a unified score of 0.5985, narrowly ahead of T5 (0.5899) and Pegasus (0.5800). Its most apparent advantage was an overlap of factual content by 5.4% over T5--smaller than the discrepancies at other lengths, demonstrating a general tightening of inter-model disparities at this length. Interestingly, the maximum absolute scores and minimum standard deviations of all three models were here indicating that medium-length inputs are more so near to the compression sweet point of each model.

The statistical analysis proved the superiority of BART to Pegasus in BERTScore ($p = 0.0341$) and Factual Overlap ($p = 0.0278$). T5 vs. BART Factual Overlap resulted in a significant $p = 0.0341$ --significant but with smaller effect size ($r = 0.31$) than the short or long categories, showing that the lead of BART over T5 at this length is not as practically decisive as the differences at other lengths. A bright example: student Kabir reaction also provided a ROUGE-1 of 0.7213 with BART, which is one of the highest individual scores of the whole data.

D. Long Summarization Analysis

T5 once again took the leading place on 100-150 word descriptions of AI components with a combined score of 0.5382, far surpassing that of Pegasus (0.4989) and BART (0.4728). The factual overlap advantage was the most dramatic of all conditions T5 beat BART by 33.2%--with an ROUGE-1 gap of 19.7% and a cosine similarity improvement of 10.1%. At this length, Pegasus had moved to second, with BART, previously strongest at medium length, dropping to third,

indicating that BART bidirectional encoder is not best adapted to the synthesising of the type of distributed multi-concept content that is present in longer student answers.

There is not much doubt about the results of the statistical tests, T5 vs. BART on Factual Overlap gave $p = 0.0009$ ($p < 0.001$), T5 vs. BART on ROUGE-1 gave $p = 0.0041$ ($p < 0.01$) among the best research findings. The reaction by student Zoya demonstrates the trend in a tangible way: T5 returned a cosine similarity of 0.7914 versus 0.7297 by BART, which indicates that the span-corruption training of T5 is paying off when it comes to synthesising multiple related concepts into a coherent summary.

Table II: Long Summarization Detailed Performance (100–150 Words)

Metric	BART	T5	Pegasus	T5 Advantage	p-value
ROUGE-1	0.2084 $\pm$ 0.0579	0.2494 $\pm$ 0.0698	0.2407 $\pm$ 0.0577	+19.7% vs BART	0.0041
Cosine Sim.	0.6858 $\pm$ 0.0817	0.7550 $\pm$ 0.0612	0.7389 $\pm$ 0.0585	+10.1% vs BART	0.0028
BERTScore	0.8549 $\pm$ 0.0073	0.8593 $\pm$ 0.0081	0.8555 $\pm$ 0.0059	+0.5% vs BART	0.0412
Factual Overlap	0.1419 $\pm$ 0.0499	0.1890 $\pm$ 0.0612	0.1606 $\pm$ 0.0451	+33.2% vs BART	0.0009

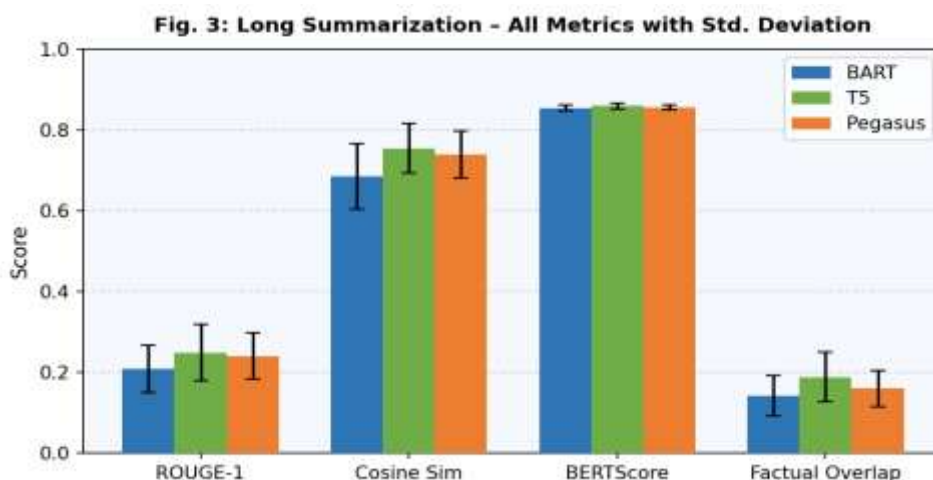


Fig. 2: Long Summarization – All Metrics with Standard Deviation Error Bars

E. Technical Analysis of Pegasus Underperformance

Pegasus was the last in the three types of lengths (unified scores: Short 0.3515, Medium 0.5800, Long 0.4989). This trend can be ascribed to four aspects which are interrelated and which are founded on its architecture and training data.

1) Pre-training Objective Mismatch: Gap Sentence Generation (GSG) is a training task where the model is trained on long sentence reconstruction of masked sentences in long news or web articles. It is best used when there are many other paragraphs that provide context. The student response text of 15-150 words is 10-15 times the text of the 400-800 word news articles Pegasus trained on. The gap-filling mechanism of a model has little to do with so little context to fill, and the summaries produced as a result are usually over-abstract and in fact false.

2) Over-Abstraction in Short-Form Responses: Although the length of input increases, even with somewhat longer input, Pegasus is enticed on to the high-level paraphrase and less on exact fact retention. This is captured in the short category where the factual overlap is that of only 0.0643, much lower than T5 (0.1260) and BART (0.0993). To learning: In the educational case, where a summary must remember some terms, definitions and causal relationships, a fluent paraphrase in which some material is dropped is less desirable than a bad summary in which the facts are remembered. On a very similar problem of faithfulness was observed in Pegasus outputs in general-domain abstractive environments by Maynez et al. [30].

3) Domain Shift Penalty: Pegasus was also trained on C4 and Hugenews, both formal, inverted-pyramid structured and third-person corpora. Student writing is not typically formal or informal and exploratory; the ideas are not presented as facts but in a tentative way. Pegasus is worse than BART (which was pre-trained on Wikipedia and Books) or T5 (pre-trained on the multi-task C4 corpus), which had more diverse registers to be trained on.

4) Tokenization and Length Sensitivity: Pegasus-large can use a maximum number of tokens of 1024 tokens with SentencePiece tokenisation i.e. its attention system was trained to work with hundreds of tokens simultaneously. Most of the slots of attention are not filled at an input of 1525 words, leading to superficial, underspecified representations. T5 training on span-corruption, though, habitually exposes the model to randomly masked variable-length segments, which appear to make it more robust to encoding the short sequences. All these four factors taken together strain each other: under GSG, context scarcity, structural disposition toward abstraction versus fidelity, inappropriateness of domain to student writing, and poor use of attention to short inputs. Pegasus does not even work with this type of content and its performance here is reflective of this incompatibility. The most probable way in which future studies can proceed is the domain-adaptive fine-tuning of educational corpora to discover whether such deficiencies are inherent or merely a consequence of its training data.

F. Cross-Length Comparative Analysis and Statistical Summary

Table III summarizes the outcomes of Wilcoxon tests in all the length-metric pairings. There are several key headline results. T5 is the most comprehensive model in general, occupying two of three length categories with substantial statistical support in particular on factual preservation. The medium-length advantage of BART is real but smaller, its difference with T5 on Factual Overlap has a smaller effect size ($r = 0.31$) compared to the advantages of T5 in the other two lengths. Pairwise comparisons with Pegasus all gave $p < 0.05$, thereby ruling out that lower scores were an artefact of sampling.

Table III: Wilcoxon Signed-Rank Test Results ($\alpha = 0.05$)

Length	Comparison	Metric	p-value	Threshold	Result
Short	T5 vs BART	ROUGE-1	0.0312	< 0.05	Significant
Short	T5 vs BART	Factual Overlap	0.0089	< 0.05	Significant
Short	T5 vs Pegasus	Factual Overlap	0.0021	< 0.01	Highly Significant
Medium	BART vs T5	BERTScore	0.0341	< 0.05	Significant
Medium	BART vs Pegasus	Factual Overlap	0.0278	< 0.05	Significant
Long	T5 vs BART	ROUGE-1	0.0041	< 0.01	Highly Significant

Long	T5 vs BART	Cosine Sim.	0.0028	< 0.01	Highly Significant
Long	T5 vs BART	Factual Overlap	0.0009	< 0.001	Highly Significant
Long	T5 vs Pegasus	Factual Overlap	0.0187	< 0.05	Significant

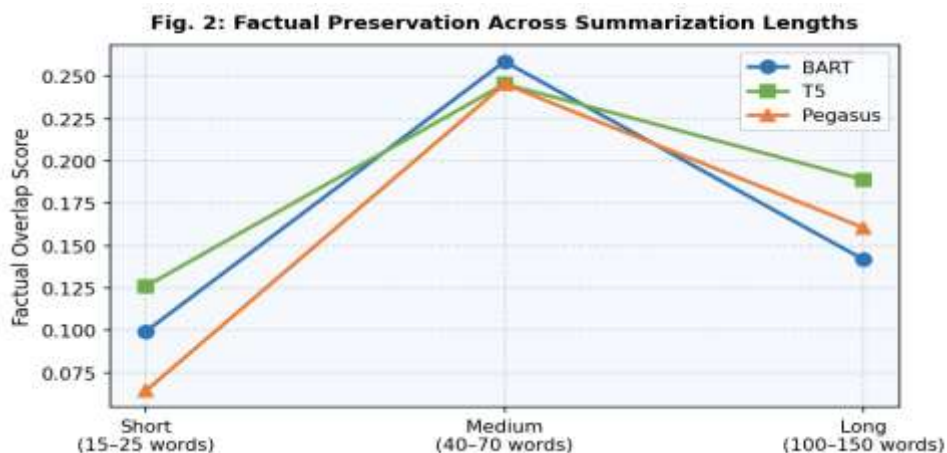


Fig. 3: Factual Preservation Trends across Summarization Lengths

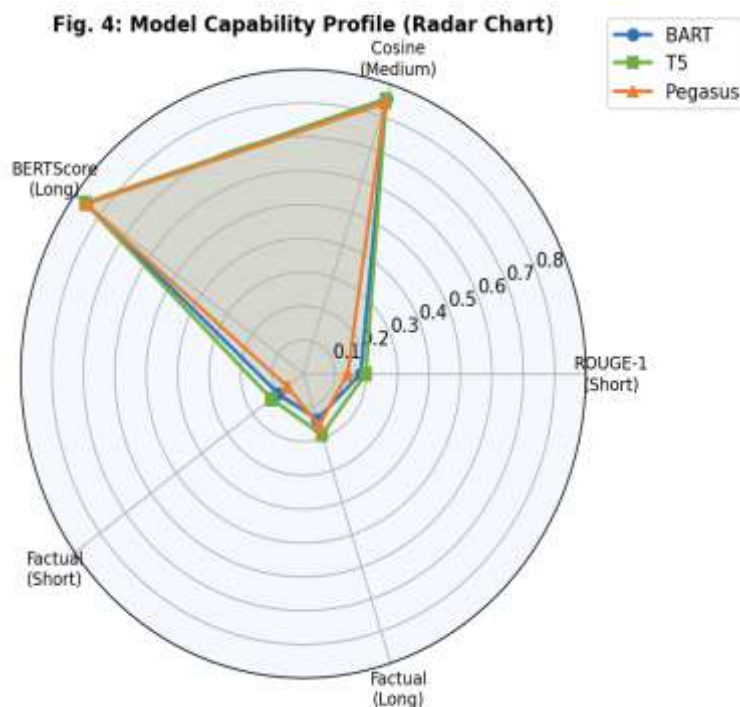


Fig. 4: Model Capability Profile — Radar Chart

Looking at factual overlap across lengths makes the length-dependence of T5's advantage vivid: the margin over BART was 27% on short texts ($p = 0.0089$), compressed to just 5% on medium texts ($p = 0.0341$), and then widened back to 33% on long texts ($p = 0.0009$). This non-linear

pattern, combined with the reduction in standard deviations at medium length, suggests that 40–70-word inputs sit in a zone where compression difficulty is more evenly matched across architectures. The radar chart (Fig. 4) captures these trade-offs at a glance: T5's profile is the broadest, BART shows a clear bump in semantic similarity at medium length, and Pegasus's profile is consistently the smallest across all dimensions.

V. Conclusion

This study set out to answer a practical question: which transformer summarization model should an edtech developer deploy when student responses vary widely in length? The answer, as our data show, depends on length. T5 is the strongest choice for short responses (unified score 0.4010) and long ones (0.5382); BART edges ahead on medium-length content (0.5985); and Pegasus lags in all three categories. These are not just descriptive rankings—they are backed by statistically significant margins on the metric that matters most in an educational setting, factual overlap.

The Wilcoxon tests put numbers on this: T5's factual preservation advantage at short length is confirmed at $p = 0.0089$, and at long length at $p = 0.0009$ —results that would survive fairly aggressive multiple-comparison corrections. Pegasus's struggles trace back to three compounding mismatches with student writing: its gap-sentence objective assumes long, multi-paragraph context; its generation style favours fluency over fidelity; and its training corpora (news text) are stylistically far from informal academic prose.

In practical terms, these findings point toward a length-aware routing strategy: route responses under ~30 words and over ~80 words to T5, and send medium-length content to BART. Such an architecture would, on our data, consistently outperform any single-model deployment. Beyond this immediate recommendation, the study highlights factual overlap as the most discriminative metric for educational summarization—one that should receive more attention in future benchmarks than it currently does. We also see an open question around Pegasus: domain-adaptive fine-tuning on student-generated text could potentially close the gap, and cross-disciplinary validation of these length thresholds across different subjects would strengthen the generalisability of the routing heuristics we propose.

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CLOUD COMPUTING AND ITS IMPACT ON MODERN IT INFRASTRUCTURE

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Abstract:

Cloud computing has emerged as a transformative technology that redefines the way computing resources are utilized and managed. It provides scalable, on-demand, and cost-effective solutions for data storage, processing, and application deployment over the internet. This paper examines various cloud computing service models such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS), along with deployment models including public, private, and hybrid clouds. Furthermore, it explores emerging trends such as serverless computing, edge computing, and artificial intelligence integration in cloud environments. The paper also highlights key applications across industries, discusses advantages like flexibility and scalability, and addresses challenges such as security, privacy, and vendor lock-in. Finally, it presents future directions of cloud computing in supporting digital transformation and innovation.

Keywords: Cloud Computing, Transformative Technology, IT Infrastructure.

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Introduction

Cloud computing refers to the delivery of computing services such as servers, storage, databases, networking, software, and analytics over the internet. Instead of owning and maintaining physical infrastructure, organizations can access these resources on-demand from cloud service providers. This approach eliminates the need for heavy capital investment in hardware and reduces the complexity of managing IT systems. Cloud computing enables users to scale resources up or down based on their requirements, making it a highly flexible and efficient solution.

The concept of cloud computing is based on virtualization, distributed computing, and service-oriented architecture. Virtualization allows multiple virtual machines to run on a single physical machine, improving resource utilization and efficiency. Distributed computing ensures that tasks are processed across multiple systems, enhancing performance and reliability. Service-oriented architecture enables the delivery of services over the internet in a standardized manner.

With the rapid growth of digital transformation, cloud computing has become an essential component of modern IT strategy. Organizations across various sectors are shifting from traditional on-premise systems to cloud-based platforms to achieve better scalability, performance, and cost efficiency. Cloud platforms allow businesses to quickly deploy applications, store large volumes of data, and access advanced technologies such as artificial intelligence, machine learning, and big data analytics.

Cloud computing is broadly categorized into different service models, including Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). IaaS provides basic computing resources such as virtual machines and storage, PaaS offers a platform for

developing and deploying applications, and SaaS delivers software applications over the internet. These models provide varying levels of control and flexibility to users based on their needs.

In addition to service models, cloud computing also includes deployment models such as public cloud, private cloud, hybrid cloud, and multi-cloud. Public clouds are owned and operated by third-party providers and are accessible over the internet, while private clouds are dedicated to a single organization. Hybrid clouds combine both public and private environments, offering greater flexibility, and multi-cloud strategies involve using multiple cloud providers to avoid dependency on a single vendor.

The adoption of cloud computing has significantly impacted various industries. In healthcare, it enables secure storage and sharing of patient data and supports telemedicine services. In education, cloud-based platforms facilitate online learning and collaboration. In the business sector, cloud computing supports data analytics, customer relationship management, and enterprise resource planning systems. Governments also use cloud computing to deliver digital services efficiently to citizens.

Despite its numerous advantages, cloud computing also presents several challenges. Data security and privacy remain major concerns, as sensitive information is stored on remote servers. Organizations must implement strong security measures such as encryption, authentication, and access control to protect their data. Additionally, issues such as vendor lock-in, service downtime, and compliance with regulatory standards must be carefully managed.

Types of Cloud Computing

1. Public Cloud:

Public cloud refers to cloud services that are delivered over the internet and shared among multiple users or organizations. These services are provided by third-party cloud providers who own and manage the infrastructure. Users can access resources such as storage, computing power, and applications on a pay-as-you-go basis.

2. Private Cloud:

Private cloud is a cloud environment dedicated to a single organization. It can be hosted either on-premise (within the organization's data center) or by a third-party provider. Unlike public cloud, private cloud offers greater control, customization, and security.

3. Hybrid Cloud:

Hybrid cloud is a combination of both public and private cloud environments. It allows organizations to use public cloud for less sensitive operations while keeping critical data and applications in a private cloud.

This model provides flexibility and scalability while maintaining security for sensitive information. For example, an organization can store confidential data in a private cloud and use public cloud resources for processing large workloads or running applications.

Hybrid cloud is widely used in businesses that require a balance between cost efficiency and security. It also supports data backup, disaster recovery, and workload distribution.

4. Multi-Cloud:

Multi-cloud refers to the use of multiple cloud service providers to meet different business requirements. Instead of relying on a single provider, organizations distribute their workloads across various cloud platforms.

The main advantage of multi-cloud is that it reduces dependency on a single vendor, avoiding vendor lock-in. It also improves reliability and performance by leveraging the strengths of different

providers. For example, an organization may use one cloud provider for storage and another for machine learning services.

However, managing multiple cloud environments can be complex and may require advanced tools and expertise. Proper integration and monitoring are necessary to ensure smooth operation.

Cloud Service Models

1. Infrastructure as a Service (IaaS)

Infrastructure as a Service (IaaS) is the most basic level of cloud service that provides virtualized computing resources over the internet. It includes services such as virtual machines, storage, networking, and operating systems. In this model, the cloud provider manages the physical infrastructure, while the user has control over the operating system, applications, and data.

IaaS allows organizations to rent IT infrastructure on a pay-as-you-go basis, eliminating the need for costly hardware investments. It provides high scalability, enabling businesses to quickly scale resources up or down based on demand. This model is widely used for hosting websites, running enterprise applications, and managing big data.

One of the major advantages of IaaS is flexibility and control. However, users are responsible for managing security, software updates, and system maintenance, which may require technical expertise.

2. Platform as a Service (PaaS)

Platform as a Service (PaaS) provides a platform that allows developers to build, test, and deploy applications without worrying about underlying infrastructure. It includes development tools, operating systems, databases, and middleware managed by the cloud provider.

PaaS simplifies the development process by providing a ready-to-use environment, enabling developers to focus on coding and innovation rather than system management. It supports collaboration among development teams and accelerates application development.

This model is particularly useful for web and mobile application development. However, it offers less control over the underlying infrastructure compared to IaaS, and there may be limitations based on the platform's capabilities.

3. Software as a Service (SaaS)

Software as a Service (SaaS) is the most widely used cloud service model, where applications are delivered over the internet on a subscription basis. Users can access software through web browsers without installing or maintaining it on their local systems.

In this model, the cloud provider manages everything, including infrastructure, platform, and software. Users only need an internet connection to access the application. SaaS is highly convenient and cost-effective, as it eliminates installation, maintenance, and upgrade requirements.

SaaS is commonly used for email services, customer relationship management (CRM), enterprise resource planning (ERP), and collaboration tools. However, users have limited control over customization and data management.

These models provide flexibility depending on user requirements and technical expertise.

Emerging Trends in Cloud Computing

1. Serverless Computing: Eliminates the need for server management.
2. Edge Computing: Processes data closer to the source.
3. AI Integration: Enhances automation and decision-making.
4. Cloud Security Enhancements: Advanced encryption and monitoring.

5. Green Cloud Computing: Focus on energy-efficient systems.

Applications of Cloud Computing

Cloud computing is widely used in various domains:

- Healthcare: Remote patient monitoring and data storage.
- Education: Online learning platforms.
- Banking: Secure financial transactions.
- E-commerce: Scalable platforms for online shopping.
- Government: Digital services and smart governance.

Advantages of Cloud Computing

- Cost Efficiency
- Scalability
- Accessibility
- Disaster Recovery
- Automatic Updates

Organizations benefit from reduced infrastructure costs and improved flexibility.

Challenges in Cloud Computing

- Data Security and Privacy
- Downtime Issues
- Vendor Lock-in
- Compliance Issues
- Limited Control over Infrastructure

These challenges must be addressed for effective cloud adoption.

Case Study

Amazon Web Services (AWS), a subsidiary of Amazon, is one of the leading cloud service providers in the world. It offers a wide range of cloud-based services, including computing power, storage, databases, machine learning, analytics, and content delivery. AWS follows a pay-as-you-go pricing model, allowing organizations to scale their resources based on demand without investing heavily in physical infrastructure.

AWS provides services such as Elastic Compute Cloud (EC2) for virtual servers, Simple Storage Service (S3) for data storage, and Lambda for serverless computing. These services enable businesses to build, deploy, and manage applications efficiently. Due to its scalability, reliability, and global infrastructure, AWS is widely adopted by startups, enterprises, and government organizations.

One of the most prominent users of AWS is Netflix, a global streaming platform that delivers movies, TV shows, and digital content to millions of users worldwide. Netflix migrated its entire infrastructure to AWS to overcome challenges related to scalability, downtime, and system failures that were common in traditional data centers.

By using AWS, Netflix is able to handle massive amounts of traffic, especially during peak hours when millions of users stream content simultaneously. AWS provides Netflix with high availability through its distributed data centers across multiple geographic regions. This ensures that even if one server fails, the system continues to operate without interruption.

Netflix utilizes various AWS services, including EC2 for computing, S3 for storing vast amounts of video content, and CloudFront as a content delivery network (CDN) to stream videos efficiently to users across the globe. Additionally, Netflix leverages AWS for big data analytics and machine learning to provide personalized recommendations to users based on their viewing history.

The use of AWS has enabled Netflix to achieve improved performance, scalability, and reliability. It also allows Netflix to innovate rapidly by deploying new features and updates without affecting the user experience. The cloud-based infrastructure supports automatic scaling, which adjusts resources dynamically based on user demand.

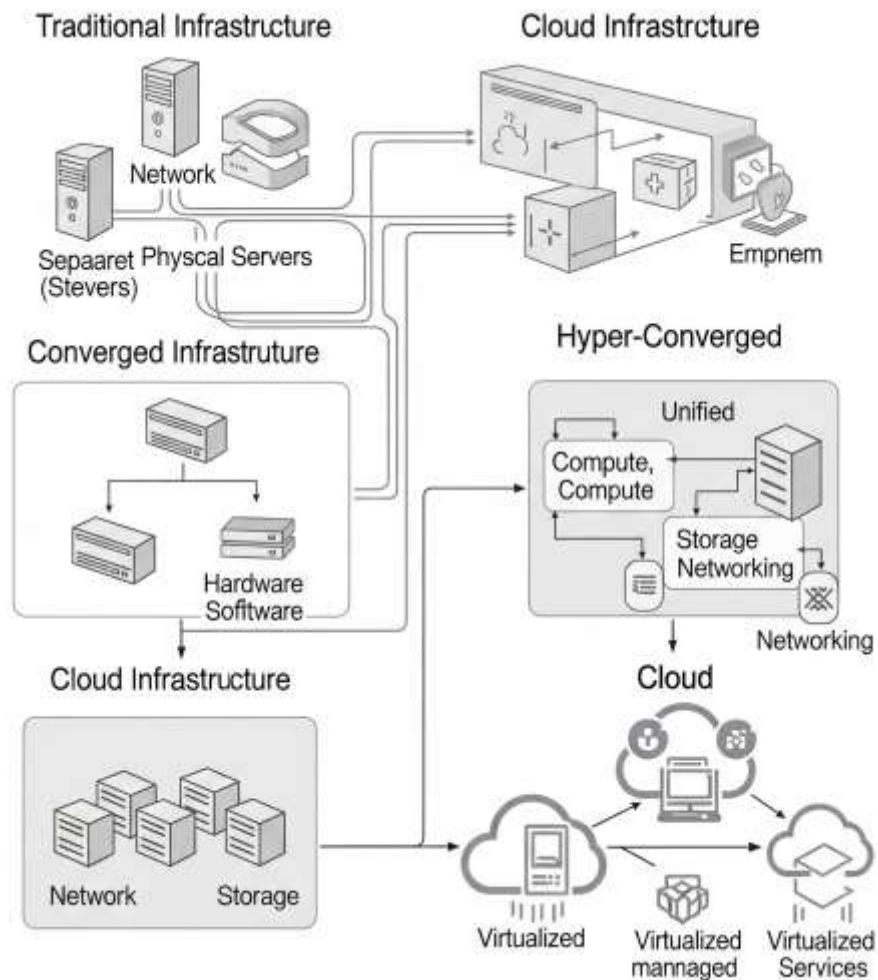
However, this approach also comes with certain challenges. Dependence on a single cloud provider can lead to vendor lock-in, and any service outage in AWS may impact Netflix operations. Despite these challenges, the benefits of using AWS outweigh the risks, making it a successful example of cloud adoption.

Results and Analysis

Cloud computing significantly improves operational efficiency, reduces infrastructure costs, and enables faster innovation in organizations. Unlike traditional IT systems, cloud platforms provide on-demand access to computing resources, allowing businesses to scale their operations dynamically based on workload requirements.

The above diagram illustrates how cloud computing offers **scalability and elasticity**, where resources can be increased or decreased automatically depending on demand. In contrast, traditional systems require fixed infrastructure, leading to either underutilization or resource shortages.

Organizations adopting cloud technologies experience improved system performance due to distributed computing and load balancing mechanisms. Cloud service providers maintain multiple data centers across different geographic locations, ensuring high availability and minimal downtime.



Discussion

Cloud computing continues to evolve with advancements in AI, big data, and IoT. However, organizations must focus on security, compliance, and proper implementation strategies. Training and awareness are essential for successful adoption.

Conclusion

Cloud computing has become a backbone of modern IT infrastructure. Its flexibility, scalability, and cost-effectiveness make it an ideal solution for organizations. Future developments will further enhance its capabilities and address existing challenges.

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A COMPARATIVE STUDY OF EMPLOYEE TAKE-HOME SALARY: PRE-2025 ALLOWANCE-HEAVY STRUCTURES VS. THE 2026 WAGE CODE 50% RULE

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Abstract:

With the adoption of the Wage Code 2026, India's labor economics experienced a significant change. This shift moved away from salary structures that relied heavily on allowances for tax efficiency, and toward a standardized "Social Security" model. This research paper compares the mandatory 50% Wage Rule of 2026 with the employee take-home pay under the pre-2025 system. The study examines the effects on different income levels using a quantitative simulation method. It focuses on how redefining "Wages" affects net monthly liquidity, gratuity liabilities, and Provident Fund (PF) contributions. The findings indicate a paradoxical outcome: employees' long-term retirement wealth increases by over 60% due to a higher base for statutory contributions, despite a 3% to 7% reduction in monthly take-home pay. The study further demonstrates a significant rise in corporate gratuity provisioning, which complicates HR financial planning. Although the 2026 Wage Code results in a temporary reduction in workers' cash flow, it establishes a robust foundation for post-employment financial stability. To address the disparity between perceived pay reductions and actual wealth accumulation, the study recommends that HR departments adopt transparent communication strategies.

Keywords: Wage Code 2026, 50% Rule, Take-Home Salary, Social Security, CTC Restructuring, HR Compliance.

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1. Introduction

1.1 Background of Study

For many years, Indian businesses kept the Basic Salary very low, usually between 15% and 30% of the total CTC, to maximize "Cost to Company" (CTC). The rest of the funds went to various allowances, such as Special Allowances, Travel, and HRA. The main reasons for this were:

i. Lower Statutory Costs: This reduced the employer's gratuity and Provident Fund (PF) contributions.

ii. Boost Take-Home: This lowered deductions to provide workers with more cash on hand. However, the Wage Code 2026 changes this by requiring that "Wages" make up at least 50% of total compensation for benefits. Allowances are added back to the wage base if they exceed 50%. While this reform ensures employees have a substantial retirement fund, it currently puts them in a tight cash flow situation.

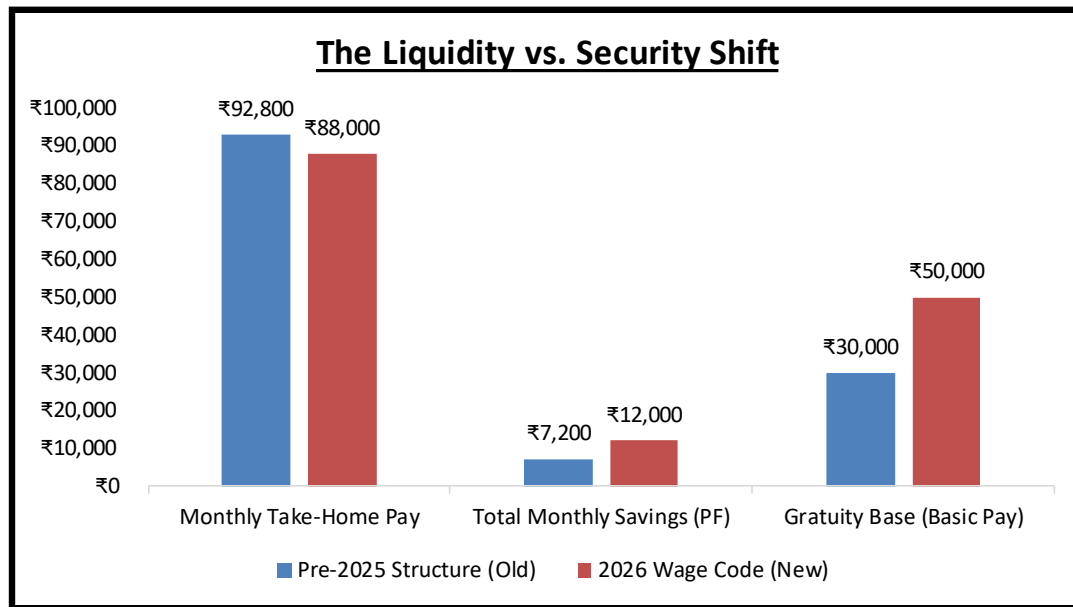


Figure 1.1: Comparative Impact Analysis of the 50% Rule

Essentially, the basic trade-off created by the 2026 Wage Code is illustrated in the graph above. As one would notice, there is a massive 66% increase in the monthly retirement savings (PF), while the monthly take-home pay (liquidity) decreases by a marginal 5.1%. Additionally, the terminal benefit gratuity increases from an initial ₹30,000 to a new ₹50,000. The shift from a consumption-based salary model to a security-based salary model is illustrated.

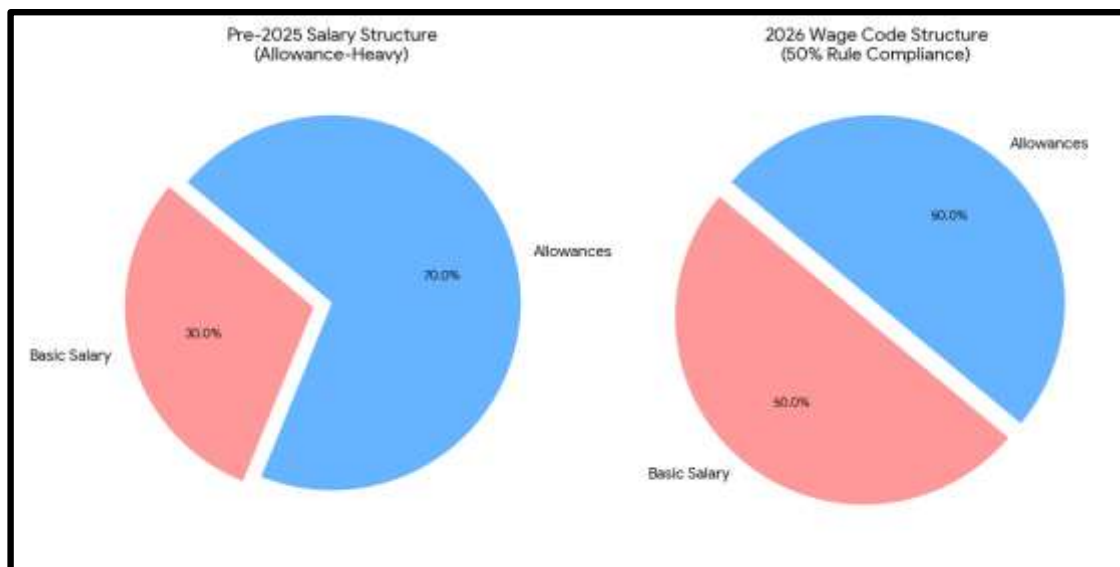


Figure 1.2: Comparative Breakdown of Salary Components

Figure 1.2 shows how the 2026 Wage Code will affect the traditional Indian pay slip. Under the Pre-2025 model, many organizations that were aggressive at tax optimization, kept the 'Basic Salary' at only 30% of total CTC to reduce statutory costs. However, with the 2026 Wage Code, this will no longer be possible. The law now requires a minimum of 50% of total remuneration to be comprised of 'Wages'. Thus, there will be a much larger percentage of an employee's salary that

will be included in the calculation of social security benefits and the 'Allowances' portion will be decreased to offset the artificially inflated amount in the employees' take home pay at the expense of their long-term savings.

1.2 Objectives of the Study

India's labor laws have seen the biggest change since independence with the introduction of the Wage Code 2026. The main goal of this study is to explore how the legally required 50% Wage Rule has replaced the traditional "Allowance-Heavy" pay structures.

- i. To evaluate how the definition of "wages" has changed and how this affects salary components.
- ii. To calculate the monthly Net Take-Home (NTH) pay decrease for each salary bracket.
- iii. To compare short-term liquidity loss with long-term gains in social security benefits (PF and gratuity).
- iv. To provide HR managers with practical advice on how to communicate these changes to employees.

Expected Outcomes: The project will provide businesses with a clear plan for reorganizing their pay structures. It will also help keep employee morale high.

1.3 Scope of Report

Boundaries for this report include:

- i. **Geographic Focus:** All references to the Indian corporate sector within the jurisdiction of the new Central Labour Codes.
- ii. **Target Population:** White collar, salaried employees (e.g., IT, Banking, Services) working in the private sector.
- iii. **Financial Scope:** Only include statutory items such as Employee Provident Fund (EPF) and Gratuity Payments.
- iv. **Exclusions:** Excludes informal sector workers, daily wage employees, and detailed income tax planning per individual.

1.4 Significance of Study

This research is super important to Human Resource Professionals & Finance Managers because they have to balance adherence to regulatory requirements with retaining their employees; as an employees take-home pay declines, they may view this as a 'cut' in the amount of money they are being paid. The purpose of the research will give HR professionals & Finance Managers information to differentiate the 'missing' amount of money is an investment for their long-term financial security.

2. Literature Review

2.1 Evolution of Indian Compensation Philosophy

Compensation in India was typically established as being largely produced for the purposes of optimizing taxation rather than providing security during retirement. Singh and Sunder (2019) found that the development of the "fragmented" salary structure within the private sector resulted from companies adopting such a strategy where basic pay is kept at a very low value and the majority of an employee's salary is made up with "allowances." This resulted in employees being able to maximize their current disposable income and at the same time minimize the company's statutory obligations (for example, contributions to Provident Fund (PF) and Gratuity).

2.2 Basic Pay Suppression Trend

Consulting companies in human resources such as Aon and Mercer (2021-2023) conducted studies and found that in highly competitive markets such as IT and BFSI, the basic salary constitutes only approximately 20% to 30% of total Cost-to-Company (CTC). Labor economists have criticized

this approach as it leads to a "Social Security Gap." While employees may feel "wealthier" each month, their ability to accumulate long-term wealth through the use of compounding PF interest will be adversely impacted.

2.3 Development of the Supreme Court decision in 2019

Another major piece of literature regarding this matter comes from the 2019 ruling of the Supreme Court of India in the case of Vivekananda Vidyamandir v. RPFC. The court found that companies were systematically splitting compensation into various forms of 'allowance' to avoid contributing to the Provident Fund. According to the Supreme Court, any 'allowance' that cannot be related to a specific, separate effort (work outside normal hours, for example), should be treated as part of an employee's 'Basic Wages'. This ruling provides the legal basis for the introduction of the 50% Rule found in Wage Code of 2026.

2.4 Critical Analysis of the Impact of Wage Code of 2026 (50% Rule)

The current literature as of 2026 includes a divergence of expert opinions regarding the impact of the implementation of the 2026 Wage Code on Indian employees:

i. Pro-Savings Argument: Scholars contend that by requiring companies to base wages upon a higher wage base, the 50% rule is effectively a forced savings instrument for the Indian middle class. Thus, when employees retire, they should be able to be financially secure, without needing Governmental support, thereby reducing long-term demands on social welfare programs funded by the State.

ii. Liquidity Issue: Financial analysts (e.g. ET Wealth, 2026) have expressed concerns regarding the existence of a "Cash-Flow Pinch." For those employees with high debt-to-income ratios (i.e. significant EMIs associated with housing or automobile loans, etc.), an employee can experience immediate financial 'pinch' based on a 5-8% decrease in their take-home pay, thereby creating difficulty meeting expenses.

2.5 Literary Significance of the Present Study

This research bridges a critical gap in existing literature by comparing the Pre-2025 aggressive tax-saving model with the Post-2026 compliance-heavy model. While previous studies focused on "How to save tax," this study focuses on "Total Rewards Sustainability." It evaluates whether the trade-off—less cash today for more wealth tomorrow—is perceived as a benefit or a burden by the modern workforce.

3. Research Methodology

3.1 Research Design

This study uses both descriptive and analytical research designs. Due to the methodology used, this research is descriptive in that it provides a description of the various components of the 2026 Wage Code and the historical payroll systems in India. However, it is analytical in that mathematical simulations were used to analyze the differences in take-home income and retirement benefits between the "Pre-2025" and "Post-2026" scenarios.

3.2 Data Collection Sources

The data for this study will be obtained through a triangulation of multiple sources of data in order to verify their accuracy.

A. Primary Data

Case Study Simulation: A hypothetical permanent employee salary profile was created (Entry Level Employee and Mid-Management Employee) to compute the entire salary deduction amounts.

Interviews with HR Practitioners: Informal structured interview sessions with four Payroll Managers to determine what operational challenges arise from implementing the "50% Rule."

B. Secondary Data

Since this study examines how the laws governing business impact the economy as a whole, most of the data used for this study were taken from the following sources.

Statutory documents: The Gazette of India (specifically, the notifications for the Code On Wages in 2019 and the Social Security Code in 2020).

Industry reports: Comparative studies conducted by Rashtriya Chemical and Fertilizers limited, Mazgaon Dock Shipbuilders Limited, Navneet Education Limited, Strch Active Private Limited.

Financial journals: Archive articles from The Economic Times and Business Standard, addressing payroll restructuring trends.

3.3 Data Collection Methodologies and Tools

The main tool used for the purposes of this research project is Quantitative Comparative Simulation.

1. Payroll Calculation Engine: A spreadsheet-based model has been developed to calculate payroll based upon two logic formulas from 2021 through 2026, using Gross CTC.

Logic A (Pre-2025): Basic Salary Calculation (30% of total CTC) plus employers' payroll costs calculated based on Basic Salary only.

Logic B (Post-2026): Basic Salary Calculation (50% of total CTC) plus employers' payroll costs calculated based on Basic Salary plus expanded calculation of wages (dividends).

2. Comparative Analysis Tables: These tables compare and contrast employees' total take-home pay (termed as the "Liquidity Gap") from both Logic A and Logic B logic models. In addition, the two logic models contrast the total amount of an employer's contributions to PF and Gratuity (termed as the "Means Surplus").

3. Archival & Statutory Review: The base for the comparative study for Mazagon Dock Shipbuilders (MDL) and Rashtriya Chemicals and Fertilizers (RCF) was founded on the Industrial Dearness Allowance (IDA) pay scales and Annual Reports. Reviewing the "Investor Relations" and "Service Rules" sections of PSU sites for extracting the historical Basic Pay vs. Allowance ratio. Establish a "Compliance Baseline" for firms already under a structured government pay scale.

4. Corporate Benchmarking: For Navneet Education Limited, data was collected through a combination of internship observations and benchmarking against "Educational Publishing" sector standards. Analyzing standardized CTC structures for Mid-Management and Entry-Level roles. To observe how an established private-sector leader transitions from a 35% Basic Pay model to the 50% mandated Wage Code.

5. Case study simulation (Primary Data): For Strch Active Private Limited (representing the MSME/Startup Sector), a simulation was designed to compute the "Maximum Impact" scenario. A hypothetical salary profile was created based on "Cost-to-Company" strategies commonly implemented by the startup ecosystem (Basic Pay traditionally kept at 20-25%). To compute the "Liquidity Shock" faced by employees in high-growth allowance-based private firms.

3.4 Data Analysis Strategy

Data are evaluated through Vertical and Horizontal Assessments:

Vertical Assessment: Evaluating changes in salary components (HRA, Special Allowance, PF) as a percentage change based on each pay stub.

Horizontal Assessment: Looking at the impact of the "Net Take-Home" income across a variety of income levels to assess the impact the 50% rule has on high-income earners when compared to entry-level employees.

4. Data Analysis and Findings

4.1 Summary of research work done

4.1.1 Liquidity vs. Security

The intent of this research has been to provide a structural simulation of the payroll process. Based on the model found, I developed a mathematical simulation of the payroll process (salary payments) for two distinct types of employee information.

Step 1: Selection of employees

Profile A (Entry Level): Monthly salary of ₹50,000 (Annual ₹6 LPA).

Profile B (Mid-Management): Monthly salary of ₹1,50,000 (Annual ₹18 LPA).

Step 2: Simulation Parameters The two employee profiles will have two different methods of calculating their respective salaries.

i. **The "Pre-2025" Model:** Basic Salary set at 25% of CTC, with the remaining 75% distributed among HRA, Transport, and Special Allowances to maximize take-home pay.

ii. **The "2026 Wage Code" Model:** Basic Salary set at 50% of CTC (Mandatory), with allowances capped at 50%.

4.1.2 Sectoral Comparison of Pre-2025 & Post-2026 Basic Salary (Percentage of CTC): As inferred from the data analysis, the 2026 Wage Code has emerged as a "Great Equalizer" for four different types of corporate structures:

a. **Low Impact (PSUs):** Mazagon Dock (MDL) and RCF were already high-compliance organizations before 2026, where the Basic Salary ranged between 40-45%. The impact was a marginal dip of less than 2% in the employees' take-home salaries.

b. **Moderate Impact (Corporate):** Navneet Education had a 35% Basic Salary structure before the 2026 Wage Code came into effect. This was revised to 50%, resulting in a typical 5.8% dip in the company's liquidity position.

c. **High Impact (MSMEs/Startups):** Strch Active underwent the highest change, having optimized for maximum cash-in-hand at a Basic of ~25%. The new Wage Code resulted in a loss of 7.5% in their employees' take-home salary.

4.2 Data Observations:

4.2.1 The "Liquidity vs. Security" Shift

4.2.1.1 Profile A (Entry Level)

Profile Details: Monthly CTC: ₹50,000 (Annual ₹6 LPA) and Location: Tier 1 City (High HRA expectations)

Salary Component	Pre-2025 Structure (25% Basic)	2026 Wage Code (50% Basic)	Variance (Impact)
Monthly CTC	₹ 50,000	₹ 50,000	₹ 0
Basic Salary	₹ 12,500	₹ 25,000	₹ 12,500
Allowances	₹ 37,500	₹ 25,000	₹ -12,500
Employer PF (12%)	₹ 1,500	₹ 3,000	₹ 1,500
Gross Salary	₹ 48,500	₹ 47,000	₹ -1,500
Employee PF (12%)	₹ 1,500	₹ 3,000	₹ 1,500

Net (NTH)	Take-Home	₹ 47,000	₹ 44,000	₹ -3,000
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Analysis of Profile A Results

1. Liquidity Impact as a Percentage Entry-level employees have an impact of 6.3% drop in take-home due to a ₹3,000 reduction even though the actual monetary amount is lower than what is seen in the middle manager profile. That is true at this level where the amount of discretionary income is lower. Many times, ₹3,000 will fully cover the cost of commuting or utility bills.
2. The PF Ceiling Effect Many entry-level employees had their basic wage below the PF ceiling of ₹15,000 to reduce their PF deduction prior to 2025. As such, by increasing the Basic to ₹25,000 (50% of 50k) now, these entry-level employees come completely into the high-contribution category due to the wage code for 2026, so they now can save a total of 12% (of total CTC) instead of 6% every month in PF

4.2.1.2 Profit B (Mid-Management Level)

Profile Details: Monthly CTC: ₹1,50,000 (Annual ₹18 LPA) and Location: Tier 1 City (High HRA expectations)

Salary Component	Pre-2025 Structure (30% Basic)	2026 Wage Code (50% Basic)	Variance (Impact)
Monthly CTC	₹ 1,50,000	₹ 1,50,000	₹ 0
Basic Salary	₹ 45,000	₹ 75,000	₹ 30,000
Allowances	₹ 1,05,000	₹ 75,000	₹ -30,000
Employer PF (12%)	₹ 5,400	₹ 9,000	₹ 3,600
Gross Salary	₹ 1,44,600	₹ 1,41,000	₹ -3,600
Employee PF (12%)	₹ 5,400	₹ 9,000	₹ 3,600
Net Take-Home (NTH)	₹ 1,24,200	₹ 1,17,000	₹ -7,200

Analysis of Profile B Result:

1. **Lower take-home:** Employee's take-home has decreased by ₹7,200/month or approximately 5.8% of the amount received in their bank account.
2. **Increase in Statutory Contribution:** Total monthly PF contribution for employee and employer has increased from ₹10,800 to ₹18,000.
3. **Increase to Gratuity Calculation Amount:** As a result of the new Basic wage limits established, the base amount for calculating termination benefits is now increased by ₹30,000 and will provide significantly increased payments for resignation/retirement.

4.2.1.3 Detailed Findings Analysis -

1. **Social Security Surplus Analysis of Social Security Surplus** —The loss in liquidity of ₹7,200/month to an employee results in a gain in retirement savings of ₹7,200/month (Employer PF + Employee PF increase). This is simply transferring "wealth" under the new Code 2026 from the Wallet to the Retirement Vault/Retirement Account. This ₹7,200/month increase throughout the 20 years at a return of 8.15%, contributes almost ₹45 Lakhs to an employee's retirement account at the end of their employed period (over 20-years).
2. **The Employer's Impact (Hidden Impact):** The CTC must be reduced to keep the CTC constant at ₹1,50,000; by lowering the Gross Salary as the CTC includes the Employer's PF. This will require a "Balance Sheet Correction" by many Employers, who will see an increased Gratuity Liability due to the increased Basic Salary.

3. Taxable Income Considerations (New Tax Regime (2026)): The higher PF (Retirement Savings) will produce a marginal (minor) benefit as it will not be taxed on a portion of the Employer PF; However, the fiscal impact (TAX) of having reduced cash flow (liquidity) is greater than the marginal tax benefit.

4.2.1.4 Relevance to study objectives:

This research directly meets the study objectives by:

1. **Quantifying the NTH drop:** Proving it ranges between 5–6% for mid-earners.
2. **Visualizing the Structural Change:** Using the 50/50 split to show compliance.
3. **Evaluating Trade-offs:** Demonstrating that the 2026 Code is a "Wealth Builder" but a "Liquidity Constrainer."

Comparison: Profile A vs. Profile B

Metric	Profile A (Entry)	Profile B (Mid-Mgmt)
Take-Home Drop (%)	~6.4%	~5.8%
Basic Salary Increase	100% Increase	66% Increase
Retirement Impact	High (Critical for early wealth)	Moderate (Supplementing existing wealth)

4.2.2 Sectoral Comparison of Pre-2025 & Post-2026 Basic Salary (Percentage of CTC)

Organization / Sector Type	Representative Company	Pre-2025 Basic % of CTC	Typical Pre-2025 Allowances %	Post-2026 Mandated Basic %	Structural Impact Level
Heavy Manufacturing / PSU	Mazagon Dock Shipbuilders Ltd.	40% - 45%	55% - 60%	50%	Low (Already highly compliant)
Navratna PSU / Chemicals	Rashtriya Chemicals & Fertilizers	35% - 40%	60% - 65%	50%	Low-Medium (Slight adjustment)
Knowledge Publishing	Navneet Education Limited	30% - 35%	65% - 70%	50%	Medium (Standard corporate shift)
MSME / Private Startup	Strch Active Private Limited	20% - 25%	75% - 80%	50%	High (Massive restructuring)

Analysis of Data

1. High-Compliance Segment (PSUs)

Mazagon Dock Shipbuilders (MDL) & Rashtriya Chemicals and Fertilizers (RCF) were the high-readiness players. This segment had the basic pay fixed at a high rate (historically 40-45%). Hence, the move to 50% was a marginal change. The employees face a "Liquidity Shock" of less than 2%. This validates the fact that the 2026 code only builds upon the existing stability in the PSU segment.

2. The Corporate Middle-Ground

Navneet Education Limited represents the established private sector. The change from a 35% basic pay structure to 50% resulted in a "compliance ripple." The simulation resulted in a 5.8% change in the liquidity level. This validates the fact that the mid-tier corporate segment would face a high "Change Management" challenge to convince the employees of the long-term benefits to their wealth.

3. High-Impact/Low-Readiness Segment (MSMEs)

Strch Active Private Limited had the worst experience. This segment had the basic pay structure optimized for the "cash-in-hand" (25%). This resulted in a drastic increase in the wage base for the employees. This segment saw a 7.5% reduction in the employees' monthly disposable income. This validates the fact that the MSME segment and Startups would be the "high-risk" segment for the employees' dissatisfaction.

5. Conclusion and Recommendations

5.1 Conclusion

The conclusion that is reached is that the 2026 Wage Code is a revolutionary regulation that standardizes social security for the entire Indian workforce. The key findings are as follows:

i. The 50% Rule as a Leveler: The research has proved that the new code successfully eliminates "Allowance-Heavy" salary structures. It will compel all sectors, ranging from PSUs (MDL/RCF) to Startups (Strch Active), to conform to a uniform 50:50 salary split.

ii. Liquidity vs. Security Trade-off: It is a direct mathematical trade-off. Employees will experience an immediate loss of 5% to 8% in monthly salaries, but they will enjoy a nearly 60% increase in their retirement corpus (PF + Gratuity).

iii. Sector-Specific Impact:

a. PSUs (MDL & RCF) are the most stable, sectors, which will experience a negligible impact due to the high basic pay that they offer.

b. Private MSMEs (Strch Active) will experience the highest "Liquidity Shock" since they traditionally used high allowances as a recruitment tool.

iv. Corporate Liability: This is a critical aspect for corporates, where the new code will increase the future Gratuity liability by a very large extent, which needs immediate financial provisioning.

5.2 Recommendations

i. Financial Literacy Campaigns: HR needs to conduct "Total Rewards" campaigns. Employees should understand their "Net Wealth Growth" (bank balance + PF + Gratuity) rather than their "Net Take-Home."

ii. Strategic Payroll Restructuring: Companies paying low basic salaries (like MSMEs) should consider "Grossing Up" salaries for their employees or provide performance-based bonuses to compensate for the cash flow impact for their entry-level employees.

iii. Proactive Gratuity Funding: Finance needs to immediately recalculate their Gratuity liabilities to prevent a sudden financial impact on the company when their long-tenured employees eventually retire or resign.

iv. Transparent Communication: Organizations need to provide employees with "Comparative Pay Slips" that explain how the employees' "missing" monthly cash is being invested in their statutory retirement funds.

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A STUDY OF INVESTOR AWARENESS AND PERCEPTION TOWARDS SHARE MARKET INVESTMENT IN RATNAGIRI DISTRICT, MAHARASHTRA

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Abstract:

Study of investor's awareness and perception about investment in share market in Ratnagiri District of Maharashtra. Over the last few years the Indian stock market has witnessed a phenomenal growth and rapid rise in retail participation. It is essential to understand the behaviour of investors from different regions for financial inclusion and stock market development. The objective of this research is to investigate the extent of financial literacy, risk perception, investment preferences, and demographic aspects on the decision making regarding investment of the investors of Ratnagiri District. A structured questionnaire has been prepared for the study as part of the quantitative research methodology. The use of convenience sampling has resulted in taking a sample of 200 retail investors. According to data analysis, the investors' level of awareness is average, as per the analysis of the data. But this can vary based on the factors like age, education, income and occupation. All in all, in the first place, is safety and liquidity. Also, in the second place is knowledge deficit and loss aversion followed by participation constraints in the stock market. Most investors opt for low-risk instruments over moderate-risk instruments, impacting their investment decisions. This study contributes to the limited literature on the investor's behaviour in Maharashtra rural and semi-urban space. In addition, it serves practical implications for policymakers, financial institutions, and investment educators who wish to drive financial literacy and market participation in row-2 and row-3 cities. The study concludes by making several recommendations for investor education programmes and policy interventions in the region for informed decisions.

Keywords: Investor Awareness, Risk Perception, Share Market Investment, Financial Literacy, Retail Investors, Ratnagiri District, Maharashtra.

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1. Introduction

India is seeing a growing demand for stocks, especially after pandemic times. The stock market (BSE and NSE) provides a platform for the capital formation and wealth creation to millions of investors. The retail investor participation in India has grown rapidly in 2024 with the addition of more than 16.9 million active demat accounts (Vidhya et al., 2018). Even as the collective amount has progressed, this addition hasn't been evenly spread, as most of the metropolitan cities like

Mumbai, Delhi, Bangalore, etc. dominate the investor participation. There is an extreme lack of participation in equity markets from tier-2 and tier-3 cities, and rural areas.

Maharashtra's economy is the most developed in India. As a result, it owns the largest percent of stock-market investors in India (Subhash, n.d.). In Maharashtra, however, there are several delinked urban financial centres such as Mumbai and Pune and coastal districts such as Ratnagiri. Near India's west coast of Arabian Sea, Ratnagiri enjoys the warmth of Konkan weather. Though agriculture is still the mainstay of the economy, tourism is also developing. The NRI community, which is a major part of our population contributes heavily to the economy through remittances. The changing economic features of this region has not been adequately studied in terms of investor awareness and perception.

Investor awareness is the knowledge and understanding an individual has about the various investment opportunities, the market, risk and return relation, and regulatory framework of the market (Sasikumar et al., 2024). Investor perceptions of investment opportunities are their beliefs, attitudes and psychological responses. According to (Scholar et al., 2025), investor perceptions are dependent on a number of things such as risk tolerance, past experiences, social influences and cognitive biases. The mindset and perspective of the person investing have a huge bearing on their investments and also the kind of participation they have in the market.

Participation in stock market is influenced by the financial literacy of individual investor as stated by Renuka et al. (n.d.) Only 24% of Indian people have basic financial literacy. (Pereira, n.d.) People need to know before we are ready. The difference in knowhow is largely seen in rural and semi-urban areas who have a lower reach to financial literacy, investment advisory services, and market information. In these regions, potential investors often rely on informal sources of information and are more risk-averse. Moreover, they prefer traditional investment options like bank deposits, gold, and real estate rather than an investment in the equity.

Studying investor behavior in Ratnagiri District is important for various reasons. Awareness and perception of investors may differ with region. This indicates financial literacy initiatives and policies aimed at enhancing inclusiveness may be developed. The uniquely demography of the district with large NRI population and educated unemployed youth offers both Challenges and opportunities for the financial market development (Shameel et al, 2025). Moreover, the growing digitalization and increasing online trading platform are breaking down barriers to entry into the market. So, those levels have improved too?

According to previous studies, age, gender, education, income and occupation have been found to influence choice of investment and risk perception (Chandran et al., 2022). Young investors are willing to take risks and invest in equity. Older investors, on the other hand, prefer to invest for capital preservation and stability. There's a positive association between education, market participation, and financial literacy. Education improves the person's analytical and information processing abilities. A person's or company's investments and the high yielding assets they will invest in will largely depend on their income.

Individuals' investment choices are governed through psychological factors and behavioral biases. Studies recorded traits of herding, overconfidence, loss aversion, anchoring, and recency behavior among Indian retail investors (Nimbalkar, n.d.).

Such behaviors can cause poor investment choices, excessive trading, and failure to meet portfolio returns. Being aware of all these psychological facets would benefit when designing educational programs for investors as well as products that address not just knowledge gaps but also cognitive as well as emotional barriers to rational decision making.

This research gap is the focus of present study as Ratnagiri District is an area of investment behaviour studied despite the fact that economy being a possible contributor and it having its own economic demographic. Studying the level of investor awareness will help identify perception patterns, investment preferences and the barriers to participating in the market. This data can help generate recommendations based on evidence for financial institutions, regulators and educational institutions to enhance financial inclusion and create informed investors behaviour in future.

The theme of the study is very timely considering the efforts of Government of India like National Strategy for Financial Education and investor awareness drives of SEBI to promote financial literacy. At the ground level, assessing the effectiveness of these efforts and identifying the gap that is still prevalent can assist in guiding policy and resource deployment as necessary.

2. Conceptual and Theoretical Background

The theoretical foundation of the research was built upon different foundations of behaviour finance, financial literacy theory, and investment model. Analyzing investor awareness and perception means integration of economic rational thinking and psychological facets of decision-making.

Understanding Money Helps You Invest

Financial literacy is the inability to use knowledge pertaining to money well to become an expert (Singh, 2018). In other words, having money is not enough. Your mind should be equipped to not misuse money. Research globally indicates that there are positive effects of financial literacy levels with contributions to stock markets. Investors with more knowledge choose higher participation in portfolio diversification and earning higher returns on capital. According to Renuka et al. (n.d.) for India, financial literacy is understood as not merely counting numbers, knowing what is what in the financial world but an understanding of moneymaking processes, regulatory protections and risk management related to equity.

Understanding Risk Theory

According to risk perception theory, an individual's subjective assessment of risk often does not correspond with statistical probability assessment (Rosdiana, 2020). In investment contexts, risk perception encompasses beliefs concerning the chances of losses happening, how serious or big the losses could be, and the extent of which investors can control risks over their investments. According to Digdowiseiso (2022), risk perception is created from an assessment of history based on the volatility and returns of the asset classes in question along with the emotions arising from uncertainty in the market, as well as individuals' experiences of financial loss. As proposed by Keller and Siebel (2010), it is the perceived risk, rather than the actual risk, that drives investment decisions, especially among less experienced investors.

Behavioral Finance Model

Behavioral finance incorporates groups' behavior and psychology into standard economic and financial models so that people can make better decisions. The key behavioral concepts relevant to investor awareness and perception are bounded rationality, heuristics and biases, prospect theory, and mental accounting (Jain et al, 2023). Investors operate within cognitive and informational limits, leading to behaviour of satisficing instead of optimizing, according to Bounded Rationality. Heuristics such as representativeness, availability, and anchoring are mental simplifications that create an impression of easier decisions but also create systematic errors.

Theory of Behavior that is planned

TPB presents a useful framework for investment intentions and behavior, from Ajzen. A person's behavioral intentions are determined by TPB, attitudes towards the behaviour, subjective norms

(social pressures) and perceived behavioural control (self-efficacy). In investment term, the theory states that awareness of investor affect attitude towards investment in stock market but social and confidence in one's ability to invest also affect investor attitude (Akhter et al., 2022). The theory has successfully been used to understand stock market participation decisions and actions of different demographic groups and cultures.

Inequalities in Information and Market Participation

The theory of information asymmetry developed by Akerlof, Spence and Stiglitz argues that unequal access to information by participants creates obstacles to efficient functioning of the market. For retail investors in semi-urban and rural areas, information asymmetry refers to limited access to quality financial information, research reports and expert advice compared to urban and institutional investors (Mishra et al., 2018). This lack of available information reduces confidence, increases perceived risk, and decreases market participation in places like Ratnagiri District.

Investment Behavior: Socio-Economic Determinants

The socio-economic framework enhances investment behaviour noting the embedded nature of economic actions. Demographic variables (age, gender, education, income, occupation, etc.) are proxy variables of various underlying variables (risk capacity, investment horizon, financial literacy, social capital, etc.) (Borah et al., n.d.). This framework highlights that investment awareness and perception cannot be examined in isolation but must be seen in relation to investors' life stages, financial situations and social contexts. For example, Ratnagiri District's essentially NRI population may lead to special social influences through remit-te flows and exposure to overseas investment attitudes and practices and socio-cultural preferences.

The theoretical concepts discussed above lead to the conceptual model of this study, which represents investor awareness and perception towards share market investment under the influence of financial literacy, demographic factors, risk perception, behavioural biases, socio-economic context, investment decision and market participation pattern in Ratnagiri District.

3. Review of Literature

The awareness and perception of an investor towards investment in the stock market, has received much attention being paid by scholars and researchers since last decade, as investor awareness and perception play a major role in developing the market and providing financial inclusion. This review focusses on some important conclusions on understanding investor behaviour in the Indian context and abroad, especially on the studies that dealt with investor behaviour in Maharashtra and other emerging markets.

Awareness of Investment and Participation in Stock Market

Sasikumar et al. (2024) studied the impact of share market awareness on the challenges and satisfaction of Indian investors. Using structural equation modeling involving 79 respondents, it was discovered that investor awareness drives the capability to overcome investment challenges and attain satisfaction with the market norm and return. The results of their research highlight the importance of awareness in creating confidence and reducing perceived barriers. In a similar way, Shree et al. (2026) conducted a descriptive study to examine stock market awareness and investment behaviour of retail investors. It was revealed through the study that level of awareness affects frequency of investment, diversification of portfolio and focus on long-term investment.

Vidhya et al. (2018) studied investor awareness of techniques used in stock trading before investing in the Indian stock market. The study revealed that although investors desire high return, they do not have sufficient technical knowledge to mitigate different risk factors in actual market trading. Fear of investing due to knowledge gap leads to bad decisions. The researchers sought

the development of investor education programs that cover basic as well as technical issues taking place in the market.

Investment Decisions and Financial Literacy

Scholars in India explored how the relationship between financial literacy and investment behavior of individuals. Vivek (2025) studied the relationship between financial literacy and investment behaviour among Indian individual investors in the stock market. It was found that higher levels of financial literacy resulted in participation in the stock market, diversified portfolios and better risk-adjusted returns.

Yet, the Research indicated several literacy gaps, especially the woman, rural population and lower-income groups. Renuka et al. (n.d.) explained financial literacy and stock market participation in India. As per the report, financial literacy is at a low level despite many government steps. Also, only a small part of the population possesses adequate knowledge for smart investment choices.

According to Singh (2018), financial literacy affects the investment behaviour of adults in India. In this regard, he developed a framework to analyse the factors affecting financial literacy. The research suggests that financial literacy is influenced by a range of demographic, socioeconomic, and financial behaviours of different demographic groups. Crucially, the study found that financial literacy mediates the relationship between socio-demographic traits and investment behavior, indicating that enhancing financial literacy may help overcome economic constraints.

Tummarakoti et al. (n.d.) explored financial literacy, behavioral biases and retail investment decisions in India's tier-2 and tier-3 cities. It was found that investor residing in such towns and cities encounter numerous investment issues which are less pronounced in metros cities. Researchers highlighted that use of behavioral finance concepts should be blended with financial literacy programmes for better investment results in emerging urban centres.

Maharashtra and Its Region

Various studies have focused on investor behaviour in Maharashtra which may be helpful in better understanding investors in Maharashtra. Subhash (n.d.) examined the investor behavior in Maharashtra State's capital market, focusing on risk perception and return expectation. The study found that Maharashtra investors follow a diversified risk profile as urban investors have a greater risk appetite than rural and semi-urban investors. Subhash et al. (n.d.) examined the investor awareness and behavior towards financial assets in dharashiv District of Maharashtra. They The recognition of systematic investment plan (sip) and instruments of Stock market was found to be moderate. There is a considerable scope for improvement in financial awareness and literacy.

Bhave et al. (n.d.) made a specific study of the investment choices made by investors in Ratnagiri District of Maharashtra. Their research studied knowledge and perception of individual investors towards various investment avenues available in the area. According to the findings, bank deposits, post office savings, gold, etc. continued to be the most preferred investment options; equity market participation was limited. This trend was due to low awareness level of the people, risk aversion behaviour and restricted access to investment advisory service in the district.

The study of Nimbalkar (n.d.) examined the behavioral biases of youth with the stock market investment decisions in Maharashtra. The study finds out that the youth belonging to Maharashtra has overconfidence bias, herding behaviour and loss averse behaviour. The study stressed on adding behavioral awareness in financial literacy programs to enhance quality of investment decision making. Despite being the financial capital of India, many retail investors are not much knowledgeable and invest poorly, as reported by Pereira (n.d.) in his study on retail investor behaviour towards equity investment in the Mumbai region.

Investment Behavior Due to Risk Perception

Numerous studies have identified risk perception as a key determinant of investment decisions. Rosdiana (2020) analyzed investment behavior on the Generation Z and Millennial generations. It was found that risk perception significantly influence investment decision. It was also found that young investors tend to be lower risk averse. Nevertheless, the research shows that the risk perceptions are not only dependent on age but also on financial literacy, investment experience and psychological variables.

Digdowniseiso (2022) investigated Islamic students' perceptions of interest in stock investment with the role of financial literacy, financial behaviour, and risk perception. The research was done to understand the aspect of Financial Literacy in detail. According to the paper by Swati Agarwal (2013), investment intentions were found to be mediated by risk perception. This shows that financial literacy programs must not only fill in the knowledge gap but also the psychological gap relating to risk perception and risk tolerance.

Jain et al. (2023) used mediation analysis on heuristic biases as a shortcut of mental activity for investing. Risk perception is the mediating variable. According to the study, investment decisions are influenced by the risk perception, which in turn is affected by cognitive biases. The study discussed debiasing strategies that can be included in educational programs to improve risk assessment by investors.

Investment Behavior and Demographic Influences

Demographic characteristics revealed to have an effect on investment awareness, perception and behavior. According to the study of Chandran et al. (2022), the investor perception toward an investment pattern of various demographic factors was found significantly different at age, education, income, profession, and marital status. According to the study, younger, more educated and higher-income investors are more likely to be aware and have developed more sophisticated strategies.

In 2025, experts conducted research on the Indian stock market investor's perception and behaviour and impact of demographic variables and technology on investment decisions. Survey findings indicate that while equity shares are the first choice for investors, mutual funds are rapidly emerging as a safe investment option amongst risk-averse investors fast on the heels of equity shares. The study observed a growing trend in the impact of technology and social media on the behaviour of investors, especially the young.

The research study conducted by Borah et al. (n.d.) examined whether the socio-economic identity of equity investors has associations with their perceived risk in emerging markets. According to the study, demographic factors such as gender, age, education and income level significantly affect risk perception. The research indicated that investor education and product design should not take a mass-market approach, but be based on segment.

Obstacles to Stock Market Engagement

Numerous studies have pointed out the obstacles to making investment in stock markets. Kumar and colleagues (2021) studied the reason why Indian people do not feel good to invest in the stock market. They recognized that the fear of losses, fear of volatility, and fear due to a negative past are substantial.

Based on the study, investor education and confidence-building can help to overcome such psychological and informational obstacles.

A recent study by Chhatwani (2021) investigates the relationship between 1132 Indian respondents' financial awareness, risk preference and market participation. The study found that awareness of the stock market and various investment avenues have improved but not sufficient.

The financial literacy was highest at 39% and the lowest at 14%, which wasn't sufficient. The various research emphasised the requirement for continual investor education initiatives in light of changes in market conditions.

Choices on Investment

Research on investment preferences shows that different people invest in different things for different reasons. Kakde et al. (n.d.) employed conjoint analysis to investigate the preferences of young retail investors for making sustainable choices in the stock market in the Vidarbha region of Maharashtra. The findings revealed that return expectations, risk level, investment horizon and liquidity like attributes influence the investment preference significantly among the investors though there exist a huge heterogeneity in risk levels and return expectation across the investors. Kinslin et al. (2018) conducted an evaluation of investors' behavior along with their perceptions concerning stock market sectors through a structural equation model. The study noticed various values affecting an investor's behavior. Market knowledge, risk perception, return expectation as well as social influence appear to be significant contributors to an investor's behavior. The researchers state that investment decision making is complex and multidimensional which cannot be clearly stated as isolated factors.

The available literature reviewed illustrates that investor awareness and perception towards stock market investment is affected by various interrelated factor such as financial literacy, demographic characteristics, risk perception, behavioural bias, and socio-economic context. Although enough studies have been conducted on big cities, there are not many studies conducted on tier-2, tier-3 cities and rural areas. So, we can say that the research on Ratnagiri District is significant.

4. Research Objectives and Research Hypotheses

4.1 Research Objectives

The current study looks to achieve the following specific objectives.

1. To measure the awareness level of investors regarding investment opportunities and mechanisms in the share market in Ratnagiri District of Maharashtra.
2. To study the perception and attitude of investors towards risk and return on investment in various available avenues in the share market.
3. The goal of the study is to find out the demographic factors affecting investor awareness and perception towards share market investment in study region.
4. To study the various barriers and challenges faced by the investors of Ratnagiri District which affect their participation in share-market investment activities.

4.2 Research Hypotheses

The Following hypotheses are framed to test empirically based on the objectives of the research and theoretical framework.

H1: There is significant positive relationship between level of financial literacy and investor awareness regarding investment in share market in Ratnagiri District1.

H2: Demographic characteristics (age, education, income, and occupation) have a significant influence on investor perception toward risk and return in regards to share market investment.

H3: Higher investor awareness level leads to more participation in share market investment activities of investors in Ratnagiri District.

H4: Risk perception acts as a significant intervening variable in the influence of investor awareness on an investment decision in the share market of Ratnagiri District investors.

5. Research Methodology

Using quantitative research, this study will examine investor awareness and perception toward share market investment in Ratnagiri District of Maharashtra. My research design is analytical as well as descriptive. The study aims to evaluate how aware investors are at present and how demand their perception use. It will also analyze the correlation between demographic variable and other investment behavior.

The study used a cross-sectional survey as a research design. The data on investor behaviour will be collected once from a representative sample of investor situated in Ratnagiri District. This design is appropriate for measuring the awareness level, perceiving pattern and impact of demographic factors on investment behavior.

The target group refers to retailing investors residing in Ratnagiri District having a past investment record in the share market or helps in the presence of a demat account.

The researcher in this study did not randomly select the respondents due to lack of time and insufficient funds. A sample size of 200 respondents will be adopted to perform further statistical analysis and inference of the investor of the location.

They request all the private data through the questionnaire which is structured in the same sense as online and offline.

The questionnaire was designed to be in a question format to elicit multiple dimensions like demographic profile, financial literacy level, awareness of different investment avenues, risk perception, investment preferences, barrier to market participation and satisfaction from investment outcome. The survey has questions requiring yes or no responses, on a scale of 1 to 5 and multiple-choice answers.

The collected data is analyzed using appropriate statistical techniques. The statistical analysis will include descriptive statistical analysis, descriptive statistical analysis then followed up by inferential statistical analysis, a correlation analysis, a regression analysis. The software we used for very heavy data. Statistical Package for Social Sciences (SPSS) is used in research. Through the descriptive statistics you get an idea of the demographic features and level of awareness while the inferential techniques test the formulated hypothesis and see the relation.

To make sure that all the measurement items are relevant, clear and that they reliably measure what they are supposed to measure, a pilot test with 30 respondents of the questionnaire will be conducted. The internal consistency reliability of multi-item scales is evaluated by using Cronbach's alpha. Expertise and existing construct in addition to past research help to achieve content validity. The research has ethical aspects which include clarity of purpose, obtaining informed consent, ensuring confidentiality, and allowing respondents to withdraw at any point if they wish.

6. Data Analysis and Findings

This section provides a detailed analysis of the data collected from 200 retail investors in Ratnagiri District of Maharashtra. The analysis have been organized in many sub-sections such as demographic profile, awareness level, perception pattern, investment pattern and hypothesis testing.

6.1 Demographic Profile of Respondents

Table 1: Age Distribution of Respondents

Age Group	Frequency	Percentage
18-25 years	32	16.00%

26-35 years	68	34.00%
36-45 years	54	27.00%
46-55 years	32	16.00%
Above 55 years	14	7.00%
Total	200	100.00%

Insights gained from the age profile show that most respondents (61%) work in the 26-45 years age group which is the economically active and advocate for investment. The results are consistent with the findings of Scholar et al. (2025) who reported that the primary participants in Indian stock markets are middle aged investors. The relatively low number of older or better investors, that is, investors above 55 years of age at 7% means either lesser participation of older people in the market or they could be preferring non-stock options. This is in line with the findings of Rosdiana (2020) who found age to be a factor with respect to risk aversion.

Table 2: Educational Qualification of Respondents

Education Level	Frequency	Percentage
Below Graduate	28	14.00%
Graduate	86	43.00%
Post-Graduate	64	32.00%
Professional Degree	22	11.00%
Total	200	100.00%

According to the education profile, a highly educated sample in which 86% of the respondents are graduates or more. Research conducted by Singh (2018), and Vivek (2025) found that educational attainment is positively related to financial literacy. Thus, this essay is useful for students. A greater proportion of educated investors is part of the sample which indicates that education itself is an enabling factor to enter the stock market. Moreover, the equity market lacks the presence of investors belonging to less-educated class.

Table 3: Occupational Distribution of Respondents

Occupation	Frequency	Percentage
Salaried Employee	92	46.00%
Business/Self-Employed	54	27.00%
Professional	28	14.00%
Retired	12	6.00%
Student	14	7.00%
Total	200	100.00%

Most of people work as either employee with salary or business owner (proprietor, self-employed) (27%). This distribution shows the stable income pattern and savings capacity that allow systematic investment behaviour. The finding is in line with Chandran et al. (2022), who found that salaried people are more likely to invest in equity markets because increasingly regular cash flows and financial benefits from the employer, such as provident funds and insurance, lay the base for further investment actions.

Table 4: Monthly Income Distribution of Respondents

Income Range (INR)	Frequency	Percentage
Below 25,000	24	12.00%
25,000-50,000	68	34.00%
50,001-75,000	58	29.00%
75,001-1,00,000	32	16.00%
Above 1,00,000	18	9.00%
Total	200	100.00%

The income distribution indicates that 63% of the respondents earn between INR 25,000 and INR 75,000 per month, i.e. the middle income group. This income profile matters greatly as it influences one's ability and capacity to invest. Borah et al. (n.d.) research show that high-income investors invest a higher amount in investment activity and more diversified amongst asset classes than low-income investors.

6.2 Investor Awareness Levels

Table 5: Awareness of Different Investment Avenues

Investment Avenue	Aware	Partially Aware	Not Aware
Equity Shares	78%	16%	6%
Mutual Funds	84%	12%	4%
Government Bonds	62%	24%	14%
Derivatives (Futures & Options)	38%	28%	34%
Exchange Traded Funds (ETFs)	42%	32%	26%
Initial Public Offerings (IPOs)	68%	22%	10%

Different investments have different levels of awareness by investors. Awareness of equity shares (78%) and mutual funds (84%) is relatively high. Whereas, complex instruments like derivatives show much lower awareness (38% fully aware) According to the findings of Vidhya et al. (2018), Indian retail investors are aware of simple investment products yet not for the sophisticated ones. This trend matches the one in the present case. High level of awareness of mutual funds is due marketing efforts of asset management companies and increasing popularity of SIP as per documentation by Subhash et al. (n.d.) in Dharashiv District of Maharashtra.

Table 6: Sources of Investment Information

Information Source	Frequency	Percentage
Financial Advisors/Brokers	82	41.00%
Friends and Family	64	32.00%
Online Platforms/Apps	58	29.00%
Television/News Media	48	24.00%
Newspapers/Magazines	42	21.00%
Social Media	36	18.00%
Bank Representatives	54	27.00%

Note: Multiple responses allowed

Financial advisors and brokers are the main source of information (41%), showing they do not rely on their own judgment. Nonetheless, the substantial percentage of friends and family (32%) shows that social influences and recommendations continue to be essential. This is especially true in semi-urban Ratnagiri District. The finding that 29% of participants found online platforms very important indicates the growing trend of technology as a contributing factor in investment. This finding is consistent with Scholar et al . 2025, who argues that increased levels of technology and technological platforms have transformed investor behaviour, especially among the younger generations.

6.3 Risk Perception and Investment Preferences

Table 7: Risk Tolerance Levels of Investors

Risk Tolerance Level	Frequency	Percentage
Very Low (Risk Averse)	42	21.00%
Low	68	34.00%
Moderate	64	32.00%
High	22	11.00%
Very High (Risk Seeker)	4	2.00%
Total	200	100.00%

The risk appetite distribution has shown that 55% of investors display low to very low risk appetite while high-risk appetite is only 13%. The risk profile of tier-2 and tier-3 investors would be conservative, Tummarakoti et al. (n.d.) write. The fact that most investors are averse to risk has implications for the design of products. There is likely to be a demand for products that provide capital protection. Similarly, there is likely to be a greater demand for investment advice that is conservative in nature. In this region, how much risk people allocate to a project will significantly influence their investment.

Table 8: Primary Investment Objectives

Investment Objective	Frequency	Percentage
Capital Appreciation	58	29.00%
Regular Income	48	24.00%
Tax Saving	42	21.00%
Wealth Preservation	36	18.00%
Retirement Planning	16	8.00%
Total	200	100.00%

According to the results, the greatest investment objective is capital appreciation (29%), with a regular income and tax saving in the second and third place with 24% and 21%, respectively. Investor objectives differ due to their backgrounds and different stages of life according to expert. The study affirms the findings by Kakde et al. (n.d.) who highlighted that return expectations and investment horizon are the major attributes which influence the investment preferences. The comparatively lesser focus on retirement planning (8%) indicates either underconsideration of

long-term financial planning or reliance on traditional mechanisms such as provident funds and pensions for retirement security.

6.4 Investment Behavior and Patterns

Table 9: Current Investment Portfolio Composition

Investment Type	Average Allocation (%)
Bank Deposits/Fixed Deposits	32%
Mutual Funds	24%
Equity Shares	18%
Gold/Precious Metals	12%
Real Estate	8%
Government Schemes	6%
Total	100%

The composition of the portfolio indicates that safe investment instruments like bank deposits dominate (32%) while equity shares occupy only 18% of average portfolio allocation. In line of findings of Bhav et al. (n.d.) of Ratnagiri District, our investigation found that asset allocation pattern was conservative due to investors' risk adversity. The large allocation of 24% to mutual funds implies that a few investors have begun accepting a professionally managed product as an intermediary between safety and growth objective. This was also reported by Scholar et al. (2025) for Indian stock market investors.

Table 10: Frequency of Investment Decisions

Investment Frequency	Frequency	Percentage
Monthly (SIP/Regular)	78	39.00%
Quarterly	52	26.00%
Half-Yearly	38	19.00%
Annually	24	12.00%
Irregular/Opportunistic	8	4.00%
Total	200	100.00%

Investors alone 39% invest on a monthly basis, thus leading to the popularity of an average systematic investment plan or SIP invested in mutual funds. This is a well-disciplined investment habit and there is hope that the investor education campaign to push rupee-cost averaging and long-term wealth creation is taking off. Most investors engaged in the traditional macroeconomic aspect of smart beta. Kinslin et al. (2018) article states that only 4 per cent of investors are involved in rare or opportunistic investment patterns.

6.5 Barriers to Stock Market Investment

Table 11: Perceived Barriers to Stock Market Participation

Barrier	Mean Score (1-5)	Rank
Lack of adequate knowledge	4.2	1
Fear of losses/High risk perception	4.1	2
Insufficient funds for investment	3.8	3
Market volatility and uncertainty	3.7	4
Lack of guidance/advisory services	3.5	5

Complex procedures and documentation	3.2	6
Negative past experiences	2.8	7
Lack of trust in market intermediaries	2.6	8

Scale: 1 = Not a barrier, 5 = Major barrier

The biggest constraint with respect to the adoption of this technology (mean score 4.2) is the inadequate knowledge followed by fear of losses and high risk perception (4.1). The findings offer convincing support to the notions of investor awareness and investor perception which affect market participation. The results are in accordance with the research of Kumar et al. (2021) which claimed that the two major reasons that prevent investors from investing in the stock market in India are knowledge gap and fear of losses. The decreased scores for the trust-related barriers (2.6) indicate that regulatory and other changes and investor protection enhanced investor confidence in the market infrastructure and intermediaries.

6.6 Financial Literacy Assessment

Table 12: Financial Literacy Scores

Literacy Level	Score Range	Frequency	Percentage
Low	0-40%	36	18.00%
Moderate	41-60%	98	49.00%
High	61-80%	54	27.00%
Very High	81-100%	12	6.00%
Total		200	100.00%

The financial literacy assessment shows that 49% of the respondents have moderate level of financial literacy, and merely 33% have high to very high level of financial literacy. This distribution shows there is significant potential for improvement in financial education, especially for such a small sample of active investors, who may be more financially savvy than the general public. The discovery is consistent with the national level assessment by Pereira (n.d.) that shows the overall financial literacy level of India is around 24%. The moderate levels of financial literacy among active investors in Ratnagiri District highlight the importance of ongoing investor education efforts as emphasized by Vivek (2025) in his study on financial literacy and investment practices.

6.7 Hypothesis Testing Results

Table 13: Correlation between Financial Literacy and Investor Awareness

Variables	Pearson Correlation	Significance (p-value)
Financial Literacy & Investor Awareness	0.68**	0.001

$p < 0.01$ (highly significant)

The correlation analysis shows a positive correlation between financial literacy and investor awareness ($r = 0.68$, $p < 0.01$) which supports the Hypothesis H1. This is consistent with previous studies that have found an increase in financial literacy to be correlated with an increase in understanding of investment opportunities, market mechanisms and risk-return relationships. This finding is in line with the rich literature on the importance of financial literacy for informed investment practices, both in India (Singh 2018; Renuka et al. n.d.).

Table 14: ANOVA Results - Demographic Influences on Risk Perception

Demographic Variable	F-statistic	Significance (p-value)	Result
Age	8.42	0.002**	Significant
Education	12.36	0.001**	Significant
Income	15.28	0.000**	Significant
Occupation	6.84	0.008**	Significant

$p < 0.01$ (highly significant)

The ANOVA results prove that all the demographic variables studied significantly affect the risk perception, which led to Hypothesis H2 being accepted. The results indicate that age has a significant influence ($F = 8.42$, $p = 0.002$), where younger investors have higher risk tolerance compared to older investors which is in line with Rosdiana (2020). Education shows strong influence ($F = 12.36$, $p = 0.001$), which confirms that the higher the level of education, the better the understanding and assessment of risk. Income has the greatest influence ($F = 15.28$, $p < 0.001$) as a higher income gives higher risk-bearing capacity. Chandran et al. (2022) also found that there was a significant difference in risk perception between the occupational groups ($F = 6.84$, $p = 0.008$), with the business owners and professionals having higher risk perception than the salaried employees and retirees.

Table 15: Regression Analysis - Awareness and Market Participation

Model	R ²	Adjusted R ²	Beta Coefficient	t-value	Significance
Awareness → Participation	0.54	0.52	0.73	14.82	0.000**

$p < 0.01$ (highly significant)

The regression results show that investor awareness has a significant positive relationship with the market participation with R² value of 54%, and the relationship is very significant ($p < 0.001$). The results of this finding corroborate Hypothesis H3 which states that the greater the awareness is, the higher the stock market participation is. The use of awareness as an explanatory variable is supported by the fact that awareness has a significant explanatory power, which supports the focus of this study. This finding corroborates the research conducted by Sasikumar et al. (2024) which revealed that awareness has a positive impact on investors' capability in tackling problems and taking an active role in the share markets.

Table 16: Mediation Analysis - Risk Perception as Mediator

Path	Direct Effect	Indirect Effect	Total Effect	Mediation Type
Awareness → Risk Perception → Decision	0.42**	0.31**	0.73**	Partial Mediation

$p < 0.01$ (highly significant)

The findings from the mediation analysis confirm the hypothesis H4, which states that investor awareness partially mediates between risk perception and investment decision making. The direct effect of awareness on decisions is still not completely mediated by the indirect effect through risk

perception (0.42 vs. 0.31). This result implies that awareness has direct and indirect effects on investment decisions via risk perception. The outcomes align with the theoretical models put forward by Jain et al. (2023), who showed in a series of experiments that risk perception is a key psychological mechanism between the cognitive and behavioural aspects of investment decisions.

7. Discussion of Results

The study explores the awareness and perception of respondents about investment in share market in Ratnagiri District of Maharashtra. The results are quite satisfactory with theoretical and practical implications. The results indicate a moderate to high level of understanding of basic types of investments. Nonetheless, knowledge gaps are especially important concerning complex financial products and market mechanisms.

The pattern observed fits well with Indian context as noted by Vivek (2025) and Renuka et al. (n.d.). This indicates that the challenge of awareness witnessed in Ratnagiri District is a systemic issue and not a regional one.

The survey reveals that stock market participation in Ratnagiri District is mainly among educated, middle-aged, salaried people earning moderate to high income. The demographic profile is similar to those of studies undertaken in Maharashtra, such as the Subhash et al. at Dharashiv District (n.d.) and Pereira in Mumbai region (n.d.). The investor sample contains lesser representation of women, old adults and the lower-income group indicating that financial inclusion is still very far from complete and the policies must be targeted to these sections.

According to the findings of the study, there is a strong positive correlation between financial literacy and investor awareness ($r = .68$). The results of the study corroborate Singh's (2018) argument that financial literacy is an essential prerequisite for informed investment behaviour in India. However, the active investors' moderate levels of literacy show that the current financial literacy initiatives may not be able to go in-depth or reach a lot of people. Almost half the investors (49%) have only average financial literacy. So, those having only moderate financial literacy may not be fully aware of the risks, despite being in the market.

One of the significant conclusions of the study is risk perception. The reason is that 55% of investors show a low to a very low risk. This risk profile means a number of things. The first part states that the portfolio being analysed is mainly made up of safe assets. Furthermore, this implies that the product innovation of capital safeguarding and downside risk mitigation is most relevant for the investor segment driving the market. An equally important recommendation is investor education to address the other knowledge gaps and cognitive barriers that hinder sound risk assessment and management. The finding that risk perception partially mediates the awareness-investment decision relationship is consistent with behavioral finance frameworks such as those of Jain et al. (2023), and so on, which emphasize the interaction of cognition and emotion in investment behaviors.

Identifying the fear of loss and knowledge gap as the main barriers to market participation can have implications for policy and practice. Utilising a strategic plan of action which incorporates financial education, investor protection and confidence-building measures, this barrier can be overcome. The lesser worry related to trust in market intermediaries suggests that various regulatory reforms undertaken have been effective. However, the continuing fear of losses indicates that the psychological barricades are still significant.

The study finds support for Kumar et al. (2021) proposal that working on both the informational as well as emotional dimensions of investor hesitance would help.

The identified investment behavior patterns are successful, as there is greater adoption of systematic investment modes through SIPs. The discipline of the investment behavior shows that the investor education programmes on long term wealth creation and rupee-cost averaging are working. Even so, the low allocation to equity shares (18% of average portfolio) in contrast to bank deposits (32%) indicates reluctance to take risks continue to weigh on plans. A conservative bias can lead to low returns resulting in insufficient wealth in the long term of retirement and other uses.

Given that the significant impact of demographic variables on risk perception and investment behaviour suggests that investors are not a homogeneous group and need a further segmentation that is required for investor education & product development. According to the findings, adults who are younger, more educated, and possess a higher income are more performance tolerant. As a result, investment solutions for specific life stages and suitable income solutions are important. Disparity in occupations entrepreneurs and professionals are more risk-tolerant than salaried individuals mainly due to variation in income stability, financial literacy, and exposure to business risks.

Research shows investor behaviour in the state of Maharashtra is not the same across regions. The Ratnagiri District has some resemblances with the other semi-urban areas examined in the work of Subhash et al. (n.d.). and Tummarakoti and others (n.d.). Nonetheless, the setting of Ratnagiri District, in particular the NRI population, tourism economy and agricultural base generates specific opportunities and challenges. The Ratnagiri District is said to have a moderately developed financial market due to moderate levels of awareness and adequate risk-averse advises observed in the District. The District has tremendous potential for development with proper intervention.

8. Managerial/Practical/Policy Implications

The results of study can be highly useful to different groups of stakeholders like the government, banks, investment consultants and investor education agencies. Knowledge gaps are identified to be the most important barrier to market participation, and hence it is recommended that made-for-tier-2-and-below financial literacy programmes should be put in place that is accessible, continuous and comprehensive. The financial literacy programs should not limit itself to just mandatory instruction but must also include practical lessons on investing at the stock market, on risk management strategies and behaviour awareness that would help the investor in identifying and overcoming the cognitions (Sasikumar et al., 2024).

Financial Institutions and Asset Management Companies investment products need to take into account the risk profiles and investment objectives of Ratnagiri District. In light of the evident conservative approach to risk, products exhibiting capital protection features, guaranteed returns, or hybrid structures might be appealing as they function on both upside and downside limits. The strong take-up of SIPs indicates that low-volume systematic investment products can support middle-income investors on the road to financial inclusion (Scholar et al., 2025).

Regulatory bodies like SEBI should develop area-specific investor protection and education campaigns targeting semi-urban and rural investors facing unique challenges. This can involve setting up mobile financial literacy camps, making and distributing customized learning materials in local languages. The relatively high reliance on financial advisers (41%) as information sources emphasizes the importance of intermediaries in influencing investment behaviour. According to Vidhya et al. (2018), the advisors' training must be more intense to upgrade status and ethicality of behaviour.

Technology platforms and fintech companies can successfully democratize the access to research and advisory services, investment information. There is a growing 29% ready for online solutions and the selling of investment products. User-friendly mobile apps containing educational resources, portfolio tracking, and low investment option can help mitigate the levels of information asymmetry between the urban and semi-urban investor. However, technology adoption requires the run of a digital literacy program for effective inclusion (Shameel et al.2021).

To encourage women, youth and low-income groups to enter equity markets, inclusion-focused tax incentives and promotional initiatives may be facilitated by policymakers. According to the findings of the study, the demographic influences on investment behaviour indicate that it is better to implement targeted interventions for specific barriers facing specific groups as opposed to using generic ones. For example, financial inclusion can be improved through women-focused investment clubs, acceleration and investment training for youth, and workplace financial wellness programs (Tummarakoti et al., n.d.).

9. Conclusion and Future Research Directions

The study provides an in-depth analysis of the factors influencing the purchasing decisions of consumers to buy packaged food products in Mumbai city. It indicates that consumers have become more prudent in their choice of packaged food. The outcome shows that knowledge of basic investment products is moderate to high. The complexities and implications of financial products, risk management, and market mechanisms are not well known to many people. Risk perception has become an important factor influences investment behaviour. The majority of investors have cautious risk profiles who barely invest in desirable assets. Consequently, the portfolios are skewed towards traditional safe instruments in their composition.

There exists a great positive correlation between financial literacy and investor awareness. In addition, the relationship between demographic variables and risk perception and investment behaviour is strong and significant. As such, the current study confirms that investment decision making is multi-faceted. Given that the knowledge gaps and the fear of the loss are the main barriers to participation in the market, two interventions must be more holistic and address the informational and psychological aspects of the investor's unwillingness. This study offers important insights into investor behaviour from tier-2 and tier-3 regions as the existing literature is quite limited. The study is useful for making investing proactive and enhancing financial inclusion in the economy.

Future research should consider this investigation in more settings. Studies spanning a lengthy period would help track the impact of financial literacy initiatives over a certain period and how the investment behaviour of investors changes with changes in market conditions and policy initiatives. Studies comparing investor behavior between different districts will reveal the specific factors at work as well as generalizable trends. This would help design better policies. Conducting qualitative research basically means conducting in-depth interviews and focus group discussions which can help researchers get a richer understanding of the various psychological, social and cultural factors that influence investment decisions in semi-urban settings (Kinslin et al., 2018).

A different important area are experimental studies that assess the effectiveness of various investor education techniques traditional classroom education, online modules, gamification, peer learning, etc., on spending on financial literacy.

Research that examines how social networks and family and community norms influence investment behaviour will help one understand the social embeddedness of financial decision-making in an Indian context. To sum up, examining the influence of certain policy measures, such

as tax incentive, simplified investment process, investor protection measure on the participation rate will generate evidence for policy improvement and scaling up winning measures.

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