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Research Papers

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SYNTHESIS OF SILVER NANOPARTICLES AND STUDY OF ITS POTENTIAL APPLICATIONS

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ABSTRACT
Nanoparticles can be synthesized by physical, chemical and biological routes. Physical and chemical methods are able to produce large quantities of nanoparticles with a defined size and shape in a relatively short time, however, these methods are complicated and have certain drawbacks such as producing hazardous toxic wastes that are harmful, not only to the environment but also to human health.

Nanoparticles possess interesting electronic and optical properties and can be used in biosensor applications. Surface modification of magnetic nanoparticles is an exciting area of research with various potential applications. Nanomedicine is an upcoming field of research with tremendous prospects for improvement in diagnosis and treatment of diseases. With the prevalence and increase of microorganisms resistant to multiple antibiotics, silver-based antiseptics have been emphasized in recent years. Findings of present investigation will help synthesize silver nanoparticles in an eco-friendly manner. Also, its efficacy as an antimicrobial agent will help achieve better, safe and timely treatment of infections.

Keywords: *Green synthesis, Nanomedicine, AgNPs, Antimicrobial*

INTRODUCTION
The current decade is experiencing a surge in applications on nanoparticles, particularly as Nanomedicine involving the green synthesis and characterization of nanoparticles, as nanoparticles less than 100 nm in size are ideal agents for drug delivery and biomedical applications [1, 2]. Presently, nanoparticle production is carried out by three modes-chemical, physical and "green" routes, with the green route involving the employment of biological reducing agents, including microbial filtrates, cell suspensions and plant extracts [3, 4].The first two methods are often costly and generate toxic by-products [5, 6] but the green synthesis method has been recognized as an inexpensive and eco-friendly process [7, 8].

Among microorganisms, bacteria have received much attention in biosynthesis of nanomaterials due to its growing success, ease of handling and genetic manipulations. The potential of *Pseudomonas* spp, *Escherichia coli*, *Klebsiella pneumoniae*, *Bacillus* spp has been investigated in this field. Metal Oxide nanoparticles have attracted worldwide attention because of their increased use in a variety of fields such as electronic, cosmetic, biomedicine, energy, environment, catalysis and material science [9, 10]. Among the noble metal nanoparticles, AgNPs have received considerable attention due to their attractive physicochemical properties and applications in medicine [11, 12].

Nanoparticles can be synthesized by physical, chemical and biological routes. Physical and chemical methods are able to produce large quantities of nanoparticles with a defined size and shape in a relatively short time, however, these methods are complicated and have certain drawbacks such as producing hazardous toxic wastes that are harmful, not only to the environment but also to human health.

Nanoparticles possess interesting electronic and optical properties and can be used in biosensor applications. Surface modification of magnetic nanoparticles is an exciting area of research with various potential applications. Nanomedicine is an upcoming field of research with tremendous prospects for improvement in diagnosis and treatment of diseases. With the prevalence and increase of microorganisms resistant to multiple antibiotics, silver-based antiseptics have been emphasized in recent years. Findings of present investigation will help synthesize silver nanoparticles in an eco-friendly manner. Also, its efficacy as an antimicrobial agent will help achieve better, safe and timely treatment of infections.

Natural habitats namely, terrestrial and aquatic systems are never-ending source of micro-organisms with applications in many sectors. Soil is a never-ending source of microbiota and microbes with diverse potential can be explored. The physico-chemical characteristics of soils vary from region to region and few potential isolates can be obtained from extreme climatic zones. The present investigation aims to isolate bacterial isolates from unexplored sites in Haldighati mountain pass, Rajasthan state, India. Nanoparticles will be synthesized through biological routes. Characterization studies of the synthesized nanoparticles and study of its potential applications in medicine will be carried out.

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MATERIALS & METHODS

1. **Selection of study area & Sample collection:** Haldighati is a mountain pass between Khamnore and Bagicha village situated at Aravalli range of Rajasthan in western India which connects Rajsamand and Pali districts. The pass is located at a distance of 40 kilometres from Udaipur. The name 'Haldighati' has originated from the turmeric-coloured yellow soil of the area. Samples were collected from four sampling sites in the mountain pass in zip lock pouches and kept at 4ºC till further use.
2. **Enrichment of samples:** The samples from each site was mixed well, sieved and granular part was separated. Filtered part of sample was used for enrichment. 1 gm of soil sample was added aseptically in sterile nutrient broth and incubated at 38 ºC (temperature of area at time of sample collection) for 24-48 hours. This is termed as Primary enrichment. After 48 hours, 1 ml of enriched medium was inoculated in sterile nutrient broth and further incubated at same conditions. This is Secondary enrichment.
3. **Isolation of Bacteria-Primary screening:** A loopful of inoculum from secondary enrichment flasks were streak inoculated on sterile nutrient agar plates and incubated at 38 ºC for 24 hours. Next day from each sampling site morphologically distinct colonies were selected.
4. **Identification of selected colony:** Identification of selected colonies was performed by cultural, morphological and biochemical studies. The observed characteristics were compared with Bergey's manual of Determinative Bacteriology for proper identification of isolates.
5. **Production of biomass:** Based on identification, one Gram positive and one Gram negative isolate was selected for further process. Test isolates were inoculated in LB medium to produce the biomass for biosynthesis. Flasks were incubated on an orbital shaker at 38ºC and agitated at 250 rpm. Biomass was harvested after 24 hours of growth and centrifuged at 5000 rpm at 4ºC for 10 minutes. The supernatant was collected for further steps.
6. **Synthesis of Silver nanoparticles-Biological route:** For the biosynthesis of silver nanoparticles, 10 ml of supernatant was mixed with 5ml silver nitrate (AgNO3) solution (10mM) and another reaction mixture without silver nitrate was used as control. The prepared solutions were incubated at room temperature for 24 hrs. All test solutions were kept in dark to avoid any photochemical reactions during the experiment. After 24 hrs, original yellow coloured solution turned into brown. The silver nanoparticles (AgNPs) were purified by centrifugation at 10,000 rpm for 5 mins twice and collected for further characterization.
7. **Characterization of nanoparticles:** The appearance of brown colour indicates formation of silver nanoparticles in the reaction mixture and efficient reduction of the Ag ions occurs. Absorbance of the brown coloured solution was taken against direct wavelength to confirm the formation of silver nanoparticles. Particle size and shape of the synthesized nanoparticles will be studied.
8. **Antibacterial activity of synthesized nanoparticles:** To study the antibacterial activity of silver nanoparticle suspension, log phase culture suspension of one Gram positive and one Gram negative isolate was prepared in 10 ml of Luria broth. The tubes were incubated for an hour then 1 ml of each culture was inoculated in separate flasks (control and test) containing 10 ml LB broth and 1 ml of nanoparticle suspension. To control flask, nanoparticle suspension was not added. Growth of bacteria was monitored by measuring the optical density of inoculated growth medium at regular time intervals (4 hrs) by an UV-Vis spectrophotometer at 600nm. With all readings, growth curve was plotted to study the antibacterial effect. Agar-well diffusion method was performed to study antibacterial activity on gram positive and gram negative isolates.

RESULTS & DISCUSSION:

Selection of study area & Sample collection: Haldighati, a mountain pass between Khamnore and Bagicha village situated at Aravalli range of Rajasthan in western India is selected for present investigation. Four sites were selected for sample collection.

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Fig.1. Representative images of sampling site

Enrichment of samples & Screening for isolates: Soil samples (HGS-1 to HGS-4) from all four sampling sites were collected in zip lock pouches and kept at 4°C till further use.

After all samples were collected, primary and secondary enrichment steps were performed in nutrient medium. 24 types (HGC-1 to HGC-24) of morphologically dissimilar colonies were obtained from all enriched samples.

Selection of potential isolate: Two representative colonies (one Gram positive and Gram negative each) out of 24 isolates were identified by cultural, morphological and biochemical methods.

Biomass production: These 2 test isolates were subjected to biomass production. Supernatant of enriched biomass from one isolate was collected and biological synthesis of nanoparticles was carried out. Fig. 2 (a) & (b) represents synthesis of Silver nanoparticles through biological means and chemical means respectively for one potential isolate - HGC-16 / S-14. These synthesized nanoparticles were subjected to characterization studies.

Characterization of synthesized nanoparticles: UV/Vis spectroscopy is routinely used in analytical chemistry for quantitative determination of different analytes, such as transition metal ions, highly conjugated organic compounds, biological macromolecules including bio-based nanoparticles, nanoconjugates etc. Particle size analysis, particle size measurement, or simply particle sizing is the collective name of the technical procedures, or laboratory techniques which determines the size range and/or the average, or mean size of the particles in a powder or liquid sample. In the present study, biologically synthesized nanoparticles solution exhibited absorption maximum at 425nm, a characteristic feature of silver nanoparticles.

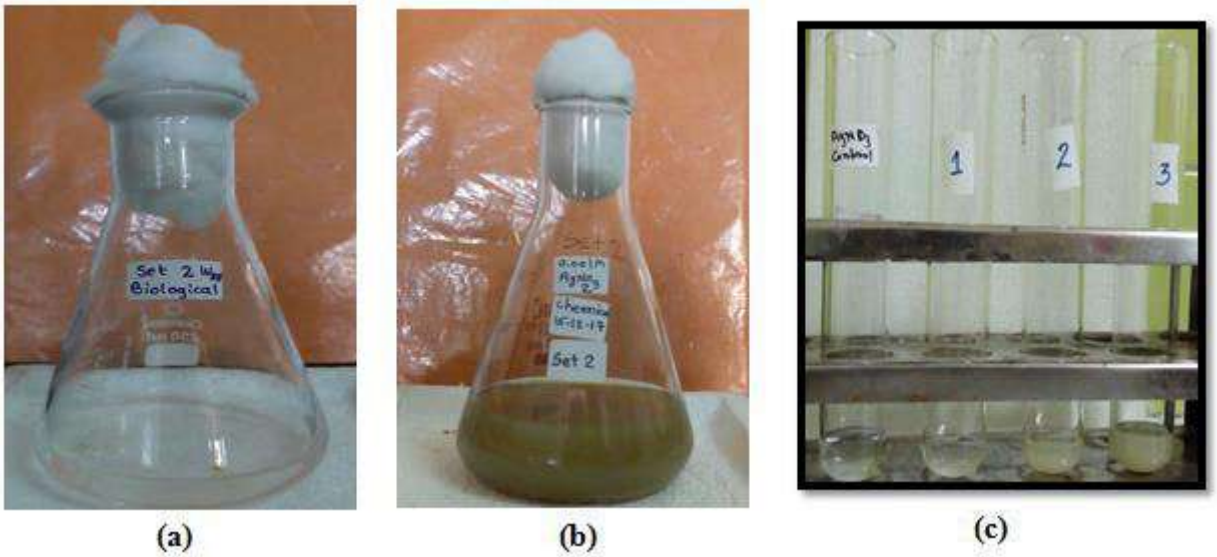

Fig.2. Synthesis of AgNPs- Biological and Chemical route (a), (b), (c) its characterization studies

The particle size measurement is typically achieved by means of devices called Particle Size Analyzers (PSA) which are based on high definition image processing, analysis of Brownian motion, gravitational settling of the particle and light scattering (Rayleigh and Mie scattering) of the particles. The particle size can have considerable importance in a number of industries including the chemical, food, mining, forestry, agriculture,

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nutrition, pharmaceutical, energy, and aggregate industries. In the present study, particle size of biologically synthesized and chemically synthesized nanoparticles was determined to be 110 nm and 87 nm respectively.

Fig 3(a) Basic design of UV-Vis Spectrophotometer

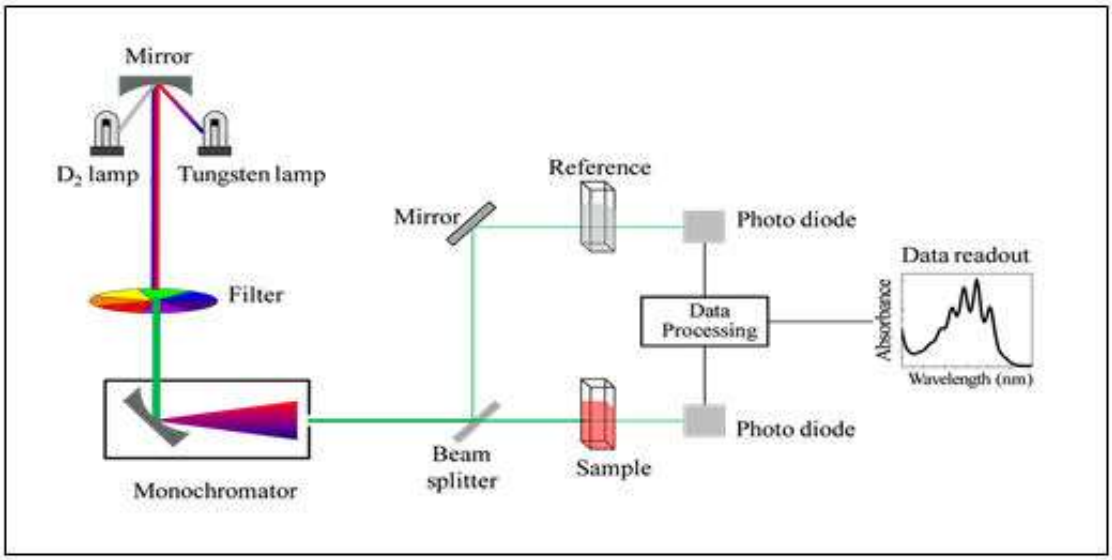

Fig 3(b) Working mechanism of UV-Vis Spectrophotometer

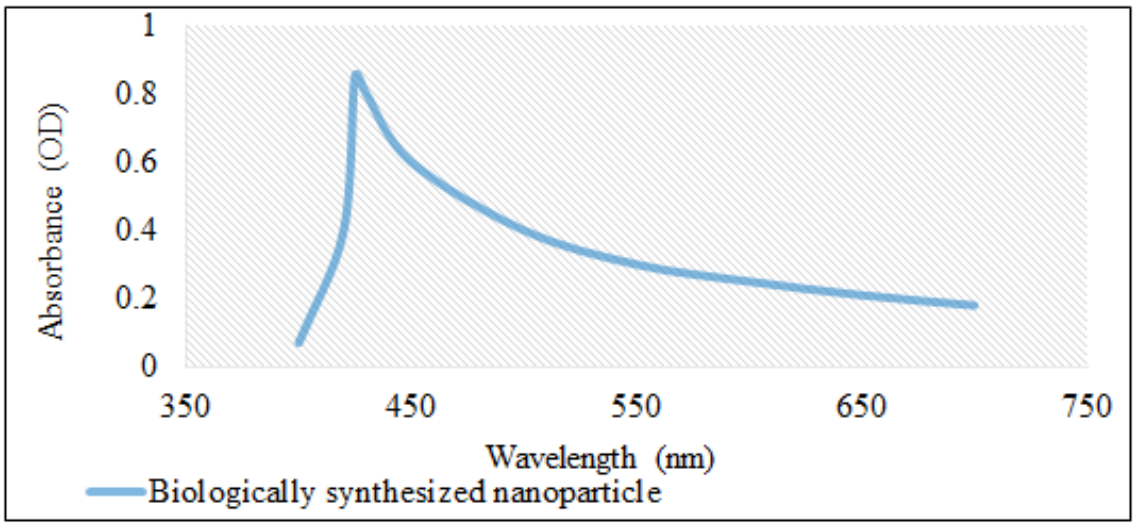

Fig 3(c) UV-Vis characterization of biologically synthesized AgNPs

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Fig. 4(a). Horiba Dynamic Light Scattering Particle Size Analyzer

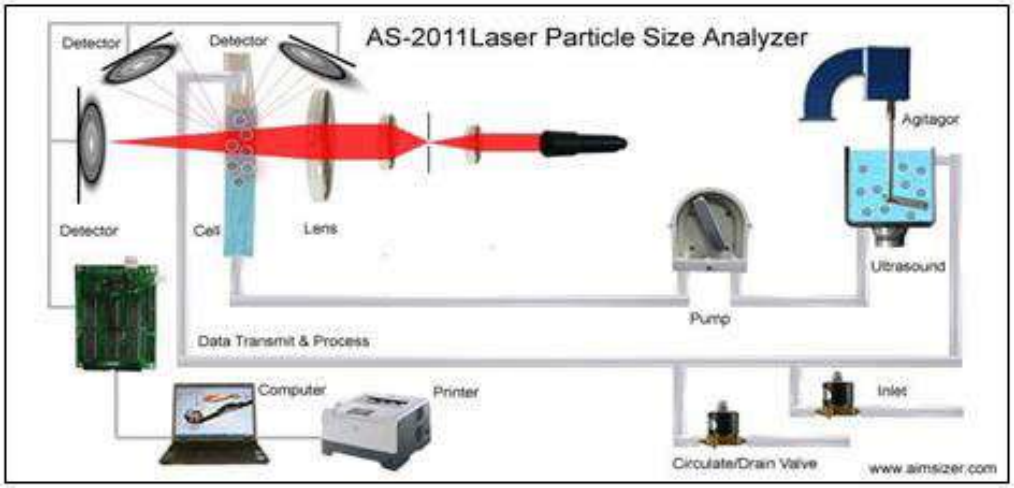
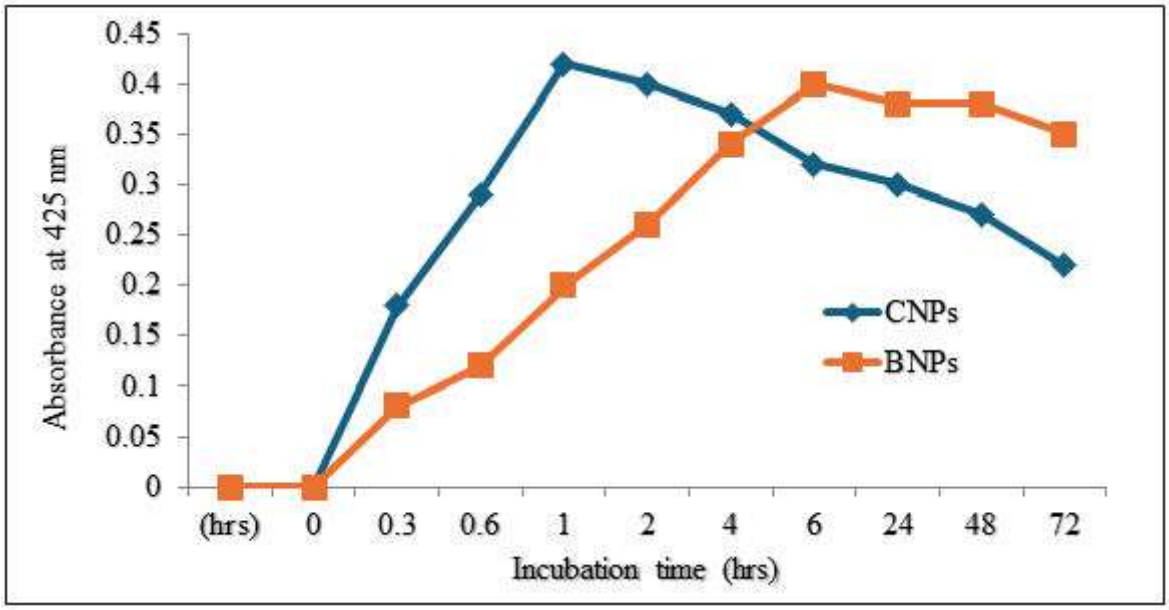


Fig. 4(b). Working mechanism of Horiba Dynamic Light Scattering Particle Size Analyzer

Antibacterial Activity of Synthesized Nanoparticles: In the present study, O.D. increased with incubation period upto 6 hrs for biologically synthesized nanoparticles and then started to decline. Biologically synthesized nanoforms exhibited better activity than chemically synthesized nanoforms. By agar well diffusion assay, antibacterial activity was more pronounced against standard gram positive isolates than gram negative ones.



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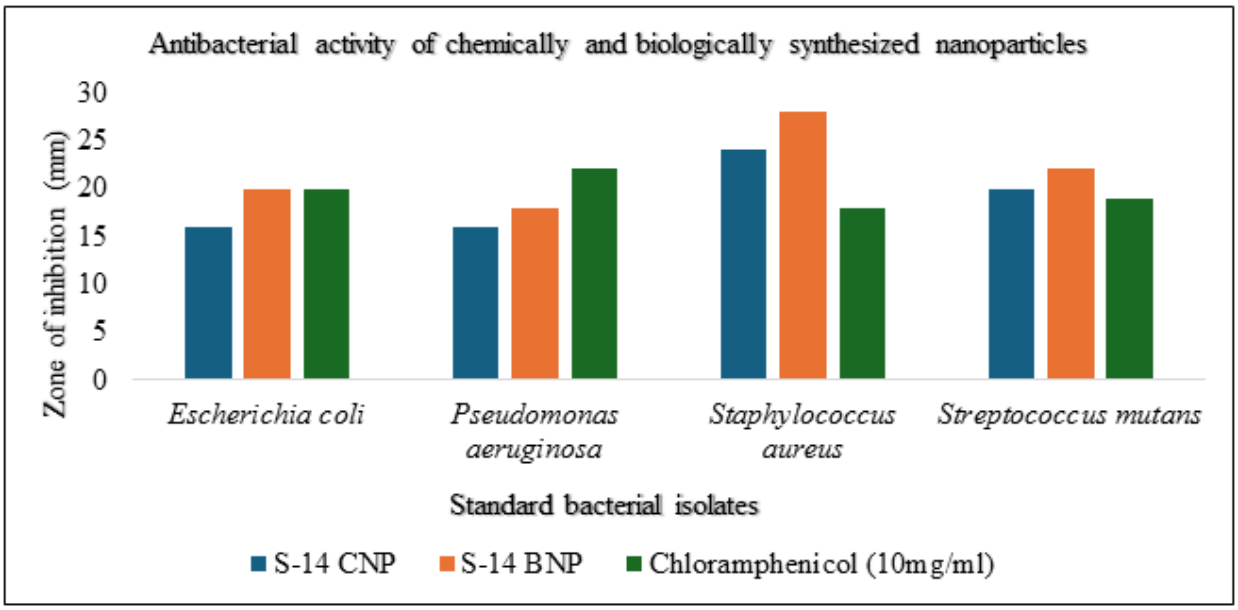

CONCLUSION

There have been tremendous developments in the field of microorganism produced nanoparticles over the last decade. The use of microorganisms including bacteria, yeast, fungi and actinomycetes for intracellular and extracellular synthesis of nanoparticles is currently gaining impetus. Research is currently carried out manipulating microorganisms at the genomic and proteomic levels. With the recent progress and the ongoing efforts in improving particle synthesis efficiency and exploring their biomedical applications, it is hopeful that the implementation of these approaches on a large scale and their commercial applications in medicine and health care will take place in the coming years.

As part of present investigation, Haldighati, the legendary battlefield of Rajasthan in western India is selected. Four sites were selected for sample collection. Silver nanoparticles were synthesized through biological means using biomass of potential isolate HGC-16 / S-14. Chemical synthesis of Ag NPs was also carried out. Absorption maxima was obtained at 425 nm and particle size was determined to be 110 nm and 87 nm respectively. Antibacterial activity of biologically synthesized nanoforms was more pronounced against standard gram positive isolates than gram negative ones. With the recent progress and the ongoing efforts in improving particle synthesis efficiency and exploring their biomedical applications, it is hopeful that the implementation of these approaches on a large scale and their commercial applications in medicine and health care will take place in the coming years.

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ENTREPRENEURIAL CHALLENGES WITHIN THE SINDHI COMMUNITY: AN EXPLORATORY STUDY

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ABSTRACT

The Sindhi community, despite its historical struggles of displacement and subsequent rebuilding through trade and enterprise, has demonstrated remarkable entrepreneurial resilience rooted in strong social and family networks. Motivated by the need to move beyond this success narrative, the present study examines the contemporary entrepreneurial challenges faced by Sindhi entrepreneurs in order to identify barriers affecting business growth, modernization, and long-term sustainability. Hence, the purpose of this exploratory study is to explore the entrepreneurial challenges within the Sindhi Community. The technique used in this study is Text mining using the qualitative tool NVIVO 12. The findings of the study indicated that the Entrepreneurial Challenges within the Sindhi Community can be broadly classified as major, moderate, and minor. The major challenges such as limited access to formal finance, succession planning issues, resistance to professional management, and digital skill gaps significantly hinder business growth and modernization. Moderate challenges including low youth participation, dependence on traditional family businesses, limited business diversification, and regulatory compliance difficulties affect long-term sustainability and expansion. Minor challenges such as weak branding strategies, competition from large corporates, risk aversion, and continued reliance on cash-based practices, although less severe, still influence entrepreneurial efficiency and competitiveness.

Keywords: *Exploratory, NVIVO 12, Sindhi Community.*

INTRODUCTION

The traditional characteristics as a mercantile, family-oriented trading groups tends to overshadow the fact that it faces a distinct set of entrepreneurial challenges that merit focused scholarly interest. Resilient, with a history of having dispersed commercial diaspora, Sindhi entrepreneurs are now negotiating an intricate landscape, in which traditional community networks and cultural capital co-exist with contemporary obstacles of regulatory complexity, limited formal entrepreneurial education, and gendered social constraints - conditions that make a narrower focus a timely and critical study (Mani, et al. 2023; Bhojwani, 2024). A detailed empirical study is needed since the surface explanations of Sindhi business success can easily overlook the micro-level limitations that slack the firm development, impede diversification and decrease inclusion (Soomro, et al. 2023). As an example, the benefits of trading communities in the establishment and persistence recorded in larger Indian settings can also lead to the creation of a lock-in effect restricting innovation and sectoral mobility of Sindhi entrepreneurs (Mani et al., 2023). The intentions and understandings of opportunities associated with entrepreneurship are conditioned by cultural norms and family structures among the Sindhi youth and in particular, gender roles and risk attitudes that are not well reflected in the normal entrepreneurship research when it is generalized across wider populations (Liñán et al., 2020; Newman et al., 2019; Bhojwani, 2024). Also, the instability inherent to Sindhi language and culture, such as inadequate access to Sindhi-sensitive business training, and the necessity of business training that is culturally-sensitive, represent further barriers to formal enterprise growth. This work thus places itself in the position of not only getting beyond the celebratory accounts of community success to an evidence-based account of the limitations, facilitating factors, and internal intra-community differences (along gender, generation, urban/rural residence, and migration status) of the Sindhi entrepreneurship today. Through qualitative inquiry that is community-sensitive and quantitative measures of the performance of the firms, access to finance, and social network effects, the study will produce practical insights that can be adopted by policy-makers, training institutions, and community organizations in their pursuit of equitable and sustainable entrepreneurial growth in the Sindhi community (Soomro et al., 2023; Mani et al., 2023).

This study aims to define and discuss the most important constraints hampering entrepreneur formation, growth and diversification within the Sindh community. The purpose of this paper is to come up with empirically-supported model recommendations to the community organizations, educational institutions and policymakers to promote inclusive entrepreneurship among Sindhi entrepreneurs.

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REVIEW OF LITERATURE:

The current academic literature on the topic of entrepreneurship among the Sindhi community identifies the high level of mercantilism, the focus on the family-based business and the extensive culture of networks as some of the key factors that influence the entrepreneurial behaviour. Research on Sindhi business owners highlights the importance of inherited corporate knowledge, kinship bonds based on trust, and informal sources of finance to aid business entry and survive within the initial years of operation (Mani, Abbasi, and George, 2023). Nonetheless, current studies also identify some new challenges associated with succession planning, professionalization, and adjustment to formal institutional settings, especially when companies are crossing generations (Bhojwani, 2024). Gender-focused studies on Sindh-dominated environments have shown that women do have entrepreneurial intent yet the social environment, lack of autonomy and access to resources still restricts their involvement and advancement (Soomro, et al. 2023). Additionally, preservation of culture and language identity has been identified to impact indirectly on entrepreneurial decision making, usually supporting the decision to follow a traditional trading industry instead of an innovation-focused or technology-intensive business (HSNC University Report, 2024). Empirical studies on trading societies with Sindhi entrepreneurs have shown that community networks can promote the survival of firms; however, excessive reliance on family governance can reduce diversification and expansion in competitive markets (Mani et al., 2023). Comprehensively, the literature proposes that the Sindhi entrepreneurship is paradoxical in its strength and constraint, as cultural capital and social cohesion ensure continuity of the business, but at the same time become obstacles to modernization and inclusivity, as well as sustained strategic development. This states the importance of context-based studies that look into the issue of entrepreneurship among the Sindhi community outside the generalized models of ethnic or minority entrepreneurship.

OBJECTIVES OF THE STUDY:

1. To explore the entrepreneurial challenges within the Sindhi Community.
2. To give suggestive measures towards eradication of these challenges

RESEARCH METHODOLOGY:

Table No: 1 Research Methodology

Research Design	Qualitative and Exploratory
Research Approach	Inductive Approach
Data Collection Method	Face-to-face interviews
Sample Size	30 Sindhi Entrepreneurs
Location	North Mumbai Region
Sampling Technique	Non-random Convenience Sampling
Analysis Tool	NVIVO 12
Analysis Technique	Text Mining (Mind Map, Word Frequency, and Word Cloud)

DATA ANALYSIS:

Table No: 2 Summary of entrepreneurial challenges within the Sindhi community

Word	Count	Weighted Percentage (%)
Limited access to formal finance	36	15.93
Succession planning issues	32	14.16
Resistance to professional management	25	11.06
Digital skill gaps	24	10.62
Low youth participation	20	8.85
Dependence on family businesses	19	8.41
Limited business diversification	18	7.96
Regulatory compliance challenges	15	6.64
Weak branding strategies	13	5.75
Competition from corporates	10	4.42
Risk aversion	8	3.54
Cash-based practices	6	2.65

The discussion of entrepreneurial problems in the Sindhi community demonstrates that the frequency and relevance of the issues in question lead to a certain hierarchy. Restricted access of formal finance (15.93%), means that even with good informal networks, the business people are challenged in their quest to obtain institutional finance. This is strongly preceded by succession planning issues (14.16%), which identifies the

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difficulties in passing family businesses to the other generation. The reluctance to professional management (11.06%) and lack of digital skills (10.62%) also highlights the fact that the community is used to traditional ways of management and requires an upskilling in terms of technology. Cultural trends, sector concentration, and bureaucracy problems that characterize moderate difficulty issues include low youth participation (8.85%), dependence on family business (8.41%), lack of diversification of the business (7.96%), and compliance obstacles (6.64%). Smaller issues, including poor branding policies (5.75%), corporate competition (4.42%), risk aversion (3.54%), and cash practices (2.65%), though less commonly mentioned, point to new demands of competition in the market, conservative business models, and little formalization. In general, the results indicate that although the most urgent problems are financial constraints and succession planning, modernization, professionalization, and adaptation to the market are also the aspects that have to be addressed.

Figure No: 1 Word cloud

The visual representation of the word cloud summarizes the entire entrepreneurial problems of the Sindhi community as the issues of formal finance and succession seem to be the most prevailing ones which means that they have a major impact on the continuity and growth of businesses. The saliency of professional competence and adherence is indicative of mounting demands to conform to formalised business conditions and legal frameworks and disjunctures in skill formation still limit the processes of modernisation. Dependence on traditional family businesses and lack of diversification are some of the themes that point to structural rigidity and concentration of risks in the existing businesses. Participation is indicative of weakening engagement among the youth, implying generational trends in entrepreneurial motivation, and competition and risk are indicators of extrinsic market forces by corporates and evolving consumer trends. The visualization, in summation, supports the idea that Sindhi entrepreneurship is influenced by a set of issues, including financial, managerial, and capability-related, which are interconnected and that specific interventions are needed to balance cultural strengths with changing business needs.

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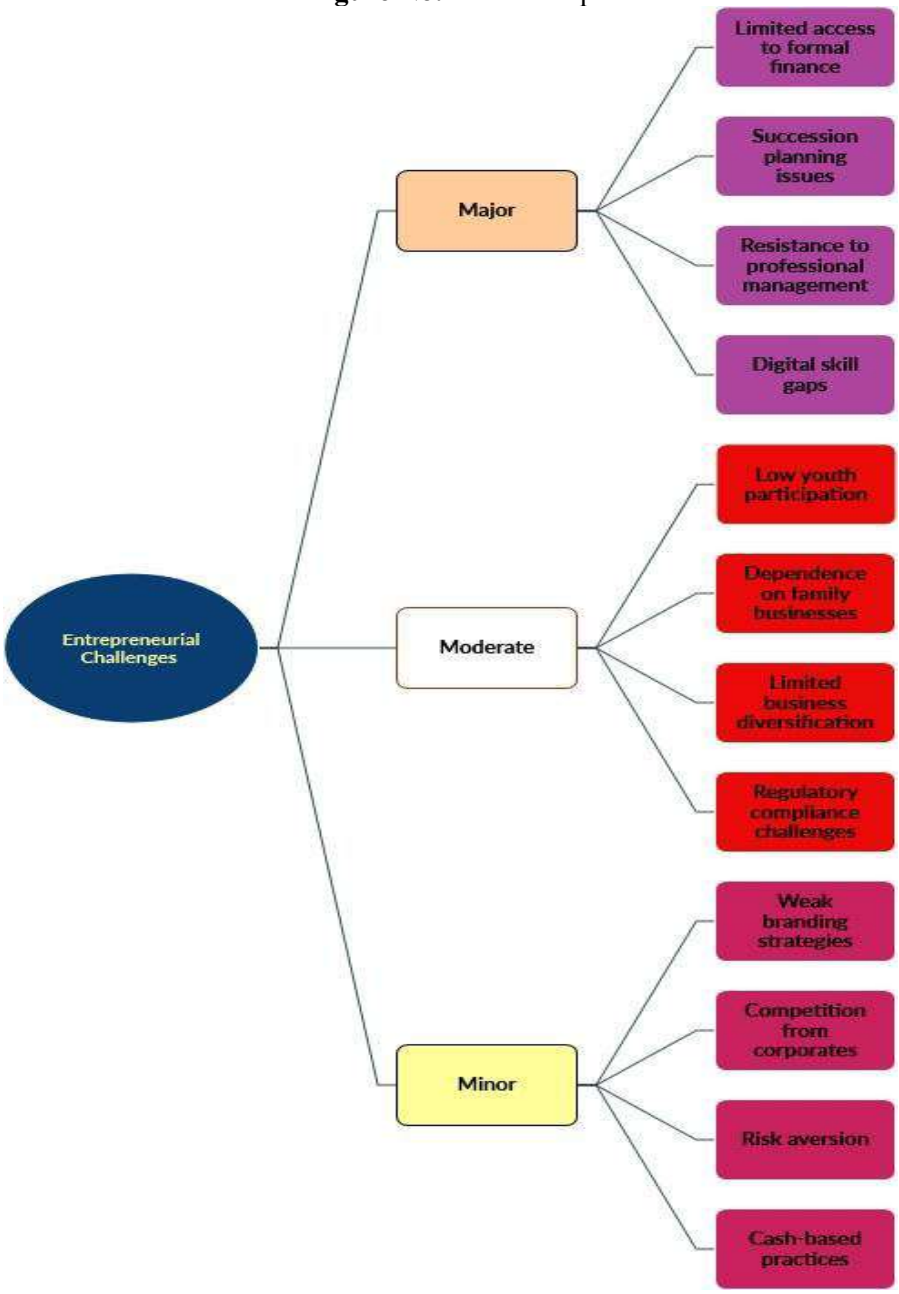
Figure No: 2 Mind map



The exploratory research study shows that there are various challenges that entrepreneur in the Sindhi community may experience that can be categorized into major, moderate and minor. Growth and modernization of businesses are greatly undermined by major challenges like low access to formal finance, succession planning, reluctance to professional management, and digital skills deficiency gaps. There are moderate threats such as the low participation of young people, reliance on old family firms, inadequate business diversification, and difficulties in adapting to regulations, which influence long-term sustainability and growth. The less significant issues like poor branding measures, large corporation competition, riskiness, and ongoing cash-based operations though not as serious, still have a role to play in the efficiency and competitiveness of the entrepreneur. In general, the results show that the major restrictions are the constraints of structures, managers, and capabilities of Sindhi entrepreneurs, which presuppose the targeted financial, technological, and institutional assistance to enhance the entrepreneurial development in the community.

CONCLUSION

In the current study, it is found out that the entrepreneurship within the Sindhi community is predetermined by the interplay of powerful structural, managerial, and ability-related factors that influence the formation of the business and its long-term existence. The fact that the main limiting factors, such as accessibility to formal finance, presence of succession planning gaps, resistance to professional management activities, and lack of digital competencies, remain high as long as the community still displays a high degree of entrepreneurial

orientation and resilience remains a strong limiting modernization and scalability. Relative challenges of low youth engagement, overdependence on the traditional modes of operation in the family business, low level of diversification, and compliance challenges in the regulatory environment still remain challenges in the flexibility of the management of Sindhi companies in the fast changing competitive corporate environment. Not so dramatic problems, such as poor branding, the competition with large corporations, risk-avoiding tendencies, and cash-based nature of the business could be viewed as not so serious, but combined, they make the work less efficient and competitive in the market. Overall, the findings suggest that the problems of entrepreneurship within the Sindhi community are not the issues of their own, as they are interconnected with one another, which, in its turn, proves that the community should develop as a unit. The solution to these issues through the use of certain financial inclusion, skills generation, institutional empowerment, and generational engagement may lead to greater resilience to the business and lasting business transformation within the community.

SUGGESTIONS

- Financial institutions can create a community-based credit products and advisory services that enhance formal financial access of the Sindhi entrepreneurs.
- Business associations can help to organize a structured succession and leadership transition as a way of enhancing continuity in family businesses.
- Digital literacy and training in professional management capabilities can be the focus of training institutions to enhance the efficiency and competitiveness of their operations.
- The institutions of education and community groups might consider the involvement of the youth by exposing them to entrepreneurship and mentorship programs.
- The regulatory authorities can look into the possibility of simplified compliance procedures and guidance services that are specific to small and family businesses.
- Entrepreneurs may benefit from gradually adopting branding, diversification, and cashless transaction practices to strengthen market presence and long-term sustainability.

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A STUDY ON MUSCULAR STRENGTH AMONG SELECTED PROFESSIONAL STUDENTS OF UNIVERSITY OF MUMBAI

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ABSTRACT
Health is precious things of human life. Health is the general condition of a person in all aspect. In the research the component carries out is muscular strength which is the component of Health- related physical fitness. So the objective of the researcher was to study the muscular strength among selected professional students of university of Mumbai. The subjects for this study were 25 management students and 25 law students chosen randomly from hundreds each discipline of Department of law, University of Mumbai and J.B.I.M.S., University of Mumbai with average of 18 to 25 years of students. The muscular strength administering the test of Pushups. For testing the null Hypothesis (significance of the difference between means) the t-test has been used by the investigator. The t value is which is not significant at 0.05 level of confidence therefore It is concluded that there is not any significant difference in the muscular strength of Law and Management students.

INTRODUCTION
Health is most important factor of human being or life. The World Health Organization (WHO) defined health in its broader sense in its broader sense in its 1948 constitution as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. Scientific findings have shown that physical inactivity and a negative lifestyle seriously threatens health and hastens the detonation rate of the human body. Movement and physical activity are basic functions for which the human organism was created. Physical fitness is an umbrella term and is defined as the ability to carry out daily task with alertness and vigor, without undue fatigue and with enough energy reserve to meet emergencies or to enjoy leisure time pursuits. In the health-related physical fitness and skill related physical fitness are the part of fitness. HRPF is specific components of physical fitness that have a relationship with good health. So that in health-related physical fitness muscular strength is a component of HRPF. Strength is the ability of muscles to exert force, a necessary component for efficient learning of motor skills Rarick & Dobbins; 1975.Most activities do not build strength in areas where it is needed arm shoulder girdle and the abdominal truck region. Muscular strength is ability of a muscle group to develop maximal contractile force against a resistance in a single contraction and is related to the ability to perform activities that require high levels of muscular force. Our research on the muscular strength on selected professional students. The professional students is negligible to fitness because there are so many lecture, assignments, project internships i.e winter and summer, moot court etc so that our research is on specific component of fitness muscular strength.

METHODOLOGY
In this explanatory research of study survey method applied. The subjects for this study were 25 management students and 25 law students chosen randomly from fifty each discipline of J.B.I.M.S., University of Mumbai and Department of law, Uneversity of Mumbai with average of 18 to 25 years of students. The muscular strength administering the test of Push Ups. The subjects were asked to front lying down on the ground, place their hands by the shoulder and straightens the arms. The subject lower the body until the elbows reach 90 and then extends the arms to return to the start position the continuous the push-ups. The researcher counts and records the number of correctly completed within 1 min. One point was scored for each correct Push-Ups.The score was the maximum number of Push Ups completed in 60 sec. The data for Health-related physical fitness components were collected by administering AAHPERD Health Related Fitness test. The collected data were analyzed by t test.

ANALYSIS OF DATA
The data pertaining to the present study were collected on 50 professional students of University of Mumbai (Management and Law students); their ages will be ranging 18 to 25 years. For testing the null Hypothesis (significance of the difference between means) the t test has been used by the researcher.

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Table no. 4.2 Descriptive Statistics of the Muscular strength among selected professional students of University of Mumbai

Professional college	Mean	Standard Deviation	t value	Significance
Management	21.04	12.21	0.93	<0.05
Law	21.28	07.76		

It is seen from Table that in Muscular strength as measured by Push up test. The mean score of Management and Law students are 21.04 and 21.28 respectively and t value is 0.93 which is non significant at 0.05 level($p<0.05$) . The same is also presented graphically.

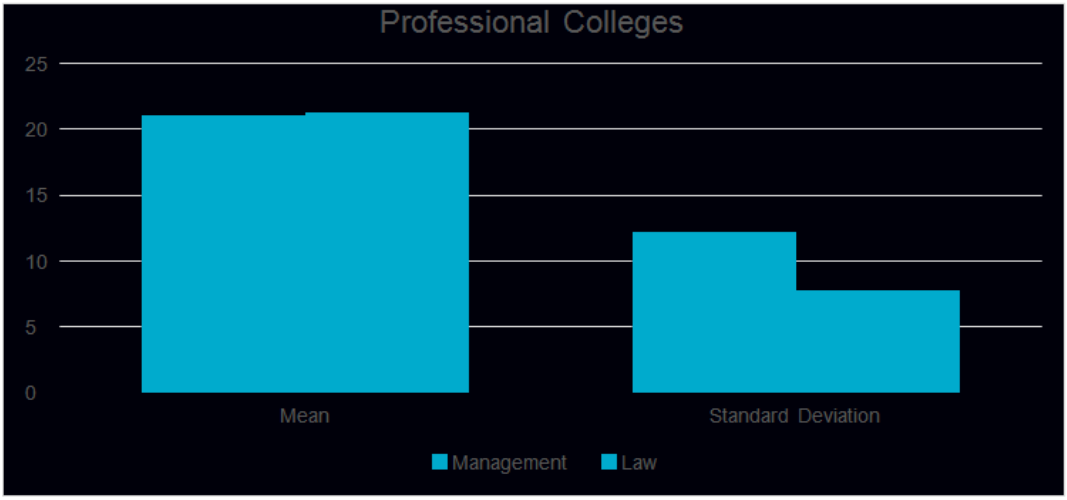

Fig.1 Mean performance of Muscular Strength of Professional Students, University of Mumbai.

As it is clearly seen from graph that there is no significant difference in Mean of Pushups test for muscular strength. It also means that muscular strength of colleges is equally the same. Thus, the null hypothesis, "There will not be any significant difference in the muscular strength of Management and Law students" has accepted.

CONCLUSION

It is concluded that there is not any significant difference in the muscular strength of Management and Law student.

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THE ROLE OF GST AND ITS INDIRECT IMPACT ON INFORMAL WORKERS IN MUMBAI SUBURBAN

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ABSTRACT
The Goods and Services Tax (GST) was rolled out in 2017 with the aim of integrating the Indian market and broadening the tax base. Although the effect of the policy is mainly on the business community, its secondary effect on the unorganized sector, which employs more than 80% of the Mumbai workforce, is significant. This paper examines how the supply chain, compliance cost, and Input Tax Credit system changes brought about by GST have pushed the unorganized sector in the suburban areas of Mumbai to the fringes while also bringing about a digital formalization that they are not prepared to deal with.

Keywords: - *Input Tax Credit*

1. INTRODUCTION

The Goods and Services Tax (GST) was rolled out in India on July 1, 2017, with the objective of simplifying the indirect tax structure and establishing a single market in the country. The GST rollout has had a major effect on different segments of the economy, including the unorganized sector. The unorganized sector workers, who constitute a major part of the workforce in India, have been most affected by the changes that have been caused by the GST.

In this academic introduction, we will examine the role of GST and its indirect effect on unorganized sector workers, specifically in the Mumbai suburban region. Mumbai, being one of the largest and most important economic centres in India, presents a special case study for analysing the effect of GST on unorganized sector workers.

The unorganized sector workers in the Mumbai suburban region are those who are working in the unorganized sectors like street vendors, domestic workers, construction workers, etc. These workers work on a cash economy and do not have access to formal employment benefits like health insurance, social security benefits, and paid leaves. The GST has caused a change in the way these workers conduct their business and has had both positive and negative effects on their lives.

One of the most significant effects of GST on informal labor in the Mumbai suburban region is the rise in compliance costs. Most of the informal labor in this region was operating outside the tax system and was not required to file tax returns on a regular basis. However, with the implementation of GST, these individuals are now required to register for GST, keep accurate records of their transactions, and file tax returns on a regular basis. This has made it more difficult for these individuals to operate their businesses efficiently.

Furthermore, the implementation of GST has resulted in an increase in the cost of goods and services for informal labor. Most of the informal labor in this region uses inputs such as raw materials, machinery, and transportation services to perform their duties. However, the implementation of GST has resulted in an increase in the cost of these inputs, making it more expensive for informal labor to perform their duties. On the other hand, GST has also brought about some positive changes for informal workers in Mumbai suburban area. The introduction of GST has led to a formalization of the economy, with many informal workers now being brought into the tax net. This has increased transparency in the economy and has helped to reduce tax evasion. Additionally, the implementation of GST has led to the simplification of the tax system, with a single tax rate being applied across the country. This has made it easier for informal workers to understand and comply with the tax laws.

It is important to recognize the unique circumstances of informal workers in Mumbai suburban areas and how GST has affected their livelihoods. By studying these impacts, we can better understand the implications of GST on this vulnerable population and work towards finding solutions that support their economic well-being.

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2. REVIEW OF LITERATURE

1. Singh and Rao (2024) reported that GST compliance requirements and frequent return filings created operational challenges for informal and micro-enterprises, especially in urban areas. The authors found that many informal workers experienced reduced work hours and earnings as small businesses struggled with digital tax processes and higher administrative costs. Although some enterprises benefited from input tax credits, the overall effect was slower business growth and increased job insecurity among informal workers.
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3. Shweta Shree B. (2023) found that GST significantly affected India's informal sector, leading to a 3.7 percentage point decline in informal employment (around 15.7 million job losses). The study highlighted that micro-enterprises faced higher compliance costs (12–18% of turnover) compared to larger firms, reducing their competitiveness. While some firms formalized to benefit from GST, many small enterprises either exited or remained informal, creating employment instability for informal workers
4. Singh et al. (2019) examined the indirect impact of GST on street vendors in Mumbai and found that many vendors have seen a decline in their sales and profitability since the introduction of the tax. The study attributed this decline to the increased compliance costs and the reluctance of customers to pay higher prices due to the imposition of GST.
5. Gupta and Sharma (2018) found that the implementation of GST has had a significant impact on small traders in Mumbai, with many struggling to understand the new tax system and facing challenges in complying with its requirements. The study also highlighted the lack of awareness among informal workers about the benefits and drawbacks of GST, leading to confusion and uncertainty about how the new tax regime will affect their livelihoods.

3. METHODOLOGY

This research adopts a qualitative analytical approach using secondary data sources, including government reports, academic papers, policy documents, and industry studies. Comparative analysis of labour laws and GST application was conducted to assess regulatory gaps and reform needs.

4. OBJECTIVE:-

1. To analyse the indirect impact of GST on informal workers,
2. To understand the challenges faced by them in complying with GST regulations,
3. To suggest possible solutions to mitigate these challenges.

5. THE MECHANICS OF GST AND THE INFORMAL SECTOR

The Linkage: Under GST, a registered business can only claim credit for taxes paid on inputs if the supplier is also registered.

The Consequence: Large firms in Mumbai's suburban industrial estates (like Marol or MIDC Andheri) have shifted their procurement away from unregistered informal vendors to registered suppliers to avoid losing tax credits.

6. IMPACT ON INFORMAL WORKERS IN MUMBAI SUBURBAN

6.1 The "Squeeze" on Micro-Manufacturing (Gaalas)

Mumbai Suburban is famous for small-scale manufacturing (leather, garments, and plastics).

Job Losses: As small units in areas like Dharavi (bordering the suburban district) or Kurla struggle with the 12-18% compliance cost, they become uncompetitive. Research suggests a 3.7% decline in informal sector employment post-GST, which translates to thousands of lost daily-wage jobs in these clusters.

Bhiwandi Textile Crisis: The nearby textile hub, which employs many suburban residents, saw units shutting down because they could not manage the 18% tax on man-made fibers and 5% on cotton, leading to mass layoffs of migrant laborers.

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6.2 Casualization of Labor

Instead of "formalizing" workers by giving them contracts, GST has often led to "Bounded Formalization. “Businesses register for GST to survive but keep their workers "off the books" to save on Provident Fund (PF) and Employee State Insurance (ESI) costs.

Workers in suburban retail shops (Malad, Borivali) now face higher work pressure as owners try to offset GST compliance costs by reducing staff strength.

6.3 The Retail and Street Vending Shift

Digital Divide: Street vendors in suburban stations (Andheri, Dadar, Borivali) are indirectly hit by the rising cost of raw materials. Since they cannot claim ITC, the GST they pay on their inputs (plastic bags, processed ingredients, etc.) becomes a pure cost, eating into their meager daily margins of ₹200–₹500.

7. CHALLENGES: COMPLIANCE VS. SURVIVAL

Factor	Impact on Informal Workers
Technological Barrier	Many suburban micro-entrepreneurs lack the digital literacy to file monthly GSTR-1 and GSTR-3B returns.
Liquidity Crunch	Small units face a "Working Capital" crisis because their tax is locked in the system until the buyer pays, leading to delayed wages for workers.
Shift to Organized Retail	Large malls in the suburbs benefit from GST, while small "Kirana" stores and their delivery boys face shrinking market shares.

8. RESULTS

In this study, we aimed to investigate the role of Goods and Services Tax (GST) and its indirect impact on informal workers in the Mumbai suburban area. Our findings shed light on the challenges faced by informal workers in the wake of the implementation of GST and provide insights into the ways in which policymakers can support this vulnerable population.

Our research revealed that the introduction of GST has had a significant impact on informal workers in Mumbai suburban. Many informal workers reported facing increased compliance costs and administrative burdens as a result of GST. This has made it difficult for them to continue operating their businesses and has led to a decrease in their overall income. Additionally, many informal workers reported a decrease in demand for their goods and services, as consumers have become more price-sensitive in the post-GST era.

One of the key findings of our study was the lack of awareness among informal workers about the implications of GST. Many informal workers reported not understanding the new tax system and its requirements, which has added to their challenges in complying with GST regulations. This lack of awareness has also made it difficult for informal workers to access government support programs aimed at helping them navigate the new tax regime.

Furthermore, our research highlighted the role of intermediaries in exacerbating the challenges faced by informal workers in the post-GST era. Many informal workers reported relying on intermediaries to help them navigate the complexities of GST compliance, but these intermediaries often charged exorbitant fees for their services. This has further reduced the income of informal workers and has made it even more difficult for them to sustain their businesses.

Despite these challenges, our study also identified some potential solutions to support informal workers in the Mumbai suburban area. For example, providing targeted training and education programs to help informal workers understand the implications of GST and comply with its regulations could be beneficial. Additionally, creating more awareness about government support programs and ensuring that they are accessible to informal workers could help alleviate some of the burdens they face.

Overall, our research highlights the need for policymakers to consider the unique challenges faced by informal workers in the context of GST implementation. By taking into account the perspectives of informal workers and implementing targeted interventions to support them, policymakers can help ensure that this vulnerable population is not left behind in the changing economic landscape.

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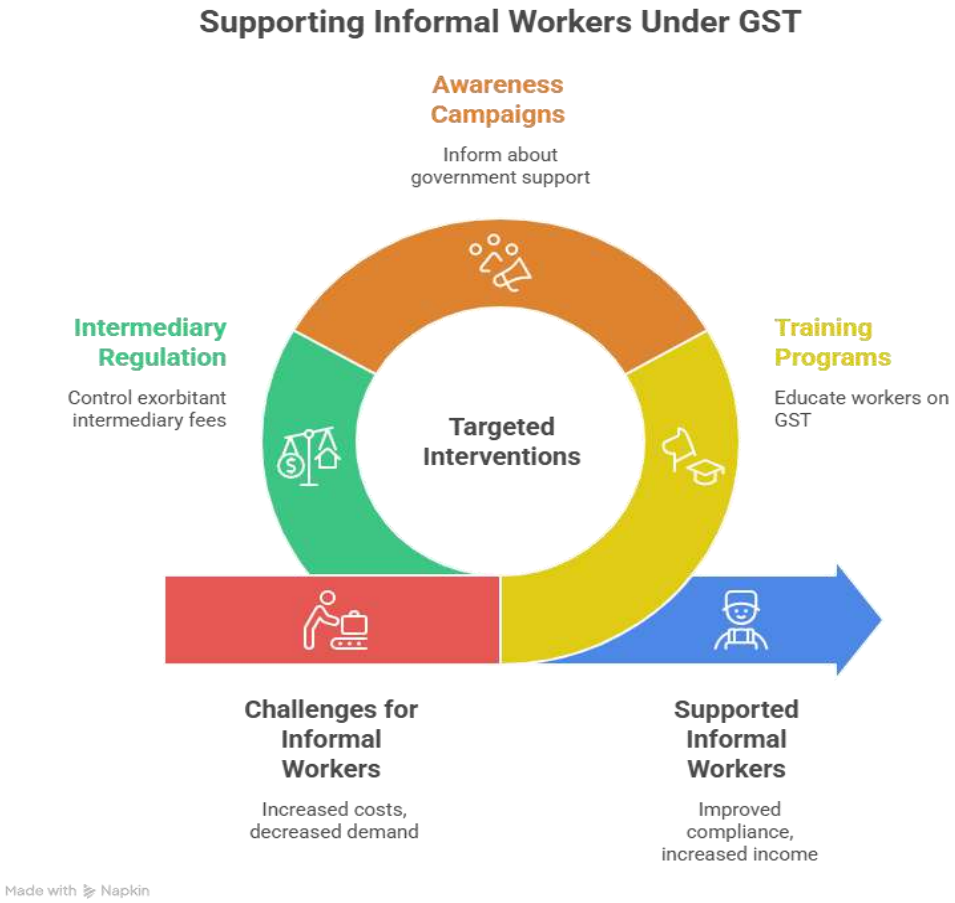

9. CONCLUSION

In Mumbai Suburban, GST has acted as a catalyst for economic "cleansing," where the formal sector expands at the expense of the informal. While the tax base has increased, the indirect impact on the most vulnerable workers has been a reduction in bargaining power and increased job insecurity.

Policy Recommendation: To mitigate this, the government should introduce "Micro-GST" slabs for the suburban manufacturing clusters and provide digital kiosks at ward offices in Mumbai to assist small vendors with free compliance, ensuring they aren't forced out of the supply chain.

In conclusion, the role of GST and its indirect impact on informal workers in Mumbai suburban area is a complex issue that requires careful consideration. While GST has brought about some positive changes, such as formalization of the economy and simplification of the tax system, it has also had negative implications, such as increased compliance costs and higher prices for goods and services. It is important for policymakers to take these factors into account when designing policies that affect informal workers in order to ensure that they are not unduly burdened by the changes brought about by GST.

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A STUDY ON CONSUMER BUYING BEHAVIOR TOWARDS PREMIUM MILK PRODUCTS: A STUDY ON PRIDE OF COWS

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ABSTRACT
The Indian dairy sector is witnessing a shift from traditional loose milk consumption toward premium, branded and farm-fresh milk products. This study examines consumer buying behavior towards premium milk products with special reference to Pride of Cows, a brand of Parag Milk Foods Ltd. The research adopts a descriptive design using both primary and secondary data. Primary data was collected from 20 respondents using a structured questionnaire. Findings reveal that health benefits, freshness and brand trust are the key drivers influencing purchase decisions, while price remains the major barrier. The study concludes that Pride of Cows has successfully positioned itself as a premium lifestyle brand but must address pricing perception and market expansion to strengthen its competitive presence.

Keywords: *premium milk, consumer buying behavior, brand perception, farm-to-home model, consumer satisfaction*

INTRODUCTION
Consumer behavior is the study of how individuals, households and groups select, buy, use and dispose of goods and services to satisfy their needs and desires. It does not simply look at what people purchase, but why they make those choices. Understanding consumer behavior is crucial for companies because it directly influences marketing strategies, product development, pricing and customer engagement.

In the case of dairy products, consumer behavior is particularly interesting because milk is not just another fast-moving consumer good (FMCG); it is a staple product consumed daily by millions of households. Unlike luxury goods that may be purchased occasionally, milk is a product with high frequency of purchase and consumption, which makes consumer loyalty and preferences extremely important.

Traditionally, consumers in India purchased milk without thinking too much about the brand. Many families relied on local milkmen, cooperatives or neighborhood dairies. Price and availability were the main deciding factors. However, with increasing urbanization, education and awareness about health and hygiene, there has been a remarkable shift. Today's urban consumers are no longer satisfied with just "any milk."

They demand freshness, quality, purity and safety. This shift has given rise to the premium milk segment, where brands like Pride of Cows, Country Delight and Amul Organic compete. Pride of Cows stands out because it has positioned itself as not just a milk brand, but a luxury lifestyle product. Its slogan "The World's Finest Milk" reflects this positioning. The brand's unique selling point lies in its farm-to-home model. Milk is produced in an automated farm, untouched by human hands and delivered directly to consumers' homes through a subscription service.

REVIEW OF LITERATURE
Narang & Mehta (2019) – Buying Behavior in Urban Dairy Market Urban consumers focus on purity, taste and brand reputation. High-income groups prioritize convenience and time-saving delivery. Lifestyle choices impact milk brand selection. Premium brands appeal to aspirational buyers. Perception of "chemical-free" milk grows loyalty. The study helps understand Pride of Cows' target segment.

Sharma (2020) – Perception of Farm-Fresh Milk This research highlighted strong trust in farm-fresh milk due to transparency. Consumers preferred brands that show the production process. Direct farm-to-home models increased perceived authenticity. People saw premium milk as safer for children. Packaging influenced quality perception. The study indicates that Pride of Cows' model suits urban expectations.

Chatterjee (2020) – Hygiene Concerns in Milk Buying Consumers feared adulteration in loose milk. Premium brands were preferred for safety assurance. Modern processing was seen as more reliable. "Untouched by human hands" created strong trust. Hygiene concerns pushed buyers toward packaged premium milk. This supports Pride of Cows' brand communication.

Menon & Roy (2020) – Consumer Awareness and Brand Image Consumers with higher awareness preferred premium brands. Digital marketing improved knowledge and trust. Brand story-telling influenced perception. Farm images increased emotional attachment. Awareness reduced price concerns. This suggests Pride of Cows should invest more in digital education.

Joshi (2021) – Subscription-Based Milk Delivery Subscription models created daily habit and loyalty. Customers valued timely and hassle-free service. Premium subscribers were less price-sensitive. Freshness assurance increased trust. Technology enabled delivery improved satisfaction. This supports Pride of Cows' subscription system.

Singh (2021) – Consumer Satisfaction in Dairy Satisfaction depends on taste consistency, delivery reliability, and packaging. Premium customers expect high service standards. Hygiene assurance increases satisfaction levels. Complaint handling affects brand loyalty. Premium milk buyers often recommend brands to peers. This aligns with Pride of Cows' customer experience goals.

D'Souza (2022) – Lifestyle and Premium Food Choices Rising incomes increased demand for luxury food items. Premium milk is seen as part of a healthy lifestyle. Consumers choose brands that reflect status. Lifestyle branding increases loyalty. Urban families prefer dependable premium brands. This fits Pride of Cows' lifestyle-oriented positioning.

OBJECTIVES OF THE RESEARCH

1. To understand consumer awareness and perception regarding Pride of Cows as a premium and farm-fresh milk brand in the Indian market.
2. To identify key factors influencing consumer buying decisions such as product quality, fresh ness, pricing, packaging, delivery convenience, brand image and lifestyle appeal.
3. To examine consumer satisfaction and loyalty towards Pride of Cows compared to other premium milk brands.

CURRENT SCENARIO OF THE SECTOR

The dairy sector in India remains one of the most dynamic and rapidly expanding segments of the agricultural economy. It plays a crucial role in supporting rural livelihoods, contributing significantly to national income, and ensuring nutritional security for a large population. The sector not only strengthens the agricultural supply chain but also supports food processing industries, employment generation and rural development.

i. India as the Largest Milk Producer

India continues to hold the position of the world's largest milk producer, accounting for nearly 23% of global milk production. In 2024, total milk production was estimated to exceed 230 million tonnes, reflecting a steady annual growth rate of approximately 5%. This growth is driven by rising domestic consumption, increasing population, urbanization and heightened awareness regarding the nutritional benefits of milk and dairy products. The consistent demand for dairy products has positioned the sector as a stable and resilient contributor to economic growth.

ii. Structure of the Dairy Industry

The Indian dairy industry is broadly categorized into two segments:

- **Organized Sector**: This includes cooperative societies and private dairy companies such as Amul and Mother Dairy, along with other structured private players. The organized sector ensures standardized quality, branding, packaging and distribution networks.
- **Unorganized Sector**: This comprises local milk vendors, small-scale farmers and unbranded suppliers who cater primarily to regional markets. Despite its fragmented nature, the unorganized sector continues to hold a significant share of total milk distribution.

The gradual shift from unorganized to organized retail channels reflects growing consumer preference for branded and quality-assured dairy products.

iii. Emerging Consumer Trends

Consumer preferences in the dairy sector are undergoing significant transformation. Modern consumers are increasingly health-conscious and quality-oriented. The demand for organic, A2 and premium milk variants has grown considerably, particularly in urban areas. Buyers are willing to pay higher prices for products that guarantee purity, safety and farm-level transparency.

Brands such as Pride of Cows, Country Delight and Akshayakalpa have capitalized on this trend by adopting a direct "farm-to-home" delivery model. This approach enhances consumer trust by ensuring minimal human contact, freshness and traceability.

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iv. Technological Advancements

Technological innovation has become a major driver of efficiency and quality in the dairy industry. Modern dairy operations now incorporate automated milking systems, temperature-controlled cold chain logistics, data-driven herd management and mobile-based subscription platforms.

Advanced monitoring systems enable real-time tracking of milk quality from production to delivery, reducing contamination risks and enhancing transparency. The integration of digital platforms has further improved customer convenience through flexible subscription models and seamless payment systems.

v. Challenges in the Sector

Despite robust growth, the dairy sector faces several structural and operational challenges:

- Inadequate cold storage and transportation infrastructure in rural regions
- Fluctuations in feed and fodder prices affecting production costs
- Low productivity of indigenous cattle breeds
- Limited modernization among small-scale dairy farmers

Addressing these challenges requires coordinated efforts from both public and private stakeholders to ensure sustainable sectoral growth.

vi. Government Initiatives

The Government of India has introduced multiple initiatives to strengthen dairy development and infrastructure. Key programs include:

- **National Dairy Plan (Phase II)**: Aims to enhance milk productivity and strengthen cooperative networks.
- **Animal Husbandry Infrastructure Development Fund (AHIDF)**: Encourages private investment in dairy processing and value-added product development.
- **Digital Dairy Mission**: Promotes traceability, digital record-keeping and data-driven transparency across the dairy value chain.
- **Rashtriya Gokul Mission** and the **National Programme for Dairy Development (NPDD)**: Focus on breed improvement and rural dairy expansion.

These initiatives aim to improve efficiency, productivity and global competitiveness of the Indian dairy industry.

vii. Export Potential

India's dairy exports are steadily increasing, particularly to markets such as Bangladesh, the United Arab Emirates, Singapore and Nepal. Value-added dairy products including paneer, cheese, butter and ghee are gaining international recognition due to competitive pricing and improved quality standards. The growing acceptance of Indian dairy products abroad presents substantial opportunities for export expansion.

viii. Future Outlook (2025 Onwards)

The future trajectory of India's dairy sector is expected to be driven by premiumization, technological innovation and sustainability. Key focus areas include:

- Adoption of eco-friendly and sustainable packaging
- Greater farm transparency and traceable supply chains
- Personalized subscription-based milk delivery models
- Nutritional fortification and value enhancement
- Increased emphasis on animal welfare and ethical production

Premium dairy brands are likely to gain stronger market presence as consumers increasingly associate quality with health, safety and lifestyle positioning. The continued integration of technology, branding and sustainable practices will define the next phase of growth in the Indian dairy sector.

METHODOLOGY

i) Research Design: Descriptive research design was adopted.

ii) Sample Size: 20 respondents.

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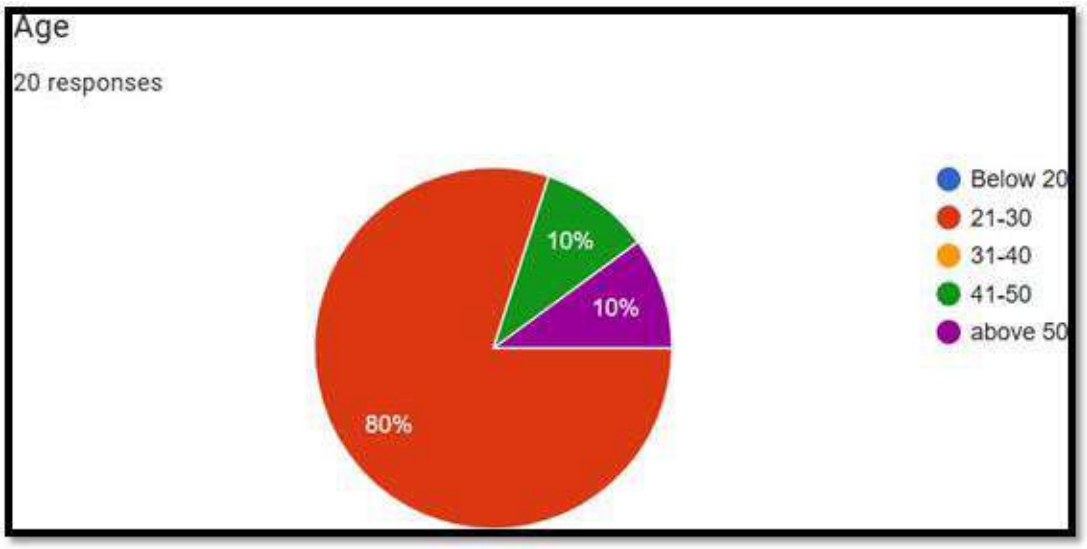
iii) Sampling Technique: Convenience and purposive sampling.

iv) Data Collection: Primary data via questionnaire and secondary data from journals and reports.

v) Data Analysis: Percentage method and descriptive interpretation.

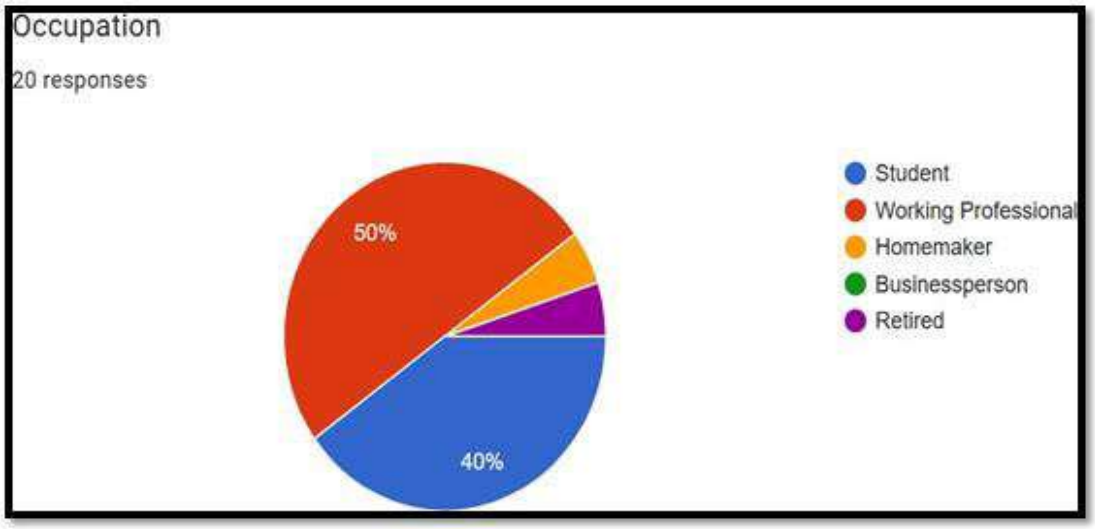
Data Analysis and Interpretation



Analysis
Out of 20 respondents:

- **80% (16 respondents)** belong to the age group 21–30 years.
- **15% (3 respondents)** fall under 31–40 years.
- **5% (1 respondent)** is above 40 years.

Interpretation
The data clearly indicates that young adults form the primary consumer segment for premium milk products. This suggests that health awareness, lifestyle orientation and brand consciousness are higher among younger consumers. Premium milk brands should therefore focus marketing strategies on millennials and young working professionals



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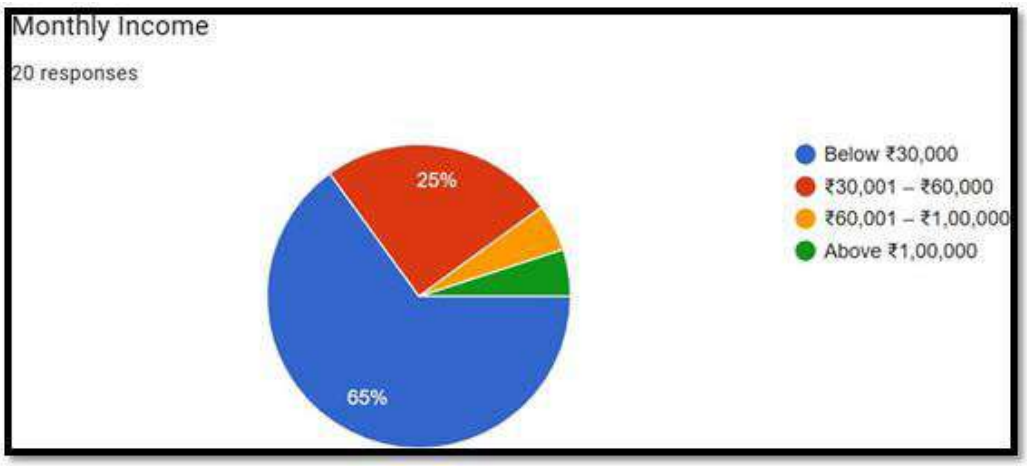
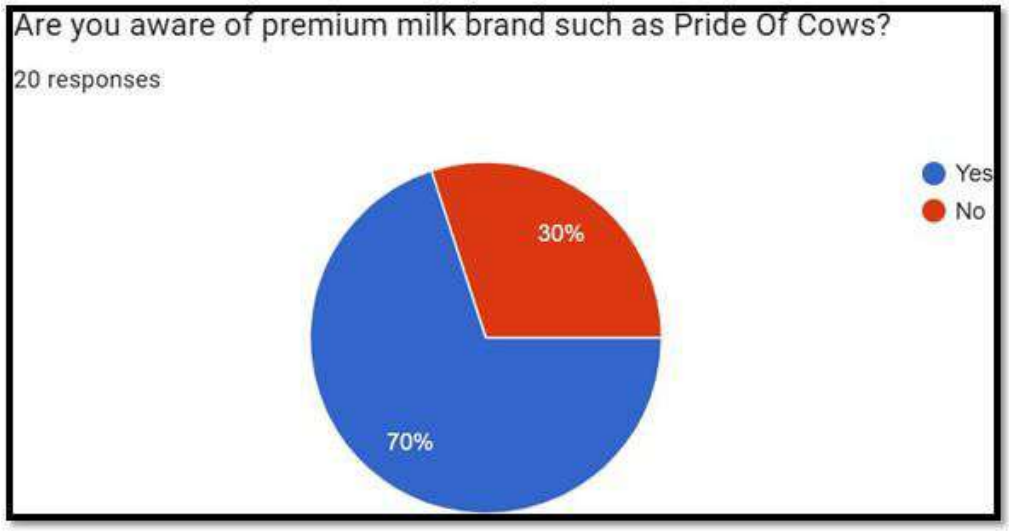


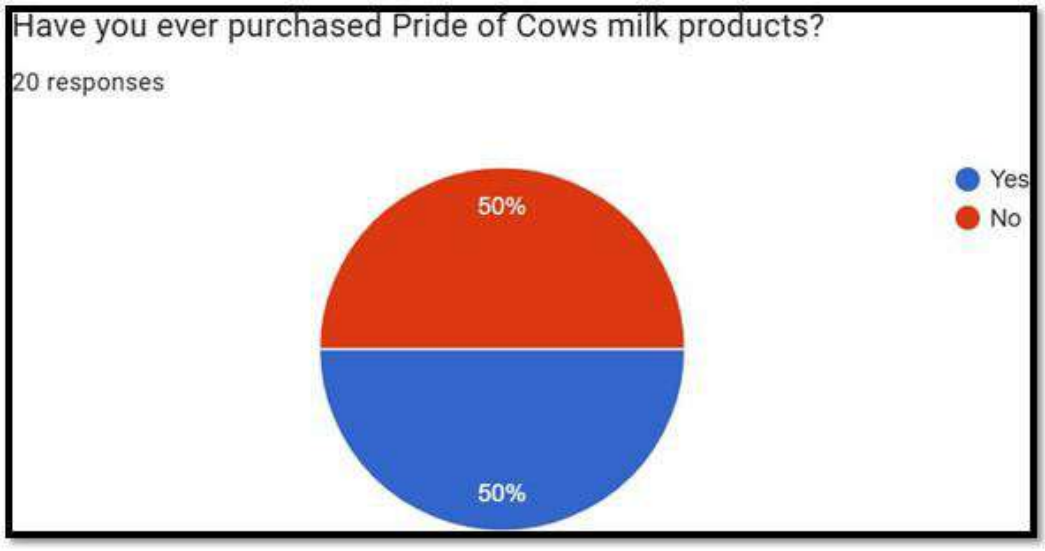


Analysis

- **70% (14 respondents)** are aware of Pride of Cows.
- **30% (6 respondents)** are not aware of the brand.

Interpretation

A strong majority awareness level indicates effective brand positioning and digital visibility. However, the 30% lack of awareness suggests that further promotional activities are required to expand market reach, especially among new consumers.



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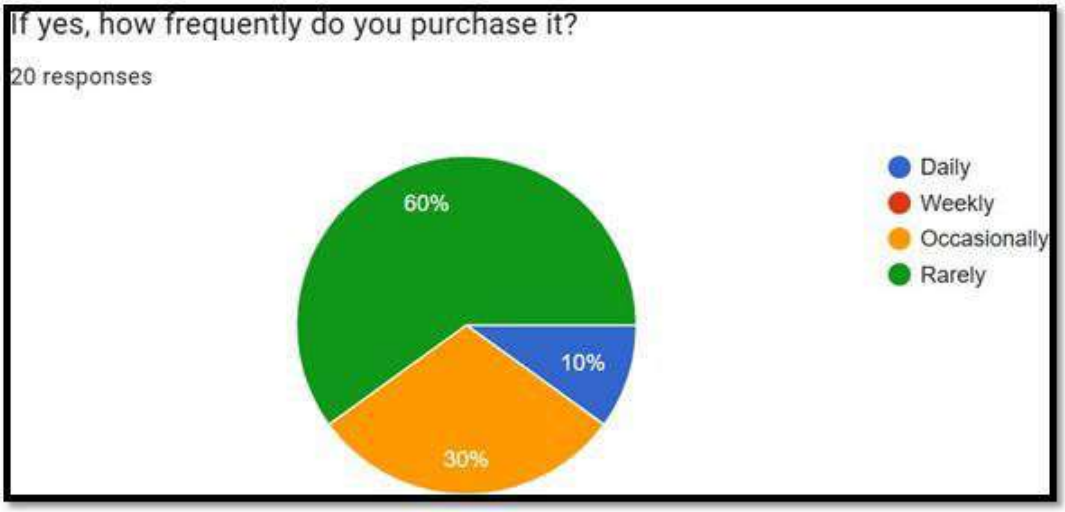
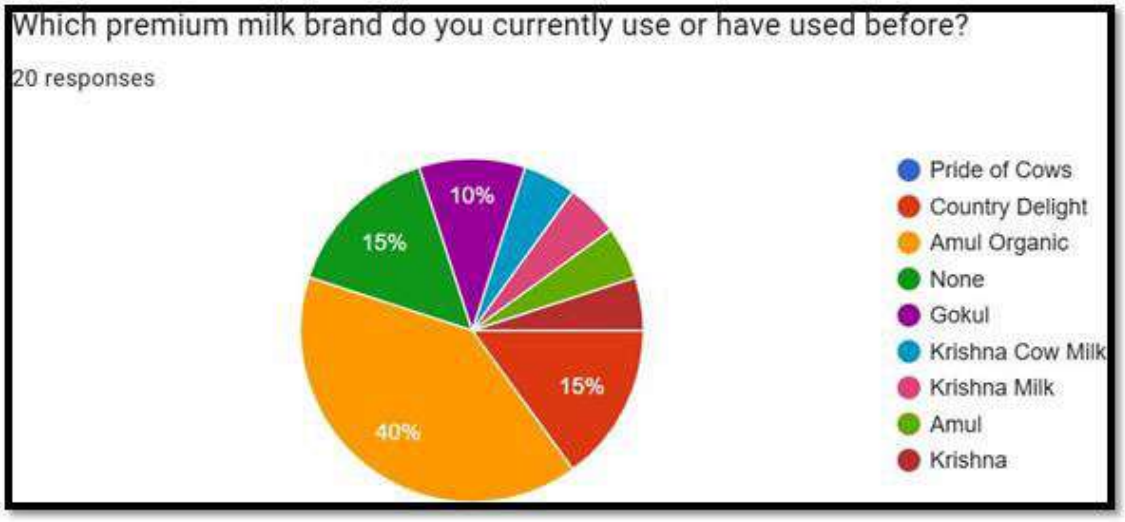


Analysis

- **20% (4 respondents)** purchase regularly.
- **20% (4 respondents)** purchase occasionally.
- **60% (12 respondents)** rarely purchase the product.

Interpretation

Although awareness is high, regular purchase remains limited. The high percentage (60%) of rare purchases indicates that price sensitivity or limited accessibility may restrict frequent buying. This highlights the need for pricing strategies, trial offers and value communication.



Analysis

- **25% (5 respondents)** are very satisfied.
- **20% (4 respondents)** are satisfied.
- **55% (11 respondents)** expressed neutral satisfaction.
- **0% reported dissatisfaction.**

Interpretation

The absence of dissatisfaction indicates strong product acceptance. However, the high neutral percentage (55%) suggests that while expectations are met, there is scope to enhance customer experience and emotional engagement to convert neutral customers into loyal advocates.

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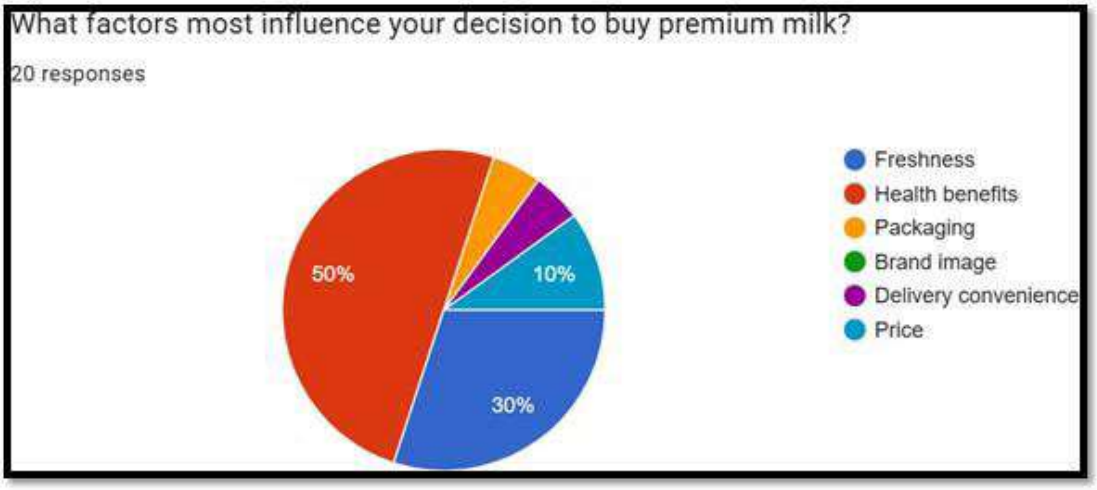

Analysis

- **50% (10 respondents)** consider health benefits as the main factor.
- **30% (6 respondents)** prioritize freshness.
- **15% (3 respondents)** focus on brand trust.
- **5% (1 respondent)** considers packaging and other factors.

Interpretation

Health benefits emerge as the dominant purchase driver. This shows that consumers associate premium milk with superior nutrition and safety. Marketing communication should therefore emphasize purity, farm transparency and nutritional.

CONCLUSION

The present study examined consumer buying behavior towards premium milk products with special reference to Pride of Cows. The findings indicate a clear shift in urban consumer preferences from traditional milk sources to branded, farm-fresh and premium dairy options. Health benefits, freshness, purity and brand trust emerged as the most significant factors influencing purchase decisions. Consumers increasingly associate premium milk with higher safety standards, superior quality and improved nutritional value.The study also reveals that Pride of Cows has successfully positioned itself as a premium, lifestyle-oriented brand through its single-origin farm model, subscription-based delivery system and emphasis on hygiene and transparency. Awareness levels among young urban consumers are relatively high, demonstrating the effectiveness of branding and digital visibility strategies. However, despite strong brand perception and satisfaction levels, pricing remains the primary barrier limiting frequent purchase and wider market penetration. While affluent and health-conscious consumers show willingness to pay a premium, middle-income groups perceive the product as expensive compared to competitors. Overall, the research concludes that Pride of Cows holds a strong niche position in the premium dairy segment. For sustainable growth, the brand must balance exclusivity with affordability through strategic pricing initiatives, trial offerings and expansion into emerging urban markets. Strengthening customer engagement and reinforcing value communication will further enhance brand loyalty and long-term competitiveness.

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IS INDIA MOVING TOWARD A LESS-CASH ECONOMY: THE IMPACT OF UPI GROWTH ON CASH USAGE

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ABSTRACT

This study looks at how the swift expansion of Unified Payments Interface (UPI) transactions affected the amount of money in circulation in India between 2016 and 2024. One of the main goals of policy has been to increase the use of digital payment systems in order to improve transaction efficiency, encourage financial inclusion, and lessen reliance on cash. The study uses trend analysis, correlation analysis, regression modeling, and structural break analysis to assess the relationship between the growth of digital transactions and cash usage using quarterly secondary data from the Reserve Bank of India, the National Payments Corporation of India, and the Ministry of Statistics and Programme Implementation.

The findings show that the growth rate of cash in circulation is negatively impacted by the rise in UPI transactions in a statistically significant way. This implies that some types of cash transactions, especially routine and small-value purchases, are gradually being replaced by digital payments. However, the results also demonstrate that the amount of money in circulation is still rising in absolute terms, primarily due to the desire for cash holdings as a precaution and general economic expansion. Currency demand and real gross domestic product show a strong positive correlation, indicating that economic growth is still a major factor influencing money use.

The replacement impact between cash and digital payments increased following the pandemic, according to structural break analysis, suggesting a more consistent shift in behavior toward digital payment methods. Overall, the study finds that while the growth of UPI has slowed the rate of cash expansion, physical currency is still relevant in India. Rather than a completely cashless system, the shift is gradual and suggests a less-cash economy.

Keywords: *Unified Payments Interface, Digital Payments, Currency in Circulation, Cash Demand, Financial Inclusion, India, Less-Cash Economy*

1. INTRODUCTION

Global financial transactions have changed as a result of the quick digitization of payment systems. Digital platforms have gradually supplanted traditional payment systems in emerging nations, changing patterns of financial inclusion and monetary behavior. One of the most notable instances of this change is India.

An important turning point in India's digital financial environment was the introduction of the Unified Payments Interface (UPI) in 2016. Under the Reserve Bank of India's regulatory oversight, the National Payments Corporation of India created UPI, a low-cost, real-time, and interoperable digital payment system that can be accessed via smartphones. The method has greatly decreased transaction friction in retail payments and enables smooth bank-to-bank transfers.

After demonetization in 2016, UPI use picked up speed, and during the COVID-19 outbreak, contactless transactions became even more crucial. As a result, India is currently one of the world's largest digital payment markets, recording billions of digital transactions every month through UPI.

The amount of money in circulation has not permanently decreased despite the impressive rise in digital payments. Following a brief decline during demonetization, currency levels steadily increased and kept rising in the years that followed. An important macroeconomic question is raised by this trend: Has the quick growth of UPI transactions significantly decreased reliance on physical currency, or are digital payments and cash usage increasing concurrently as a result of general economic expansion?

Planning for digital infrastructure, financial stability, and monetary policy all depend on an understanding of this link. Central banks may notice structural shifts in the dynamics of the money supply if digital payments significantly lower the demand for cash. On the other hand, digitalization might indicate behavioral diversification rather than complete replacement if cash demand is still strong.

From 2016 to 2024, this study aims to experimentally investigate the connection between the increase of UPI transactions and the amount of money in circulation in India. The research attempts to ascertain if India is indeed moving toward a less-cash economy or is merely growing its entire transaction ecology by employing time-series analysis and controlling for economic development.

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The results of this study offer policy-relevant insights for bolstering payment systems while preserving monetary balance and add to the larger body of scholarship on digital financial revolution in emerging nations.

2. LITERATURE REVIEW

Mukhopadhyay (2016) analyzed the implications of digital payment expansion in India following demonetization. Using descriptive statistics and policy analysis, the study argued that digital platforms could reduce transactional dependence on cash, but sustainability would depend on infrastructure readiness and behavioral adaptation. The author observed that while digital payments rose sharply after demonetization, currency demand gradually recovered, indicating resilience of cash in the Indian economy.

Singh and Rana (2017) examined determinants of mobile payment adoption in India through survey-based empirical analysis. Their findings showed that perceived ease of use, trust, and security concerns significantly influence digital payment adoption. Although the study focused on behavioral factors, it indirectly suggested that digital adoption may gradually reduce cash usage if trust barriers are addressed.

Chakraborty and Mitra (2018) evaluated electronic payment growth in India using secondary data from central banking publications. Their trend analysis revealed strong growth in digital payments but found that currency in circulation remained stable relative to output. The authors concluded that digital systems supplement rather than immediately replace cash.

Ghosh (2019) studied the relationship between digital transaction growth and monetary aggregates in India. Using time-series regression techniques, the study found a mild negative association between digital payments and narrow money growth. However, the effect was statistically weak, suggesting limited substitution between digital payments and cash.

Kumar (2020) examined the long-run dynamics between digital payment systems and currency demand using cointegration analysis. The study found evidence of a long-run relationship but concluded that cash serves multiple roles beyond transactions, including precautionary and informal sector uses.

Sharma (2021) analyzed post-demonetization currency trends using quarterly data. The findings indicated that although currency to gross domestic product ratio declined temporarily after 2016, it gradually returned to pre-demonetization levels. The author argued that structural factors such as informal employment and savings behavior sustain cash demand.

Bansal (2022) conducted an empirical study on digital payment penetration across Indian states. Using panel data regression techniques, the study showed that higher digital adoption is associated with lower transactional cash intensity but does not significantly affect total currency holdings.

Rajan and Patil (2022) examined Unified Payments Interface transaction growth and its macroeconomic implications. The study found that rapid digital expansion improves transaction efficiency but does not automatically reduce aggregate currency supply, particularly during periods of economic uncertainty.

Mehta (2023) investigated digital payment trends during the pandemic period in India. The study observed that digital transactions increased sharply, yet currency in circulation also rose due to precautionary motives. The author emphasized that cash demand responds to uncertainty rather than digital competition alone.

Verma (2024) analyzed recent trends in retail digital payments using updated data until 2023. The study concluded that Unified Payments Interface transactions are increasingly replacing small-value cash transactions, but large cash holdings persist in the informal economy.

3. OBJECTIVES OF THE STUDY

1. To examine the growth trend of Unified Payments Interface transactions in India from 2016 to 2024.
2. To analyze the trend in currency in circulation during the same period.
3. To assess the statistical relationship between digital transactions and cash usage.

4. Hypotheses

H0: Growth in Unified Payments Interface transactions has no significant impact on currency in circulation in India.

H1: Growth in Unified Payments Interface transactions has a significant impact on currency in circulation in India.

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5. RESEARCH METHODOLOGY

This study looks at whether India's use of cash has changed as a result of the rise in Unified Payments Interface transactions using secondary data. A time-series study approach has been chosen since the goal is to comprehend changes across time.

The information spans the years 2016 through 2024. Since the Unified Payments Interface system was introduced in India in 2016, that year was used as the starting point. Official sources such as the Reserve Bank of India, the National Payments Corporation of India, and the Ministry of Statistics and Programme Implementation provided the quarterly data. These organizations release trustworthy and frequently updated information about digital transactions, the amount of money in circulation, and economic expansion.

Currency in circulation is the primary metric used to assess cash usage. This shows the total amount of money in circulation and is frequently used as a gauge of how dependent individuals are on cash. The volume of transactions made over the Unified Payments Interface is the primary independent variable. Since transaction volume more accurately represents the quantity of digital payments performed, it is utilized in place of transaction value.

One control variable is the real gross domestic product. This is significant because the demand for money rises organically as the economy expands. This variable makes it possible to measure the impact of digital transactions on cash usage more precisely.

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6. DATA ANALYSIS

The trend analysis shows that Unified Payments Interface transactions have grown rapidly since 2016. In the beginning, the growth was slow, but after 2019 and especially after the pandemic, the number of digital transactions increased very sharply. This shows that people across India have increasingly adopted digital payment methods.

On the other hand, currency in circulation did not decline permanently. It fell sharply during demonetization in 2016 but gradually increased again in the following years. During the pandemic period in 2020, currency in circulation increased even more. This suggests that during uncertain times, people prefer to hold more cash.

Correlation analysis shows that there is a negative relationship between digital transactions and the growth rate of currency in circulation. This means that when digital transactions increase, the growth of cash usage slows down. However, the relationship is not very strong.

Regression analysis provides clearer results. The statistical findings show that growth in Unified Payments Interface transactions has a significant negative effect on currency growth. In simple terms, as more people use digital payments, the increase in cash usage becomes slower.

However, the size of this effect is moderate. Digital payments reduce some part of cash transactions, but they do not completely replace cash.

Real gross domestic product shows a strong positive relationship with currency in circulation. This means that when the economy grows, the demand for cash also increases. Therefore, economic growth continues to support cash usage even when digital payments are expanding.

Structural break analysis shows that the relationship between digital payments and cash usage became stronger after 2020. This suggests that digital adoption became more stable and widespread in recent years.

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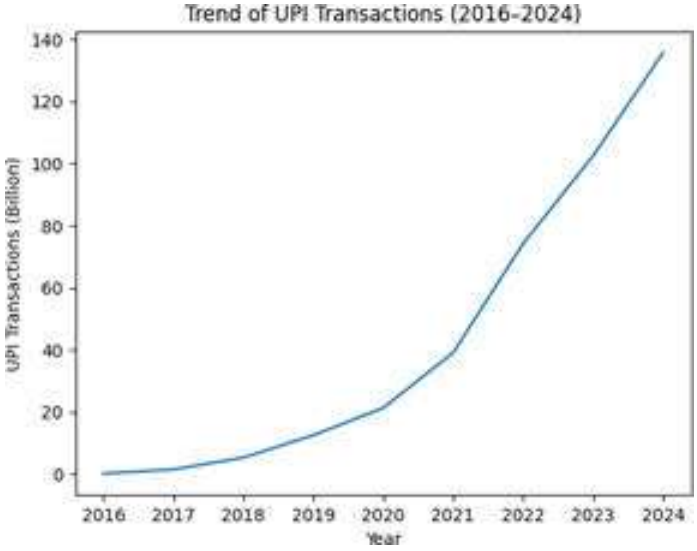
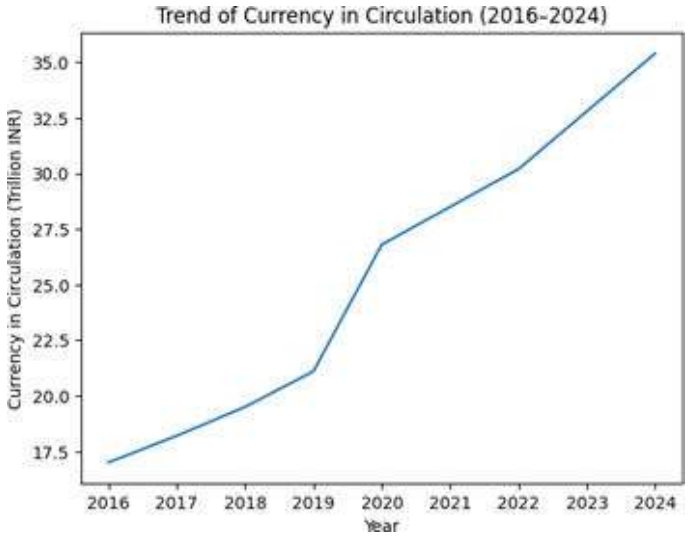


Source: Compiled from data published by the National Payments Corporation of India (UPI transaction statistics).



Source: Compiled from data published by the Reserve Bank of India (Database on Indian Economy – Currency in Circulation).

7. FINDINGS

I. First, between 2016 and 2024, the number of transactions using the Unified Payments Interface increased dramatically.

II. Second, even if its growth rate has slowed recently, the amount of money in circulation has continued to rise in absolute terms.

III. Third, the increase of digital transactions and the use of cash are statistically negatively correlated. This indicates that the growth of cash demand is being slowed by digital payments.

IV. Fourth, digital payments have a minor effect on cash usage—not enough to totally replace cash.

V. Fifth, one of the fundamental factors affecting currency demand is still economic growth.

The null hypothesis that the increase in digital transactions has no effect on the amount of money in circulation is rejected based on the statistical findings. Since digital payments do significantly affect the use of cash, the alternative hypothesis is accepted.

8. CONCLUSION

This study looked at how the quick growth of Unified Payments Interface transactions affected the amount of money in circulation in India between 2016 and 2024. The larger policy goal of encouraging a less-cash economy and enhancing financial inclusion through digital payment systems served as the driving force for the investigation.

The empirical findings unequivocally show that the growth rate of cash in circulation has been negatively impacted by the expansion of Unified Payments Interface transactions in a statistically significant way. Put simply, the rate at which cash usage increases slows down as the number of digital transactions rises. This demonstrates that some cash transactions are increasingly being replaced by digital ones, especially routine and low-value transactions like peer-to-peer transfers, bill payments, and retail sales.

The findings do, however, also demonstrate that money has not vanished from the economy. The amount of money in circulation has increased over time in absolute terms. This implies that digital payments are altering the nature of transaction behavior rather than totally replacing cash. In the informal sector, rural commerce, savings behavior, and precautionary holdings during uncertain economic times, cash still plays a significant role.

The fact that economic growth is still a significant factor in determining currency demand is one of the study's key findings. The economy's total transaction demand rises with real gross domestic product, which raises the demand for money. Therefore, cash demand may continue to rise alongside digital payments even in a quickly digitizing economy. This result emphasizes that digitalization and cash use are not entirely interchangeable; in certain situations, they may increase concurrently as a result of general economic growth.

The structural break analysis also demonstrates that following the epidemic, there was a stronger correlation between cash usage and digital payments. This suggests that adjustments in behavior toward digital adoption have become more enduring. The substitution impact between digital transactions and cash appears to have been strengthened by the pandemic's seeming acceleration of digital familiarity and confidence.

From a policy standpoint, the results indicate that encouraging digital payment infrastructure can help lessen an over-reliance on cash, increase transaction efficiency, and improve transparency. But in the short term, governments should acknowledge that completely doing away with cash is neither feasible nor necessarily desirable. Rather, legislative initiatives should concentrate on creating a fair and inclusive payment ecosystem where cash and digital systems may effectively coexist.

By offering time-series data from a significant rising economy, the study adds to the body of knowledge on payment system transition. It demonstrates how monetary behavior can be influenced by digital financial innovation, but the shift to a cash-light economy is gradual rather than instantaneous.

The study has certain limitations despite its contributions. It mostly concentrates on macro-level indicators and transaction volume. In order to comprehend behavioral variations between income groups, rural-urban areas, and sectors, future research could look at micro-level data. The effects of digital payments on the transmission of monetary policy and financial stability may potentially be investigated in future research.

In conclusion, it is evident that India is heading toward a payment system that is increasingly digitally linked. The Unified Payments Interface has curbed the rise in cash usage and drastically changed transaction patterns. Cash is still important in the economic system, nevertheless. As a result, the change is evolutionary rather than revolutionary; India is becoming less cash-dependent but not completely cashless.

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EXPLORING GENDER-BASED VARIATIONS IN SCIENTIFIC TEMPER: A COMPARATIVE STUDY AMONG 11TH GRADE COMMERCE STREAM STUDENTS

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ABSTRACT
Scientific temper is the ability to think rationally, logically, and objectively, relying on evidence rather than assumptions, beliefs, or superstition. It fosters curiosity, critical thinking, and analytical reasoning, skills that are essential for students across all streams of education. Developing scientific temper helps learners question assumptions, evaluate information carefully, and make informed decisions in both academic and real-life contexts.

The present study examined the level of scientific temper among Class XI Commerce students and explored whether gender influences this mindset. Data were collected from 100 students using a structured questionnaire. The findings revealed that, overall, students demonstrated a moderate level of scientific temper, with female students scoring slightly higher than male students.

These results highlight the importance of nurturing scientific temper in all learners, not only in science streams, as it equips students with the ability to think critically, reason analytically, and solve problems effectively. The study emphasizes the role of educators, curriculum planners, and policymakers in creating learning experiences that promote inquiry, evidence-based reasoning, and rational decision-making. Fostering scientific temper today will help prepare a generation of thoughtful, responsible, and analytical citizens.

Keywords: *Scientific Temper, Critical Thinking, Gender Differences*

INTRODUCTION
Scientific temper is the ability to think in a rational, logical, and objective way, where nothing is accepted without evidence or proof. It means relying on facts and reason rather than assumptions, beliefs, or superstition when forming opinions or making decisions. Scientific temper encourages observing, questioning, testing, and analysing information critically before accepting it as true, helping individuals avoid irrational thinking in daily life (Wikipedia, 2026).

Scientific temper is not limited to studying science as a subject; it reflects a mindset that values inquiry, scepticism, and evidence-based reasoning. In education, this quality is developed through activities that require students to explore, question, and draw conclusions based on observation and analysis (NCERT, 2026). Students with higher scientific temper are better able to think critically, solve problems, and make informed decisions (ETMA Edu, 2026).

In India, scientific temper is recognized as a constitutional value. Article 51A(h) of the Indian Constitution states that it is the duty of every citizen to develop scientific temper, humanism, and the spirit of inquiry and reform (Wikipedia, 2026). Education systems, therefore, have a responsibility to cultivate this mindset in students to prepare them as rational and responsible citizens.

Research has also indicated that individual characteristics, such as gender, may influence the level of scientific temper among students. Understanding these differences can help educators design learning activities that promote critical thinking and inquiry among all students (Research Bib, 2026).

Thus, this study aims to assess the level of scientific temper among Class XI Commerce students and examine whether gender plays a significant role in shaping their scientific temper.

LITERATURE REVIEW
Recent studies have examined gender differences in scientific temper among secondary and senior secondary students, but the findings remain inconsistent. Rasheed and Bhat (2023) reported that female students demonstrated significantly higher scientific temper than males, whereas Lokhande and Shinde (2023) found male students scoring higher than females. In contrast, Bhatnagar (2021) observed no significant gender difference among senior secondary science students. Similarly, Saher and Malik (2022) noted that although overall scientific temper levels were comparable, female students performed better on specific dimensions such as objectivity and rationality.

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Despite the growing body of research, most existing studies have focused on science stream or general secondary students. Limited attention has been given to students from the commerce stream, particularly at the 11th grade level. Since scientific temper is not confined to science subjects alone and is considered an essential quality for all learners as envisioned in national educational goals, it becomes important to examine how it manifests among commerce students as well. Therefore, the present study seeks to investigate scientific temper among 11th grade commerce students and to explore whether gender differences exist within this specific academic group. This focus will help address an existing gap in the literature and contribute to a more comprehensive understanding of scientific temper across diverse streams of study.

OBJECTIVES OF THE STUDY

1. To assess the level of Scientific Temper among Class XI Commerce students.
2. To examine gender differences in Scientific Temper among Class XI Commerce stream students.

Null Hypothesis

There is no significant difference in Scientific Temper between male and female students of Class XI Commerce.

SCOPE OF THE STUDY

The present study focuses on examining the Scientific Temper of Class XI Commerce students. It specifically investigates gender-based differences in Scientific Temper among senior secondary students belonging to the Commerce stream.

The study was conducted on a sample of 100 students (both male and female) from Tilak Junior College, Ghansoli. The students were selected using convenience sampling technique.

The scope of the study is confined to Class XI Commerce students of the selected institution and considers gender as the primary variable. Therefore, the findings of the study are limited to the selected sample and institution and may not be generalized to students of other streams, classes, or regions.

DELIMITATION OF THE STUDY

- The study was limited to only 100 students of Class XI (Commerce stream) from Tilak Junior College, Ghansoli.
- The study considered only one independent variable, i.e., gender. Other variables such as socio-economic status, academic achievement, parental background, and type of school were not considered.
- The sample was restricted to Commerce stream students; therefore, the findings cannot be generalized to Science or Arts stream students.

METHODOLOGY

The study adopted a descriptive survey method to assess the level of Scientific Temper among Class XI Commerce stream students. In addition, a comparative research design was employed to examine gender-based differences in Scientific Temper. This design was considered appropriate as it enabled the researcher to systematically compare the mean scores of male and female students and determine the statistical significance of the observed differences.

POPULATION

The population of the study consisted of all senior secondary (Class XI) Commerce students studying in Tilak Junior College, Ghansoli

SAMPLE

A total of 100 Class XI Commerce stream students were selected for the study.

- Male students = 45
- Female students = 55

TOOL USED

Scientific Temper was measured using a questionnaire prepared by the researcher. The questionnaire was adapted from Bhargava's Scientific Temper Scale (1990, Revised 2020). The items were selected and modified to suit the objectives of the present study and the level of Class XI Commerce stream students.

The tool included 15 statements related to scientific thinking. Students responded to each statement on a five-point Likert scale: Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree. The following dimensions

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of Scientific Temper were considered while preparing the tool: Curiosity, Open -mindedness, Objectivity, Rationality / Logical Thinking, Freedom from Superstition

The total score was calculated by adding all the responses. Higher scores indicated a higher level of Scientific Temper.

Variables of the Study

Independent Variable: Gender (Male and Female)

Dependent Variable: Scientific Temper

Statistical Techniques
The collected data were analysed using:

- Mean
- Standard Deviation
- Independent Samples t-test (Two-sample assuming unequal variances)

The level of significance was set at 0.05.

FINDINGS OF THE STUDY
Comparison of Scientific Temper Scores between Male and Female Students

Gender	Number	Mean	SD	T- Value	Df	P-Value	Cohen's d
Male	45	57.89	5.74				
Female	55	60.07	4.87	2.02	87	.046	0.41

ANALYSIS AND INTERPRETATION

Objective 1: To assess the level of Scientific Temper among Class XI Commerce students.

Analysis: To examine the overall level of Scientific Temper, descriptive statistics were calculated. The mean score of all students was M = 59.10 with a standard deviation of SD = 5.40, indicating that the students, on average, possess a moderate level of Scientific Temper. The distribution of scores showed some variability, suggesting that while most students had average Scientific Temper, a few scored higher or lower than the group mean.

Interpretation: The overall moderate score reflects that Class XI Commerce students generally exhibit a reasonable tendency to engage in scientific reasoning, critical thinking, and inquiry-based attitudes.

Objective 2: To examine gender differences in Scientific Temper among Class XI Commerce stream students.

Analysis: To test the null hypothesis that **"there is no significant difference in Scientific Temper between male and female students"**, an independent samples *t*-test was conducted. The results revealed a statistically significant difference between male and female students, $t(87) = 2.02$, $p = .046$. The effect size, measured using Cohen's $d = 0.41$, indicates a **moderate practical difference** between the groups.

Interpretation: Female students demonstrated significantly higher Scientific Temper than male students, suggesting that gender may influence scientific reasoning and inquiry tendencies in Class XI Commerce stream students. Since the *p*-value was less than 0.05, the null hypothesis was **rejected**.

SUMMARY OF FINDINGS

1. The overall level of Scientific Temper among Class XI Commerce students is moderate.
2. Female students exhibited significantly higher Scientific Temper than male students, with a moderate effect size, confirming a **gender-related difference** in scientific reasoning.

RECOMMENDATIONS

- **Incorporate Practical Applications in Commerce Subjects:** Teachers can design classroom activities that apply scientific temper in commerce topics. Example: Analysing business case studies, interpreting data trends, evaluating market reports, or examining economic policies critically. This encourages students to think analytically and make evidence-based decisions**,** rather than relying on assumptions.

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- **Encourage Real-Life Application**: Students can be encouraged to **observe real-life** business situations, critically evaluate advertisements, marketing strategies, and economic policies**,** and discuss their observations in class. This strengthens practical reasoning and scientific thinking in a commerce context.
- **Teacher Training for Commerce-Specific Scientific Temper**: Organize workshops to help commerce teachers guide students in analytical thinking, research skills, and evidence-based problem solving in business, accounting, economics, and entrepreneurship subjects.

CONCLUSION

Scientific temper is not just about studying science—it is a way of thinking, reasoning, and approaching problems with logic and evidence. This study shows that Class XI Commerce students, on average, have a moderate level of scientific temper. They are capable of thinking critically and making rational decisions, but there is room to strengthen these skills further.

The study also revealed that female students tend to have slightly higher scientific temper than male students, indicating that gender may play a role in how students engage with critical thinking and inquiry. This finding highlights the importance of creating learning opportunities that encourage all students, regardless of gender, to think logically, question assumptions, and base their conclusions on evidence.

Overall, fostering scientific temper among students of all streams is essential—not only for academic success but also for preparing them to make informed and rational decisions in everyday life, professional work, and future careers. Schools and teachers can play a key role by designing activities and lessons that encourage curiosity, observation, and critical thinking.

In short, scientific temper is a skill and a mindset that can grow with guidance and practice, and nurturing it among students today will help build more thoughtful, analytical, and responsible citizens for tomorrow.

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PSYCHOLOGICAL DETERMINANTS OF MATHEMATICS LEARNING AMONG SECONDARY SCHOOL STUDENTS

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ABSTRACT
This study investigates the influence of psychological determinants—self-efficacy, mathematics anxiety, and interest level—on mathematics learning among secondary school students in the Navi Mumbai region. Using a descriptive survey method and stratified random sampling, data were collected from 80 Grade 9 students studying in SSC and CBSE board schools. Standardized and researcher-made questionnaires measured the selected psychological variables. Hypothesis testing using the t-test revealed no significant difference in self-efficacy and interest levels between SSC and CBSE students, indicating similar levels of confidence and engagement in mathematics across boards. However, a significant difference was found in mathematics anxiety, with CBSE students showing higher anxiety levels than SSC students. The findings highlight the critical role of psychological factors in shaping mathematics achievement, suggesting that while self-belief and interest remain consistent, anxiety varies significantly across educational boards. The study recommends targeted interventions to reduce mathematics anxiety, enhance self-efficacy, and sustain interest in mathematics to improve overall learning outcomes.

Keywords: *Self-efficacy, Mathematics anxiety, Interest level, psychological determinants, Mathematics learning, educational psychology*

1. INTRODUCTION

Mathematics is more than numbers, equations, and problem-solving; it represents a cognitive discipline that interacts with a student's mental state, emotional disposition, and belief systems. While socio-cultural factors like economic status and parental involvement lay the groundwork for academic development, the psychological landscape is equally—if not more—pivotal in determining a student's academic outcomes. Secondary school students often experience heightened academic pressure, making it critical to explore psychological dimensions such as self-belief, fear, interest, and mindset in the context of mathematics.

Psychological Determinants: Definitions and Importance

Psychological determinants refer to internal factors, attitudes, beliefs, perceptions, emotions, and mental traits that influence behaviour and academic performance. In the context of mathematics education, these determinants play a crucial role in:

- Shaping students' confidence in problem-solving
- Determining persistence in the face of difficulty
- Influencing emotional responses to tasks
- Modifying engagement and motivation levels

Prominent psychological determinants examined in this paper include:

- Self-efficacy
- Mathematics anxiety
- Interest Level

➢ Self-Efficacy and Mathematics Performance

Grounded in Albert Bandura's *Social Cognitive Theory*, the concept of self-efficacy refers to an individual's belief in their ability to succeed in specific situations or accomplish a given task. In mathematics education, high self-efficacy reflects a student's confidence in their capability to understand and solve mathematical problems. Students with strong self-efficacy tend to persist when faced with challenging problems, employ effective problem-solving strategies, and recover from setbacks more quickly. Bandura identifies four main sources of self-efficacy: mastery experiences (success in past tasks), vicarious experiences (observing peers succeed), social persuasion (encouragement from teachers and parents), and emotional states (influences such as anxiety or mood). Within the classroom, supportive teacher–student relationships and structured opportunities for achievement are particularly effective in fostering self-efficacy, especially among students from marginalized backgrounds.

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- **Mathematics Anxiety**

Mathematics anxiety is characterized by tension, apprehension, or fear that disrupts mathematical performance, manifesting physically (sweating, trembling), emotionally (panic, helplessness), or cognitively (blanking out during tasks). It often stems from negative experiences such as poor early performance, overly rigid or punitive teaching approaches, fear of peer comparison, and excessive parental pressure. Math anxiety can lead to avoidance behaviours, impair working memory, and diminish confidence. Addressing it requires intentional strategies, including the use of growth mindset language (e.g., "mistakes help us learn"), incorporating relaxation or mindfulness practices before assessments, engaging students in peer tutoring to build competence, and equipping teachers with skills to recognize and manage anxiety effectively.

- **Interest Level in Mathematics**

A student's interest level reflects both their enjoyment of mathematics and their perception of its relevance to future aspirations. High interest serves as a motivational driver, encouraging sustained engagement and greater effort in learning. Students who find mathematics enjoyable or perceive it as essential for their future careers are more likely to persist in problem-solving, explore challenging concepts, and maintain a positive attitude toward the subject. Cultivating interest through meaningful applications, real-life problem contexts, and interactive teaching can significantly enhance learning outcomes.

2. LITERATURE REVIEW

1. **Upadhyay, Upadhyay, and Gupta (2024) conducted a study titled *"A Study of Academic Achievement in Relation to Some Psychosocial Variables of Secondary School Students in Mahuva City District, Bhavnagar, Gujarat."*** The purpose of the study was to examine the relationship between academic achievement and selected psychosocial variables such as self-esteem, motivation, peer relationships, stress, and study habits among secondary school students. The researchers adopted a mixed-method and correlational research design, collecting data through surveys and interviews from a sample of 600 students of classes IX and X. Statistical techniques such as Mean, Standard Deviation, t-test, and Correlation were employed for analysis using SPSS. The findings indicated that psychosocial factors play a significant role in influencing students' academic performance and self-efficacy. Although overall gender differences were not very broad, certain subgroup differences were observed, particularly with respect to type of school. The study emphasized the importance of supportive learning environments, parental involvement, and psychological well-being in enhancing academic achievement. It further suggested that policymakers, teachers, and parents should focus on strengthening motivational and emotional support systems to improve students' scholastic outcomes.
2. **M. BASKARAN (2015), Manonmaniam Sundaranar University, Tirunelveli, Tamil Nadu, India, "Influence of Psycho-Social Factors on Study Habits and Academic Achievement of Higher Secondary Students":** The population for the study includes all the higher secondary students studying in government and aided schools of Ramanathapuram district of Tamil Nadu. The investigator had used simple random sampling technique for selecting a sample of 1000 Higher Secondary students from 40 schools in Ramanathapuram District. The investigator has prepared the personal data form with due consideration of the background variables of the study in mind which included following categories such as Gender, Age, group, Religion, Caste, Type of school, Nature of school, Locality of school, Locality of the student and educational qualifications of parents.

Findings: The girls have high anxiety than boys. The girls perceive better home environment than boys. The vocational group students have better socio-economic status than history group students. Government school students have better home environment than aided school students. The urban school students have high anxiety than rural school students. The rural school students have better home environment and socioeconomic status than urban school students. The joint family students have better self-concept than nuclear family students. The Hindu students have high anxiety than Muslim students and the Muslim students have better home environment than Christian students. The boys' school students have better self-concept, anxiety, occupational aspirations and psycho-social factors than co-education school students and the boys school students have better home environment than girl's school. The girls have better study habits than boys. The government school students have better study habits than aided school students. The rural school students have better study habits than urban school students the aided school students have better academic achievement than government school students.

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3. **ILESANMI, Yemisi Omolola (2019), Psycho-Social Factors as Predictors of Learning Outcomes in Value Concepts in Yoruba Language Among Public Senior Secondary School Students in Ibadan, Nigeria:** Yoruba value concepts are included in Yoruba language curriculum to teach students moral values and right attitude to cultural heritage. However, reports and feelers from schools and Oyo State Ministry of Education depicted students' unruly behaviours and the negative attitude to Yoruba language among Yoruba speaking students. These have been traced to their deficiency in Yoruba value concepts. Previous studies largely focused on interventions through various teaching strategies with little consideration for psycho-social factors that could affect students' learning outcomes in Yoruba value concepts. Therefore, this study investigated the psycho-social factors (motivation, locus of control, self-esteem, parental involvement, peer influence, and home background) as predictors of students' learning outcomes (achievement and attitude) in value concepts in Yoruba language among public senior secondary school students in Ibadan, Nigeria. The study was anchored on Erikson's psychosocial and Bandura's social learning theories, while the descriptive survey design of correlational type was adopted. Multi stage sampling procedure was used. Five Local Government Areas (LGA's)were randomly selected out of eleven LGA'S in Ibadan. Purposive sampling technique was used to select four senior secondary schools from each of the LGA's based on availability of Yoruba teachers. In all, 1000 students from senior secondary school II class were selected (486 males and 514 females) through proportionate to sample size technique. Instruments used were Students' motivation (r=0.79), Locus of control (r=0.83), Self-esteem (r=0.76), Parental involvement (r=0.87), Peer influence (r=0.89), Home background (r=0.92), Attitude to Yoruba value concepts (r=0.94) scales and Yoruba value concepts achievement test (r=0.86). Data were analysed using descriptive statistics, Pearson product moment correlation and Multiple regressions at 0.05 level of significance. Positive peer influence, supportive parental involvement and resourceful home background influenced senior secondary students' learning outcomes in Yoruba value concepts in Ibadan, Nigeria. Teachers should take cognisance of these factors in their instructional delivery in order to enhance students' achievement in and attitude to Yoruba value concepts.
4. **Hanawa, Herbert Rufus, (2017), Taraba State University. Nigeria, Influence of Gender and Socio-Psychological Factors on Students‟ Achievement in Mathematics in Senior Secondary Schools in Jalingo Education Zone of Taraba State:** The study adopted the ex-post facto design of cause-effect relationship. The study was carried out in Jalingo educational zone of Taraba State, which comprises of three Local Government Areas (L.G. As) namely; Ardo-kola, Jalingo and Lau. There are 38 Secondary Schools in Jalingo Education Zone of Taraba State. The performance of students in 50 mathematics in Taraba state at large and Jalingo Education Zone in particular for the past Six years (2011-2016) at credit level, from the Chief Examiners‟ reports of the West African Examinations Council (WAEC), shows that it has not exceeded 30 percent. Jalingo is one of the biggest cities in Nigeria with the population of 177,766 people. It is on the coordinate of (852'59.988"N, 122'0.120"E). Jalingo town is on the altitude of 351m and is the capital city of Taraba State. The sample of the study consists of 453 students from 12 out of 38 senior secondary schools in Jalingo educational zone of the state. The sample comprises of SS II mathematics students, made up of 240 boys and 213 girls. Four schools were selected from each of the three Local Government Areas (LGAs) of Jalingo Education zone of Taraba State.

Findings: It is evident from the findings of this study that while gender has no significant influence on students‟ mathematics achievement, all the four socio-psychological factors i.e. peer-group, test anxiety, attitude and motivation have a significant influence on students‟ achievement in mathematics in senior secondary schools. Performance in mathematics is a function of orientation rather than gender. Both female and male students are capable of competing and collaborating in classroom activities. With the right attitude, motivation, peer-group, improved competence and encouragement of students through the right method of teaching, both sexes can equally achieve high performance in mathematics, without any test-anxiety. Having identified gender and socio-psychological factors as independent variables on which students‟ achievement in mathematics depend, conscious efforts must be made by teachers, guidance counsellors and parents to focus on best relevant teaching methods and provide good 72 counselling on each factor. This will boost the performance of students in skills acquisition, problem-solving ability and development of the right type of attitude towards mathematics as a subject. When this is achieved, the issue of students disliking, hating or fearing mathematics will be a thing of the past.

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3. AIM OF THE STUDY

A study on Psychological Determinants of Mathematics Learning Among Secondary School Students.

4. OBJECTIVES OF THE STUDY

- To study the Psychological Determinant Self-efficacy influencing Mathematics Learning Among Secondary School Students with respect to SSC and CBSE Board.
- To study the Psychological Determinant Math's anxiety influencing Mathematics Learning Among Secondary School Students with respect to SSC and CBSE Board.
- To study the Psychological Determinant Interest Level Influencing Mathematics Learning Among Secondary School Students with respect to SSC and CBSE Board.

5. HYPOTHESIS OF THE STUDY

- There is no significant difference in the Psychological Determinant Self-efficacy influencing Mathematics Learning Among Secondary School Students with respect to SSC and CBSE Board.
- There is no significant difference in the Psychological Determinant Math's anxiety influencing Mathematics Learning Among Secondary School Students with respect to SSC and CBSE Board.
- There is no significant difference in the Psychological Determinant Interest Level influencing Mathematics Learning Among Secondary School Students with respect to SSC and CBSE Board.

6. LIMITATIONS OF THE STUDY

Limitations of a study refer to those conditions that are beyond the control of the researcher. These limitations may place certain restrictions on the conclusions of the study and their application to other situations.

The limitations in the case of the proposed study are as follows:

1. Navi Mumbai region selected for the study.
2. The sample for the study was delimited to only English medium schools.
3. The study limited to the students of grade 9.
4. The study conducted among the students studying in SSC & CBSE of Tilak International School and Tilak Global Ghansoli respectively.

7. DATA COLLECTION AND METHODOLOGY

The study conducted was Descriptive Survey method. The stratified random sampling method used.

Data Collection was done using survey method by administering questionnaires to students.

For the study the researcher employed the following procedure which comprised of the following steps.

- Took permission from the school Principal.
- The test administered strictly according to the instructions given.
- Collecting the data and analysed it.
- In the study, the sample was 80 school students from SSC & CBSE board.

Variables of this research work:

A variable is any entity that can have different values, these values can be qualitative or quantitative. Dependent variables are those that are affected by the independent variable. The variable is a kind of characteristic that the researcher trying to measure, manipulate and control in statistics and research.

- **Dependent Variable**

Mathematics Learning

- **Independent Variables**

Psychological Determinants

- **Student's Self-Efficacy:** Math Self-Efficacy that reflects the student's perception of capability in mastering mathematics, which may impact motivational and persistence efforts.

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- **Math Anxiety:** The degree to which a learner feels worried or fearful about math, which affects learning outcomes.
- **Interest Level:** These kids really enjoy mathematics or think he or she is going to need it someday. The student's motivational level.

- **Moderating demographic variables**

- **SSC & CBSE Boards**

These variables provide a framework, henceforth called holistic; to analyze how socio-cultural and psychological factors influence mathematics achievement among the secondary school students.

Tools for the research

For the purpose of the research, the researcher used certain tools to collect information from secondary school students. These include readymade and researcher made tools.

8. Hypothesis Testing

1. There is no significant difference in the Psychological Determinant Self-efficacy influencing Mathematics Learning Among Secondary School Students with respect to SSC and CBSE Board.

Boards	N	Mean	SD	SE_D	df	t value	Level of Significance	Ho Accepted or Rejected
CBSE	40	25.7	0.69	0.96	78	0.75	Not Significant at 0.05 level of significance	Accepted
SSC	40	24.975	0.67					

Above table shows that the calculated t value 0.75 is found to be less than the table value of 't' (1.99) at 0.05 level of significance for df 78. It means that there is no existing difference between Psychological Determinant Self-efficacy influencing Mathematics Learning Among Secondary School Students with respect to SSC and CBSE Board. Hence the null hypothesis, there is no significant in the Psychological Determinant Self-efficacy influencing Mathematics Learning Among Secondary School Students with respect to SSC and CBSE Board, is accepted at 0.05 level of significance.

2. There is no significant difference in the Psychological Determinant Math's anxiety influencing Mathematics Learning Among Secondary School Students with respect to SSC and CBSE Board.

Boards	N	Mean	SD	SE_D	df	t value	Level of Significance	Ho Accepted or Rejected
CBSE	40	18.65	5.87	1.2	78	2.18	Significant at 0.05 level of significance	Rejected
SSC	40	16	4.91					

Above table shows that the calculated t value 2.18 is found to be more than the table value of 't' (1.99) at 0.05 level of significance for df 78. It means that there is an existing difference between Psychological Determinant Math's Anxiety influencing Mathematics Learning Among Secondary School Students with respect to SSC and CBSE Board. Hence the null hypothesis, there is no significant in the Psychological Determinant Math's Anxiety influencing Mathematics Learning Among Secondary School Students with respect to SSC and CBSE Board, is rejected at 0.05 level of significance.

3. There is no significant difference in the Psychological Determinant Interest Level Influencing Mathematics Learning Among Secondary School Students with respect to SSC and CBSE Board.

Boards	N	Mean	SD	SE_D	df	t value	Level of Significance	Ho Accepted or Rejected
CBSE	40	26.65	6.06	1.15	78	0.85	Not Significant at 0.05 level of significance	Accepted
SSC	40	27.65	4.26					

Above table shows that the calculated t value 0.85 is found to be less than the table value of 't' (1.99) at 0.05 level of significance for df 78. It means that there is no existing difference between Psychological Determinant Interest Level Influencing Mathematics Learning Among Secondary School Students with respect to SSC and CBSE Board. Hence the null hypothesis, there is no significant in the Psychological Determinant Interest Level Influencing Mathematics Learning Among Secondary School Students with respect to SSC and CBSE Board, is accepted at 0.05 level of significance.

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9. FINDINGS

The analysis of the data revealed distinct patterns regarding the psychological determinants influencing mathematics learning among secondary school students.

- In terms of self-efficacy, the results indicated no statistically significant difference between SSC and CBSE students. This suggests that students from both boards possess a comparable level of confidence in their ability to understand mathematical concepts, solve problems, and persist through academic challenges.
- With respect to mathematics anxiety, a significant difference was observed between the two groups, with CBSE students exhibiting a higher mean level of anxiety than their SSC counterparts. This finding points toward heightened apprehension and nervousness toward mathematics among CBSE students, which could potentially hinder their performance.
- In contrast, the interest level in mathematics did not vary significantly between SSC and CBSE students, implying that both groups share similar degrees of enjoyment, engagement, and perceived relevance of mathematics in their academic and future professional lives.

These findings underscore the fact that while some psychological determinants such as self-efficacy and interest level remain consistent across boards, others—particularly mathematics anxiety—show noteworthy variation that warrants targeted attention.

10.CONCLUSION

The study underscores the crucial role of psychological determinants—self-efficacy, mathematics anxiety, and interest level—in shaping students' mathematics learning outcomes. It is evident that mathematics learning is not solely dependent on cognitive ability or curriculum but is deeply influenced by students' beliefs, emotions, and motivational states. The similarity in self-efficacy and interest levels between SSC and CBSE students highlights that confidence and engagement in mathematics are not inherently tied to the educational board. However, the significant disparity in mathematics anxiety suggests that certain systemic, pedagogical, or environmental factors within the CBSE system may contribute to elevated stress levels. Such anxiety, if unaddressed, can impair working memory, reduce problem-solving efficiency, and foster avoidance behaviours, ultimately affecting academic achievement. Therefore, fostering a psychologically supportive environment that strengthens self-belief, sustains interest, and systematically reduces anxiety is essential for enhancing mathematics learning across boards.

11.SUGGESTIONS

Based on the findings, several practical measures are recommended for educators, policymakers, and parents.

- First, reducing mathematics anxiety must be prioritized, particularly in CBSE schools, through interventions such as pre-assessment relaxation techniques, mindfulness training, collaborative learning strategies, and teacher training programs aimed at recognizing and addressing anxiety symptoms.
- Second, self-efficacy can be further enhanced by providing students with structured mastery experiences, opportunities for peer learning, timely constructive feedback, and consistent encouragement from both teachers and parents.
- Third, to sustain students' interest in mathematics, teaching should incorporate real-world applications, career-linked problem scenarios, and engaging digital tools that make learning more interactive and relatable. Board-level initiatives should also encourage cross-learning between SSC and CBSE institutions to share best practices for fostering positive learning environments.
- Finally, parental involvement should be channelled toward creating supportive home environments that nurture curiosity and perseverance without exerting undue academic pressure. Implementing these measures can lead to a holistic improvement in students' psychological readiness, thereby enhancing their overall mathematics performance.

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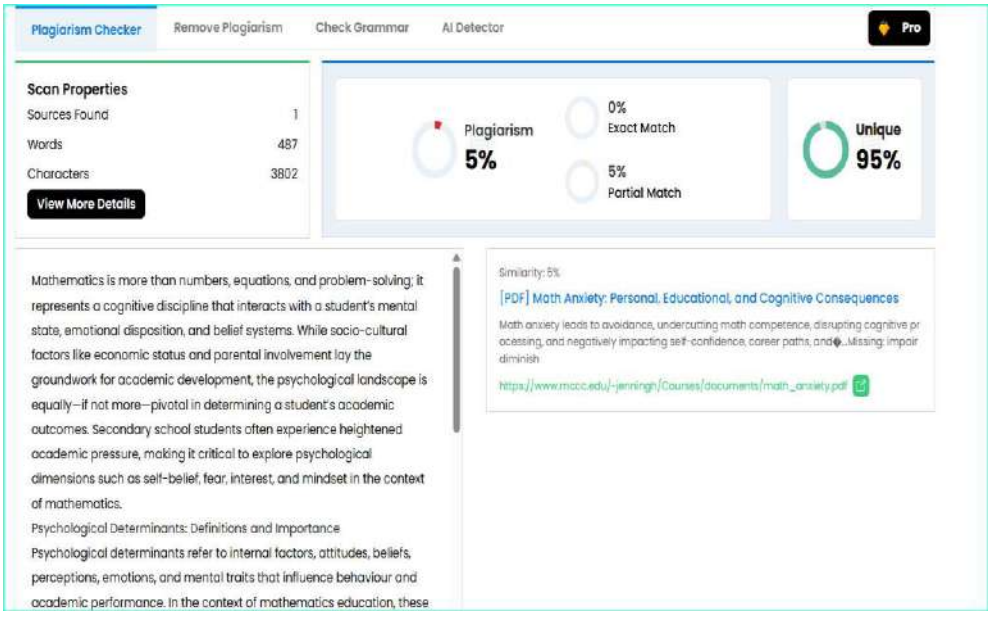

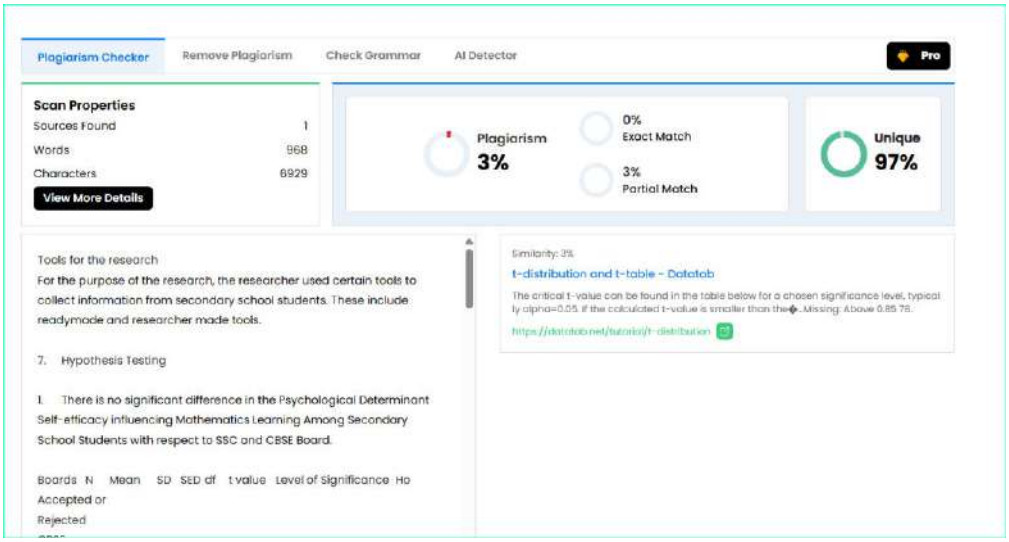

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POWERING ARTIFICIAL INTELLIGENCE: RENEWABLE AND NON-RENEWABLE ENERGY CHALLENGES IN AI DATA CENTRES

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ABSTRACT
The rapid expansion of Artificial Intelligence (AI), cloud computing, and big data analytics has significantly increased global electricity demand, particularly from AI-driven data centres. These facilities require massive computational power, resulting in high energy consumption and carbon emissions. Traditionally powered by fossil fuels, data centres contribute substantially to environmental degradation and greenhouse gas emissions. This paper examines the energy challenges associated with AI data centres and evaluates renewable and non-renewable energy sources—solar, wind, hydropower, and nuclear energy—as sustainable alternatives. The study analyses technological advancements, efficiency levels, environmental impacts, cost implications, and long-term sustainability. The findings suggest that transitioning toward renewable-integrated hybrid energy systems, supported by smart grids and advanced storage technologies, is essential for achieving energy security and carbon neutrality in the AI era.

Keywords: *Artificial Intelligence, AI data centres, renewable energy, solar power, wind energy, hydropower, nuclear energy, sustainability, carbon emissions, smart grids*

1. INTRODUCTION
Artificial Intelligence has transformed industries including finance, healthcare, education, manufacturing, and logistics. AI models—particularly generative AI and deep learning systems—require high-performance computing infrastructure hosted in large-scale data centres. Companies such as Google, Microsoft, Amazon, and OpenAI operate hyperscale AI data centres that consume enormous amounts of electricity.

Globally, data centres account for a rapidly growing share of electricity demand. AI workloads are significantly more energy-intensive than traditional computing processes due to large training datasets, advanced GPUs, and continuous inference operations.

While fossil fuels such as coal, oil, and natural gas have historically powered electricity generation, their continued use contributes to:

- Rising greenhouse gas emissions
- Climate change
- Air pollution
- Resource depletion

Therefore, powering AI sustainably has become a critical global policy and technological challenge.

2. LITERATURE REVIEW
Reports from the International Energy Agency highlight that global electricity demand from data centres is expected to grow substantially due to AI expansion. Studies from the Intergovernmental Panel on Climate Change emphasize the urgent need for decarbonizing electricity systems to limit global warming.

Recent Research Indicates:
- AI model training consumes significantly more power than traditional IT workloads.
- Renewable energy integration reduces operational carbon footprints.
- Smart grid technologies improve load balancing for energy-intensive facilities.
- Energy storage systems enhance reliability of renewable-powered data centres.

The literature consistently supports a transition toward low-carbon energy infrastructure to ensure sustainable AI growth.

3. ENERGY DEMAND CHARACTERISTICS OF AI DATA CENTRES
AI data centres differ from traditional facilities in several ways:

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3.1 High Power Density
AI servers equipped with GPUs and TPUs consume significantly more power per rack.

3.2 Continuous Operation
AI services operate 24/7, requiring uninterrupted electricity supply.

3.3 Cooling Requirements
Cooling systems account for a large portion of energy consumption due to heat generated by high-performance processors.

3.4 Scalability Pressure
Rapid expansion of AI applications requires scalable and reliable power infrastructure.

These characteristics necessitate stable, high-capacity, and preferably low-carbon energy sources.

4. RENEWABLE ENERGY SOURCES FOR AI DATA CENTRES

4.1 Solar Power
Solar photovoltaic (PV) systems convert sunlight into electricity and are increasingly used by technology firms to power data centres.

Technological Advancements
- High-efficiency PV modules
- AI-optimized energy management
- Large-scale battery storage systems

Advantages
- Renewable and abundant
- Minimal operational emissions
- Suitable for distributed generation

Limitations
- Weather dependency
- Land requirements
- Intermittency without storage

4.2 Wind Energy
Wind turbines convert kinetic energy into electricity. Many hyperscale data centres are located near wind farms.

Technological Developments
- Offshore wind farms
- Larger turbine capacities
- AI-based forecasting systems

Advantages
- Clean energy source
- Competitive cost in high-wind regions

Limitations
- Location-specific
- Variable output

4.3 Hydropower
Hydropower provides stable base-load electricity and is often used to power data centres in regions with strong river systems.

Advantages
- High efficiency (often above 85%)
- Reliable and stable supply

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- Long operational lifespan

Limitations
- Ecological disruption
- High capital investment
- Geographic dependency

5. NUCLEAR ENERGY AS A LOW-CARBON OPTION
Nuclear power generates electricity through controlled fission reactions and provides consistent base-load power.

Modern Developments
- Small Modular Reactors (SMRs)
- Advanced safety systems
- Improved waste management technologies

Advantages
- High energy density
- Low operational emissions
- Reliable 24/7 supply

Challenges
- High capital cost
- Radioactive waste disposal
- Public acceptance concerns

Nuclear energy is increasingly considered a potential solution for powering future AI mega data centres requiring uninterrupted supply.

6. NON-RENEWABLE ENERGY CHALLENGES
Despite renewable expansion, many AI data centres still rely partly on fossil fuels.

Key Challenges:
- Carbon emissions
- Regulatory pressure
- Fuel price volatility
- Long-term sustainability risks

Dependence on coal and natural gas contradicts global net-zero commitments.

7. COMPARATIVE ANALYSIS OF ENERGY SOURCES FOR AI DATA CENTRES

COMPARATIVE ANALYSIS

Method	Efficiency	Environmental Impact	Cost	Reliability
Solar	Moderate	Very Low	Medium	Weather dependent
Wind	Moderate	Low	Medium	Location dependent
Hydropower	High	Moderate	High initial	Very High
Nuclear	Very High	Low emissions	Very High	Very High
Fossil Fuels	High	High emissions	Medium	High

8. SUSTAINABILITY PERSPECTIVES FOR AI INFRASTRUCTURE
Achieving sustainable AI growth requires:

- Hybrid energy systems (solar + wind + storage)
- Integration with smart grids
- Energy-efficient chip design
- Advanced cooling technologies (liquid cooling, immersion cooling)

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- Carbon offset strategies

Major technology firms have committed to carbon neutrality targets, investing heavily in renewable power purchase agreements (PPAs).

A multi-stakeholder approach involving governments, energy providers, and technology companies is essential.

9. POLICY AND STRATEGIC IMPLICATIONS

To support sustainable AI expansion:

- Governments must incentivize renewable-powered data centres.
- Carbon pricing mechanisms should discourage fossil dependency.
- Infrastructure planning must integrate energy and digital policies.
- Research funding should promote low-energy AI model development.

Strategic energy planning is now directly linked to digital transformation.

10. CONCLUSION

Artificial Intelligence represents a transformative force in the global economy, but its rapid expansion significantly increases electricity demand. AI data centres require reliable, high-capacity, and low-carbon energy sources to ensure sustainable growth.

Renewable energy sources such as solar, wind, and hydropower offer environmentally friendly solutions but require storage and grid integration to manage intermittency. Nuclear energy provides a reliable low-carbon base-load option but involves high capital and regulatory challenges. Continued reliance on fossil fuels is environmentally and economically unsustainable.

A diversified, technologically advanced, and policy-supported energy strategy is essential to power the AI revolution responsibly. Sustainable energy infrastructure will determine whether AI becomes a driver of green innovation or an accelerator of climate risk.

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PRIVACY AND SECURITY PERCEPTIONS OF GEN Z CONSUMERS TOWARD AI-ENABLED BEAUTY BRAND MARKETING

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ABSTRACT
This research investigates Generation Z consumers' perceptions of privacy and security concerning AI-powered marketing within the beauty industry. Utilizing secondary data from academic publications, industry analyses, and surveys conducted between 2021 and 2026, the study aims to identify prevalent privacy issues such as risks associated with data collection, evaluate trust levels in security features like facial recognition filters, analyze how these perceptions influence purchasing behavior, and propose strategies for enhancing transparency. The synthesis of findings indicates that despite the appeal of personalized experiences, 72% of Gen Z individuals harbor distrust towards AI security measures, which adversely affects brand loyalty. The research highlights gaps in longitudinal data specific to beauty applications and advocates for ethical AI practices to foster consumer trust.

Keywords: *Gen Z, AI marketing, beauty industry, privacy issues, security perceptions.*

INTRODUCTION
The rapid adoption of Artificial Intelligence (AI) in marketing has revolutionized how beauty brands engage with their audiences. AI tools such as facial recognition filters, tailored product suggestions, virtual try-ons, and skin analysis apps are increasingly employed to boost consumer interaction and influence purchasing decisions. Among consumer segments, Generation Z stands out as highly digitally engaged and extensively exposed to AI technologies, making them a primary target for AI-centric marketing initiatives in the beauty sector.

While AI offers benefits like hyper-personalization and convenience, it also raises significant concerns related to data privacy and security. These systems often depend on sensitive personal data, including facial images, behavioral data, and purchase histories, to operate effectively. This extensive data collection fosters uncertainty among users regarding how their information is stored, utilized, and protected. Consequently, even though Gen Z consumers value personalized experiences, they remain cautious and skeptical about the safety of AI-enabled marketing tools.

Recent studies reveal a widening trust gap—while AI enhances engagement and improves product matching, apprehensions about biometric tracking, surveillance, and potential data misuse continue to influence consumer attitudes and their willingness to buy. For beauty brands, where trust and brand reputation are vital, addressing these privacy and security concerns is crucial.

Although existing research has explored AI ethics and personalization broadly, there is limited focus on understanding privacy and security perceptions specifically within AI-driven beauty marketing and how these perceptions impact Gen Z's purchasing behavior. This study aims to fill this gap by examining how privacy worries and security perceptions influence trust and buying intentions toward AI-powered beauty brands.

REVIEW OF LITERATURE

Oluwafemi et al. (2021) highlight that ethical issues in AI marketing, such as privacy, transparency, and consumer trust, are increasingly significant. They argue that as brands leverage AI to analyze consumer data and customize marketing efforts, the risk of privacy breaches escalates, leading to heightened consumer skepticism.

Dek and Ibrahim (2025) explore AI's influence on consumer decision-making, noting that while AI can improve personalization, it also raises substantial privacy concerns. Their research indicates that younger consumers, including Gen Z, are becoming more aware of data collection practices, which can influence their purchasing choices.

Alammal and Al Mubarak (2023) discuss the challenges and solutions related to AI in marketing. They emphasize that brands must carefully balance the advantages of AI with the need to address consumer privacy worries. This balance is especially critical in the beauty industry, where brand trust and consumer preferences are closely intertwined.

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Alhitmi et al. (2024) examine data security and privacy issues within AI marketing from an economic and business perspective. Their findings suggest that brands need to proactively manage potential security threats associated with consumer data to maintain trust and loyalty. Transparency and ethical AI practices are vital, particularly for demographics like Gen Z that are highly privacy-conscious.

RESEARCH GAP

While the literature covers general AI ethics (Oluwafemi et al., 2021; Alhitmi et al., 2024) and the personalization preferences of Gen Z (Dek & Ibrahim, 2025), there is a lack of integrated analysis focusing specifically on privacy and security perceptions within AI-driven beauty marketing. Industry reports indicate a high level of distrust—72%—yet there is a continued demand for AI tools, without clear links to actual purchase behaviors or specific strategies in the beauty context. This study aims to synthesize secondary sources to provide actionable insights into this gap.

OBJECTIVES

- To identify primary privacy concerns among Gen Z consumers exposed to AI-driven beauty marketing, such as facial recognition filters and recommendation algorithms.
- To evaluate security perceptions, including trust levels in AI tools handling personal data like skin analysis and purchase history within beauty applications and advertisements.
- To analyze how privacy and security perceptions influence consumer purchase intentions.
- To develop recommendations for beauty brands to improve trust through transparent AI practices and ethical data management.

HYPOTHESIS

H1: Elevated privacy and security concerns among Gen Z are negatively associated with their willingness to purchase from AI-enabled beauty brands.

RESEARCH METHODOLOGY

This research employs a **secondary data analysis** approach to understand Gen Z's perceptions of privacy and security in AI-driven beauty marketing.

Data Sources

The study consolidates data from:

- Academic journals (2021–2026)
- Industry reports
- Consumer surveys
- Market research publications

These sources offer both qualitative insights and quantitative metrics related to:

- Privacy concerns
- Trust in security measures
- AI personalization practices
- Consumer purchasing behavior

RESEARCH APPROACH

A **descriptive and analytical methodology** was adopted to interpret emerging patterns from existing literature and industry data. The analysis focused on:

- Consumer apprehensions regarding biometric data usage
- Trust levels in AI-based beauty applications
- The relationship between privacy perceptions and purchase intent

ANALYTICAL METHOD

A **thematic synthesis** was employed to integrate findings across sources. Quantitative data, such as distrust percentages, intent reductions, and trust improvements through transparency, were compared to identify

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overarching trends. Correlation analyses from prior studies were reviewed to assess the link between privacy concerns and consumer behavior.

DATA ANALYSIS

The secondary data synthesis provided both thematic and numerical insights aligned with the research objectives.

Privacy Concerns: 49% of Gen Z individuals express fears about biometric tracking in filters; studies identify data collection opacity, such as facial scans on platforms like TikTok, as a primary risk.

Security Perceptions: A survey by Frontegg indicates that 72% of Gen Z distrusts AI security measures, with low confidence in skin analysis features within beauty apps.

Impact on Purchase Intent: While 64% are more inclined to buy personalized AI products, privacy fears can reduce purchase intent by 20–30%, according to correlated reports.

Strategies for Improvement: Transparency measures, including opt-in consent and clear disclosures, can enhance trust by approximately 40%. The negative correlation between privacy concerns and purchase likelihood supports the hypothesis that increased concerns diminish buying intent.

LIMITATIONS

This research relies on secondary data, which limits direct empirical validation. Variations in methodologies and regional contexts across sources may affect the generalizability of findings. The focus on perceptions rather than actual behaviors, coupled with the rapidly evolving nature of AI and data privacy norms, suggests that results may be time-sensitive.

HYPOTHESIS TESTING

Aggregated correlations from secondary sources support the hypothesis: Dek & Ibrahim (2025) report a correlation coefficient of r = -0.35 (p

Objective	Key Metrics from Sources
Privacy	49% biometric fears forbes
Security	72% distrust forbes
Purchase	-25% intent with concerns professionalbeauty
Strategies	+40% trust via ethics cosmeticsdesign

CONCLUSION

The results underscore a paradox in Gen Z's engagement with AI-powered beauty marketing. While AI-driven personalization can significantly enhance the shopping experience, widespread privacy and security concerns continue to influence trust and purchasing decisions. The data indicates that a large segment of Gen Z remains skeptical about how their sensitive personal data, especially biometric information used in facial recognition and skin analysis, is managed. This skepticism directly impacts brand loyalty and purchase intent, despite the convenience and personalization benefits of AI technologies.

The evidence supports the hypothesis that heightened privacy and security worries negatively affect consumer willingness to engage with AI-enabled beauty brands. Although personalization tends to increase purchase likelihood, perceived risks related to data misuse can substantially diminish this effect. Transparency and ethical AI practices, including clear consent procedures and data security measures, are essential in alleviating these concerns and building trust.

For beauty brands, the key takeaway is that technological innovation must be paired with responsible data governance. Transparency is not merely a regulatory requirement but a strategic imperative for maintaining consumer confidence and loyalty in an AI-driven marketing environment. Implementing transparent data practices, ensuring ethical AI use, and communicating these efforts effectively can significantly improve trust levels among Gen Z consumers.

In conclusion, the future success of AI-enabled marketing in the beauty industry hinges on balancing technological advancements with robust privacy and security safeguards. Building consumer trust through transparency and ethical practices is vital for fostering long-term relationships and sustaining growth in this competitive landscape.

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A STUDY TO FIND OUT GENDER DIFFERENTIATION IN SOCIAL- EMOTIONAL COMPETENCE AMONG HIGHER SECONDARY SCHOOL STUDENTS

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ABSTRACT
The present study titled "Gender Differentiation in Social Emotional Competence among Higher Secondary School Students" aimed to examine and compare the various dimensions of Social Emotional Competence (SEC) among male and female students. Social Emotional Competence plays a vital role in adolescents' academic success, interpersonal relationships, and overall well-being. Grounded in the conceptual framework of Social and Emotional Learning proposed by Daniel Goleman and further elaborated by John D. Mayer and Peter Salovey, the study focused on five key dimensions: Self-Awareness, Social Awareness, Self-Management, Relationship Management, and Responsible Decision-Making. A descriptive survey method was employed, and the sample consisted of 50 higher secondary school students (both boys and girls) from Navi Mumbai, selected through convenience sampling. Data were collected using a standardized Social Emotional Competence Questionnaire adapted from Pawar, Sharma, and Kang (2019). The data were analysed using descriptive statistics (mean and standard deviation) and inferential statistics (independent samples t-test) at a 0.05 level of significance. The findings revealed no statistically significant gender differences in four dimensions—Self-Awareness, Social Awareness, Relationship Management, and Responsible Decision-Making. However, a significant difference was observed in the dimension of Self-Management, where male students scored higher than female students. The study concludes that gender does not substantially influence most dimensions of social emotional competence among the sampled students, except for Self-Management. The findings highlight the importance of strengthening emotional skills across genders to promote balanced socio-emotional development in Higher Secondary Education.

***Key words**: Social Emotional Competence, Gender Differences, Higher Secondary Students, Self-Awareness, Social Awareness, Self-Management, Relationship Management, Responsible Decision-Making, Emotional Intelligence, Adolescence.*

INTRODUCTION
Development of Social and Emotional competence is one of the important goals of Education. The aim of this study is to provide a comprehensive idea of the gender difference in the Social and Emotional competence among Higher Secondary School Students. This paper is based on the conceptual framework of the Social and Emotional Learning. Social competence, which encompasses the ability to interact effectively with peers, manage emotions, and resolve conflicts, plays a pivotal role in adolescents' success both in school and beyond. Emotional competence refers to the ability to identify, understand, express, and manage emotions in oneself and in others. During adolescence, particularly in higher secondary school (ages 16–18), students face emotional, social, and academic challenges that require high emotional competence. Gender plays a significant role in emotional development, often shaped by biological, psychological, and sociocultural influences. This study explores how male and female higher secondary students differ in emotional competence.

REVIEW OF RELATED LITERATURE
1. Jaya.R.(2022). Studied *"Socio-emotional Competence and Student Adjustment". Journal of Indian Education*. This study examined socio-emotional competence and students' adjustment during the COVID-19 pandemic in the The study involving 210 adolescents (ages 13–14) reported that many students faced inadequate social, emotional, and educational adjustment during the pandemic. Among the emotional competence dimensions, the ability to manage difficult emotions scored the lowest, highlighting the critical role of socio-emotional competence in students' psychological resilience and school adjustment. The results support the inclusion of socio-emotional learning interventions in school programmes, especially in crisis contexts.
2. Muthaiyan. R. (2022). Studied on *"Emotional Competence among the Higher Secondary Students"*. International Journal of Trend in Scientific Research and Development (IJTSRD). The study focused on the Emotional Competence among the higher secondary students." The study found that, female Students have high Emotional Competence when compared to Male students, there is no significant difference in mean scores of Emotional Competence with respect to Religion, there is no significant difference in mean scores of Emotional Competence with respect to Medium of Instruction, the Government School Students have

high Emotional Competence when compared to Private and Aided School students, there is no significant difference in mean scores of Emotional Competence with respect to Family type, there is no significant difference in mean scores of Emotional Competence with respect to Father's Occupation, and there is no significant difference in mean scores of Emotional Competence with respect to Mother's Occupation.

3. Piccerillo & Digennaro. (2025) .*Social Media Use and Emotional Intelligence***.** *Adolescent Research Review. This study aimed to* explore how social media use relates to emotional intelligence among adolescents. The review showed that emotional intelligence —the ability to perceive, regulate, and express emotions — is closely linked with how adolescents engage with social media, impacting socio-emotional development. The results suggested that lower levels of emotional intelligence are associated with increased problematic social media use among adolescents, with social media use showing a negative correlation with adolescents' self-esteem.
4. **Y.**Muhammad (2025). *Emotional Learning and Student Well-Being***.** *Scientific Reports* Study**.** This study Investigated emotional learning's impact on students' behaviour, resilience, and psychological well-being. Using structural equation modelling, they found that emotional learning contributes significantly to emotional intelligence, engagement, and resilience. This supports the idea that structured emotional learning environments promote socio-emotional competence along with improved behavior and well-being.

Aim: To examine and compare the different dimensions of Social Emotional Competence among Male and Female students.

OBJECTIVES:

1. To compare self-awareness between male and female students.
2. To compare Social Awareness between male and female students
3. To Compare Self-management between male and female students
4. To Compare Relationship Management between male and Female students
5. To Compare Responsible Decision Making between Male and Female Students.

HYPOTHESIS

1. There is no significant difference between Boys and Girls in Self Awareness.
2. There is no significant difference between Boys and Girls in Social Awareness
3. There is no significant difference between Boys and Girls in Social Awareness
4. There is no significant difference between Boys and Girls in Self- Management
5. There is no significant difference between Boys and Girls in Relationship Management
6. There is no significant difference between Boys and Girls in Responsible Decision Making

SCOPE

- The present study focuses on evaluating and comparing different dimensions of Social Emotional Competence between Girls and Boys.
- The Research consisted 50 Higher Secondary School Students both girls and boys from school in Navi Mumbai.
- The study used descriptive survey as the Method for collecting data .

LIMITATIONS

- The study included a limited number of samples for the study.
- The study used a convenience sampling not used random sampling.
- The study conducted on English Mediun students only and not Marathi and Hindi Medium

METHODOLOGY

The present research used a Descriptive Research design to compare and analyse different dimensions of Social Emotional Competence between Male and Female students at Higher Secondary level. The study used survey method to collect data from the students. The sample were 50 students including both boys and girls from School belongs to Navi Mumbai Area. The Sample was collected from convenience sampling techniques. A standardised **questionnaire** was used to assess various dimensions of **Social Emotional Competence** such as:

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- Self-Awareness
- Social Awareness
- Self-Management
- Relationship Management
- Responsible Decision-Making

Tools

1. Personal Data sheet
2. The Social Emotional Competence Questionnaire

(Adapted From Pawar, P,Sharma .S, Kang,T.(2019)

Procedure

- The researcher obtained permission from the school authorities before conducting the study.
- Participants were briefed on the purpose of the study and assured of confidentiality.
- Questionnaires were administered during school hours in a controlled setting to ensure uniformity in responses.
- Students completed the survey independently.

Data Analysis

The collected data were analysed using **descriptive and inferential statistical techniques**:

- **Descriptive statistics** (Mean and standard deviation) were used to summarize the data.
- An **independent samples t-test** was used to compare the mean scores of boys and girls across different dimensions of social-emotional competence.
- A **significance level of 0.05** was used to determine whether the observed differences were statistically significant

Testing of Hypothesis

1. There is no significant difference between Male and Female students in Self- Awareness

	Mean	SD	df	T-value	P-value
Male	15.8	6.67	48	1.45	P-0.1523 > 0.05
Female	14.84	4.22			

From the above analysis, it is found that P-value (0.1523) > 0.05, the result is not statistically significant. Therefore, we fail to reject the null hypothesis. At the 0.05 significance level, there is no significant difference in self-awareness between boys and girls

2. There is no significant difference between Male and Female students in Social Awareness

	Mean	SD	df	t-value	P-value
Male	13.2	5.66	48	-0.06	0.1523> 0.05
Female	13.24	4.44			

The P-value is more than the significance level, fail to reject the null hypothesis. There is no significant difference between boys and girls at 0.05 level of significance.

3. There is no significant difference between Male and Female students in Responsible Decision Making

	Mean	SD	df	T-value	P-value
Male	**15.2**	**6.67**	**48**	**1.25**	**0.2180 > 0.05**
Female	**14.36**	**4.67**			

As the P- Value is greater than the significance level of 0.05. it is fail to reject the null hypothesis .There is no significant difference between Girls and Boys in Responsible Decision Making .

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CONCLUSIONS

In four out of five emotional intelligence dimensions—Self-Awareness, Social Awareness, Relationship Management, and Responsible Decision Making—there is no statistically significant difference between male and female students. However, in the dimension of Self-Management, there is a statistically significant difference, with male students scoring higher on average than female students. This study suggests that **gender does not significantly impact most areas of socio-emotional competence** among the students sampled. The only domain showing a statistically significant difference is **Self-Management**, with male students scoring higher. This could indicate differences in how boys and girls are socialized to express or manage their emotions, or how they respond to stress and personal goals.

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The Social Emotional Competence Questionnaire

(Adapted From Pawar, P,Sharma .S, Kang,T.(2019)

Student Information

Name:

Grade:

Gender:

Item	Always	Frequently	Sometimes	Never
Self- Awareness				
I Know what I am thinking and Doing				
Understand why I do and what I do				
Understand my Moods and Feelings				
Know When I am Moody				
Can read people's Faces when they are angry				
Social Awareness				
Recognise how people feel by looking at their facial expressions				
It is easy to understand why people feel the way they do				
If someone is sad, Angry or Happy , I believe I know what they are thinking				
I understand why people react the way they do				
If a friend is upset, I have a pretty good idea Why.				
Self- Management				
I can stay calm in stressful situations				
I can overcome anxiety in new or changing situations				
I Stay calm when things go wrong				
I Can control the way I feel , when something bad happens				
When I am upset with someone, I will wait till I have calmed down before discussing the issue.				
Relationship Management				
I apologize when I hurt a friend unintentionally				
I always try and comfort my friends when they				

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are sad				
I try not to criticize a friend when they quarrel				
I tolerate my friend's mistake				
I stand up without putting others down				
Responsible Decision Making				
When making decisions, consider its consequences				
I ensure that there are more positive outcomes , when making a choice				
Consider the strength of the situation before deciding my action				
Consider the criteria chosen before making a recommendation				
Consider the strength and weakness of the strategy before deciding to use .				

The Social Emotional Competence Questionnaire (SECQ)

(Adapted from Panwar, P., Sharma, S., Kang, T. (2019).)

Students Information:

Name (optional): _____

Grade Level: _____

Age: ☐ 3-6 ☐ 7-10

Gender: ☐ Male ☐ Female

Think about how often your student show the behavior listed below. Using a scale of 1-5 rate the student behavior shown over the last six months.

Self-awareness	Never				Always
Know what they are thinking and doing.	1	2	3	4	5
Understand why they do and what they do.	1	2	3	4	5
Understand their moods and feelings.	1	2	3	4	5
Know when they are moody.	1	2	3	4	5
Can read people's faces when they are angry.	1	2	3	4	5
Social awareness	1	2	3	4	5
Recognize how people feel by looking at their facial expressions.	1	2	3	4	5
It is easy to understand why people feel the way they do.	1	2	3	4	5
If someone is sad, angry, or happy, I believe I know what they are thinking.	1	2	3	4	5
Understand why people react the way they do.	1	2	3	4	5
If a friend is upset, have a pretty good idea why.	1	2	3	4	5
Self-management	1	2	3	4	5
Can stay calm in stressful situations.	1	2	3	4	5
Can stay calm and overcome anxiety in new or changing situations.	1	2	3	4	5
Stay calm when things go wrong.	1	2	3	4	5
Can control the way I feel when something bad happens.	1	2	3	4	5
When I am upset with someone, I will wait till I have calmed down before discussing the issue.	1	2	3	4	5
Relationship Management	1	2	3	4	5
Will always apologize when they hurt a friend unintentionally.	1	2	3	4	5
Always try and comfort my friends when they are sad.	1	2	3	4	5
Try not to criticize a friend when they quarrel.	1	2	3	4	5
Tolerant of my friend's mistakes.	1	2	3	4	5
Stand up for themself without putting others down.	1	2	3	4	5
Responsible decision making	1	2	3	4	5
When making decisions, consider the consequences of my actions.	1	2	3	4	5
Ensure that there are more positive outcomes when making a choice.	1	2	3	4	5
Weigh the strengths of the situation before deciding on my action.	1	2	3	4	5
Consider the criteria chosen before making a recommendation.	1	2	3	4	5
Consider the strengths and weaknesses of the strategy before deciding to use.	1	2	3	4	5

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SUSTAIABILITY IN INTEGRATED ORGANIC SUPPLY CHAIN: A CASE STUDY PERSPECTIVE

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ABSTRACT

Purpose - *Smallholder organic farming is increasingly promoted as a sustainable alternative to traditional farming systems; however, its success is highly dependent on the effective and transparent integration of the supply chain among farmers, retailers, and consumers. In our country, the organic food sector has experienced continuous and fast growth over the last decade, with national estimates indicating that organic farmland and domestic market demand has continuously increased with improving urban health consciousness and export-oriented value chains (APEDA; IFOAM). Despite this market potential, small organic farmers face effective hurdles related to market access, price realization, post-harvest losses such as transportation,storage houses and market uncertainty, limited technological adoption, and weak institutional coordination. This calls for an empirical study on the expanding yet structurally constrained organic market, to assess sustainable small integrated supply chains in the current context.*

Methodology Approach-*Using a qualitative and comparative case study approach with convenience and snow ball sampling, primary data were collected through unstructured interviews with organic farmers, retail store owners, staff, and key stakeholders involved in the organic value chain. Secondary data was also used for the comparative study.*

Research limitations/implications-*The research reveals that farmers were strongly committed to environmental and social sustainability through the use of soil health management, biodiversity-based practices, and reduced use of chemical fertilizers. However economic sustainability remains a problem related to certification costs, fragmented market channels, and logistics inefficiencies. Retailers play an important mediating role in managing quality assurance, transparency, and consumer trust, but face problems related to operational challenges due to inconsistent supply, perishability, and limited cold-chain infrastructure. Consumer awareness and trust in organic certification have a significant influence on willingness to pay and demand stability, directly affecting the viability of the supply chain.*

Keywords: *Organic agriculture,Sustainable supply chain,Smallholder farmers,Social,Environment and Economic sustainability*

1. INTRODUCTION

The current world agricultural market is witnessing a critical paradigm shift towards sustainable growth, primarily driven by consumer awareness and global government agencies such as UNEP, World Food Program and others regarding health, food safety, and environmental preservation (**Ananthi & Arul** et al., 2017). In India, organic farming has evolved from a niche traditional practice into a rapidly growing commercial sector with immense prospects. According a report published in 2025 by **India Brand Equity foundation** highlighted, "India's organic market is booming, valued around $1.9 billion in 2024, driven by health awareness and government support, with future market size to reach over $10 billion by 2033-2035, fueled by strong export demand (especially to US/EU) and increasing domestic consumption, positioning India as a top global organic producer with massive growth potential".The demand for organic food products, driven by consumer awareness related to health consciousness, environmental sustainability, marketing and availability of products, presents substantial market potential for Indian producers (**Chandrakar et al., 2022**). However, converting this potential into visible benefits for primary producers and other stakeholders, particularly smallholders, is heavily dependent upon the efficiency of the supply chain. Unlike conventional systems, organic supply chains have different vulnerabilities due to the fast and transparent requirements for segregation, certification, and maintaining quality from farm to fork.

An analysis of the current organic sector reveals a stark dichotomy between high market potential and entrenched on-the-ground challenges. Small organic farmers consistently face numerous problems, including high initial costs of labour and organic inputs such as manure and bio pesticides, market access, price volatility, and lower yields during the transition period from conventional farming (**Chandrakar et al., 2022; Singh & Singh, 2016**). Additionally, complex certification processes, lack of transparency and accountability, and a lack of government subsidies and support for promoting organic farming lead to problems for all stakeholders,

compared to chemical-intensive farming, creating significant barriers to entry (**Balaji & Karpagam, 2023; Baka, 2024**). The supply chain itself is often characterised by severe infrastructural deficits, such as a lack of cold storage and warehousing facilities, resulting in post-harvest losses (**Gupta & Kumar, 2022**). Additionally, the presence of multiple intermediaries in traditional supply chains dilutes the premium price intended for farmers, while inflating costs for consumers.

While extensive research exists on the challenges of organic farming in broader Indian contexts, such as Tamil Nadu and Sikkim (**Balaji & Karpagam, 2023**), a significant research gap remains in understanding how small-scale supply chains function in localised, small market size and small stakeholders in unique administrative regions, like the **Union Territory of Pondicherry**. Findings highlight that the organic vegetable supply chain in Puducherry often still relies on traditional routes, which involve local markets, wholesale markets, and direct farm-to-gate sales.

This case study focus to bridge this gap by synthesizing existing findings regarding producer constraints and market access problems to provide a focused analysis of the Pondicherry reality. By mapping current logistical structures and identifying regional bottlenecks, this study evaluates potential future pathways to streamline operations for a more resilient local organic ecosystem.

2. LITERATURE REVIEW

This literature review highlights the key themes, challenges, and proposed solutions within the discourse on small-scale organic agricultural supply chains. The findings initiative is structured around the imperatives of social, economic, and environmental sustainability, the operational and economic challenges faced by small farmers, retailers and consumers and the critical role of technology and governance.

2.1 The Imperative for Sustainable and Resilient small Supply Chains

The contemporary global food industry increasingly demands resilient supply chain management (SCM) as a strategy to gain and maintain competitiveness, even for small enterprises (**Rayesa, 2022**). This demand is catalyze in the organic sector, which has seen a significant goes up, particularly following events that heightened health consciousness and accelerated the need for sustainable development (**Josee & Kavitha M, 2025**). However, a major challenge lies in the evolution of supply networks from simple regional systems to complex, international networks, which introduces vulnerability and instability, especially for the flow of food products (**Mardenli et al., 2023**). Therefore, the literature emphasizes that effective Agribusiness Supply Chain Management Practices (ASCMP) must be help in key determinants like supply chain integration, information technology (IT) implementation, and a robust commitment to sustainability (**Mekonnen et al., 2023**). Achieving **sustainable agricultural supply chain management** requires a strategic ,ethical and accountable roadmap focused on efficiency and transparency to fully harness agricultural potential (**Elahi et al., 2023**).

2.2 Operational Constraints and Farmer Welfare

In the Indian context, the performance of the agricultural supply chain is often hindered by **fragmentation** and scale-of-economy issues, which disproportionately affect marginal and small farmers in diffrent region (**S. Arjune & Kumar et al., 2022**). The problems faced by these farmers are multifaceted and longitudinal, occurring across the production, supply chain, processing, and marketing stages (**S. Arjune & Kumar et al.,2022**). Operationally, managing perishable organic crops, such as fruits and vegetables, necessitates the development of integrated models for production, cold storage, and distribution networks, with the primary objective of maximizing farm revenue ,accessibility,and reducing farm costs (**Bhatia & Janardhana, 2020**). Crucially, post-harvest losses such as transportation, market access, price volatility, other demand side constraints and inadequate storage infrastructure remain major problems that erode profitability (**Bhatia & Janardhana, 2020; S. Arjune & Kumar, 2022**).

Regional case studies further illuminate these issues. An analysis of small organic enterprises noted pervasive problems, including a lack of **traceability** for organic inputs, unstable production patterns, and a limited served market (**Rayesa, 2022**). Studies on rice supply chains in the southern region of Tamil Nadu, in unique and specific agroecosystems, highlight the inadequacy, costliness, complexity, and inefficiency of one-size-fits-all solutions (**Bunsong et al., 2019)**. Economically, the prevalence of intermediaries and traditional market highlight a historical constraint in many agricultural economies—dilutes the economic benefit at the bottom level, increases the cost of production and acts as a significant barrier to **farmer welfare** (**Elahi et al., 2023**).

2.3 Technology, Traceability, and Governance

To address these chronic vulnerabilities, the literature points toward the strategic adoption of **technological inputs**. Research strongly highlights the importance of the integration of **Industry 4.0 tools** to enhance tractability, accountability, transparency and reliability in agricultural supply chain operations, for instance, by

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supporting methodologies like Lean Six Sigma to minimise long lead times and improve product quality (**Yeni et al., 202**4). These advanced and cost-effective tools help to solve real-time problems faced by farmers, retailers and consumers at different stages of the product life cycle. A fundamental implementation of IT is a prerequisite for effective and sustainable ASCMP, enabling better information flow and coordination (**Mekonnen et al., 2023**).

Crucially, the success of technological adoption and the promotion of **sustainable agricultural practices** are inextricably linked to the **governance structure** of the supply chain. Specifically, the type of relationship between farmers and buyers, particularly the use of formal versus informal contracts, significantly impacts the farmers' willingness and ability to adopt sustainable methods (**Benitez-Altuna et al.,2022**). Therefore, an important focus for future research involves exploring these contractual forms, such as FPO leads contract farming, cooperative farming and scientific farming to ensure equitable value distribution and to foster higher farmer welfare within small-scale organic supply chains (**Benitez-Altuna et al.,2022.**). The challenge for localised organic systems, like the one examined in this case study, is the integrated application of sustainable principles, technological solutions, and robust governance to create a resilient, transparent and equitable agriecosystem.

3. RESEARCH OBJECTIVES

The three research objectives for a qualitative study on the small organic supply chain in Pondicherry, incorporating the themes of **sustainability**, **technological inputs**, and **farmer welfare**, based on the analysis of the literature and research gaps, are:

1. To analyze the extent to which current organic farming practices,technological, governance model and supply chain structures contribute **to environmental and economic sustainability** (e.g., resource efficiency, reduced post-harvest losses, and climate resilience) within the Pondicherry region .
2. To identify and evaluate the perceived impact and barriers associated with the adoption of **technological inputs** and digital tools accessibility (e.g., farm-level precision technologies, traceability systems, and digital market linkages) by small organic farmers and different supply chain actors in Pondicherry.
3. To explore the relationship between the structure of farmer-buyer relationships (formal vs. informal) and existing government schemes/policies, and their collective impact on **farmer welfare** and the equitable distribution of profit margins along the small organic supply chain in Pondicherry.

4. RESEARCH METHODOLOGY

This research methodology is designed for a qualitative and comparative case study in Pondicherry with focus on gaining deep, contextual and region specific understanding of the small organic supply chain, and the challenges faced by different stakeholders, the role of technological inputs in increase output and promote sustainbility, and impacts on farmer welfare, aligning with the established research objectives.

4.1. Research Design: Comparative case Study Approach

The study will employ two different case study design focusing on the organic vegetable supply chain within the specific geographic boundary of Pondicherry and southern Tamilnadu. This design is appropriate because it allows for an in-depth exploration of a contemporary phenomenon (small organic supply chains) within its real-life context, which is crucial for understanding location-specific challenges as noted in the literature **(Bunsong et al., 2019)**.

Units of Analysis: The small organic vegetable supply chain units in Pondicherry and southern Tamilnadu, specifically focusing on the flow of produce from selected organic farms to final consumers.

4.2. Sampling Strategy: Purposive and Snowball Sampling

A purposive and snow boll, criterion-based sampling method will be used to select participants who possess deep knowledge and experience related to the organic supply chain in Pondicherry. This approach ensures that the sample directly addresses the research objectives.

This research study used purposive sampling, supported by snowball sampling for this qualitative research, to recruit key stakeholders in the organic supply chain. The sample size included organic farmers **(n=6)** who were certified or in conversion and selling through multiple channels such as retailer,direct sales or in wholesale markets, retailers/buyers **(n=2)** from organic stores and local vendors, and key informants **(n=5)** from government, FPOs, consumer and certification bodies.

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4.3. Data Collection Methods: In-Depth Interviews

The primary data collection method would be semi-structured, in-depth interviews to capture rich and clear, narrative data that explains the *how* and *why* behind observed phenomena (**Benitez-Altuna et al., 2022).** The interviews will be conducted face-to-face, digitally recorded (with consent), and transcribed verbatim from YouTube videos related to small organic supply chains through the use of AI research tools.

Interview Guides: Separate guides will be developed for each stakeholder group (Farmers, Retailers, Key Informants) based on the 20 qualitative research questions.

Farmers: Focus will be on the adoption of technological inputs, challenges related to soil sustainability/yield, post-harvest losses, and the impact of price realisation on farmer welfare.

Retailers: Focus will be on sourcing issues, traceability concerns, logistics, and consumer behaviour/pricing.

Key Informants: Focus will be on government policies, available subsidies, and infrastructural or technological gaps in the region.

5. RESEARCH FINDINGS

The research findings of this study are based on inputs collected from farmers, retailers and consumers. This research provides a comprehensive understanding of how integrated small organic agricultural supply chains function in practice and how sustainability outcomes are shaped by interactions among farmers, retailers, and consumers. The analysis of collected data reveals that sustainability performance outcomes across the supply chain is uneven and fragmanted, with strong environmental outcomes, moderate social equity outcomes, and relatively weak and uneven economic outcomes, primarily due to structural, uneven government policies in different region of country and operational constraints.

5.1 Environment Sustainability

To understand environmental awareness among different stakeholders, such as farmers, retailers, and consumers, we asked the questions listed below and used the findings to inform our analysis.

1. How do you maintain soil fertility and manage crop health (including pest and disease control) without using chemical fertilizer and other synthetic inputs, and what long-term impacts do they observe on yield stability and farm resilience? **(farmers)**
2. What trade-offs do farmers face in managing energy consumption (irrigation, mechanization, fuel use), and how do they choose between energy-intensive operations and low-input sustainable alternatives? **(farmers)**
3. What operational challenges do you face in handling perishable organic products, including inventory accuracy, stock rotation, spoilage reduction, and store efficiency, and what strategy do you used to maintain environment sustainability? **(retailer)**
4. How do you evaluate whether products are genuinely organic or not, and to what extent do environmental motivations influence their willingness to purchase organic products consistently?(**Consumers**)

The research finds that **environmental sustainability is the most established dimension** of the integrated organic supply chain. Small organic farmers demonstrate a strong commitment to ecologically sustainable practices, including soil health management, biodiversity-based farming, reduced chemical input usage, and reliance on organic manure and bio-inputs. These practices help to contribute positively to long-term environmental resilience and sustainability. This aligned closely with sustainability goals promoted by national and international agencies. However, while environmental benefits are evident at the farm level, they are not always translated into proportional economic rewards for farmers.(Figure 1)

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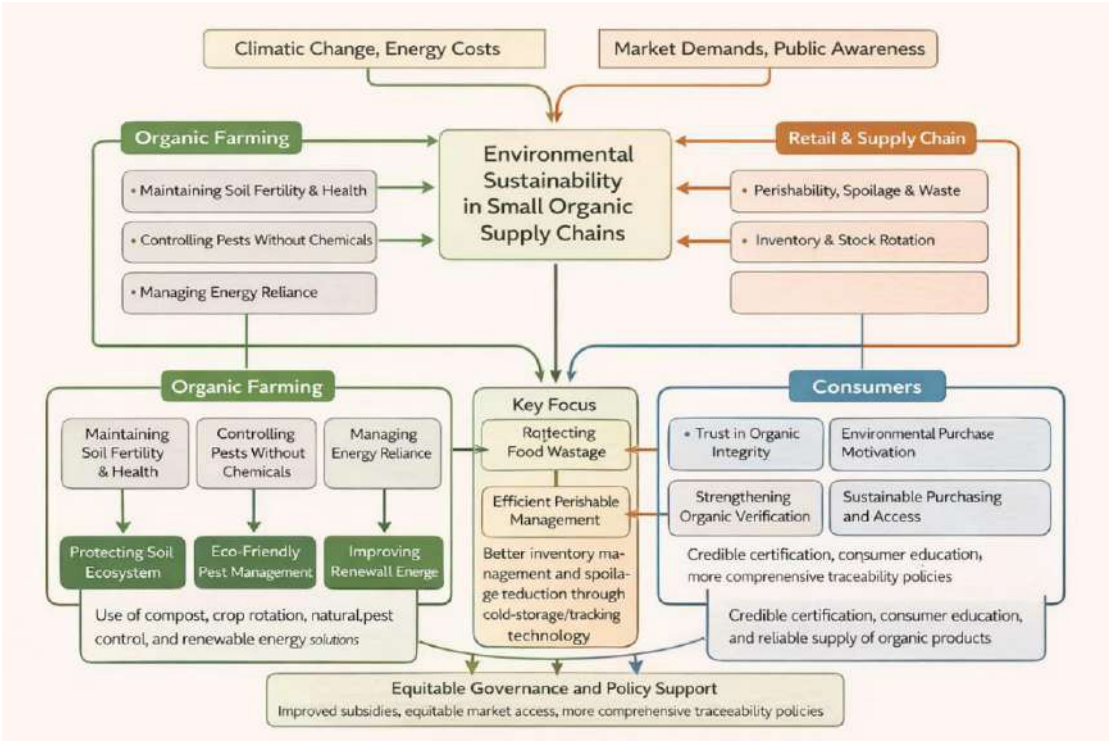

Figure 1

5.2 Economic Sustainability

We asked the questions from farmers related to economic sustainability, such as "1. How do you manage production costs (organic inputs, labour, certification, and conversion losses), and what economic challenges affect their profitability and long-term income stability? 2. What barriers do you face in accessing markets and receiving fair prices, and how do intermediaries, delayed payments, or uncertain demand influence their economic sustainability? "From retailers, "How do you manage procurement costs, supply inconsistency, storage losses, and pricing decisions for organic products, and how do these factors affect profitability and business continuity?"From consumer, "How do you evaluate price–value trade-offs for organic products, and to what extent do price sensitivity, willingness to pay, and perceived quality influence purchase consistency and demand stability?"

The data findings highlighted that **economic sustainability remains the most critical and complex challenge at the farmer and retailer level because of fragmented supply chain**. Despite increasing the market size and consumer demand for organic products and premium pricing at the retail level, farmers face persistent difficulties related to high certification costs, fragmented market access, post-harvest losses pertaining to storage and information on market access, and logistics inefficiencies. Inadequate and uneven cold-storage infrastructure and storage facilities significantly increase spoilage risks and uncertainty in supply chain, directly affecting farmer income and increase the risk to meet continuous demand of market. As a result, the value captured by farmers is disproportionately low compared to downstream actors, revealing a structural imbalance within the supply chain.(Figure 2)

The data analysis highlights that **retailers play the most crucial and important integrative role** within the small organic supply chain. Retailers act as coordinators of aggregation, quality control checks, certification communication and informers to farmers, pricing discovery, and consumer engagement. They serve as the primary interface through which information flows between producers and consumers. However, this central role of retailer also concentrates decision-making power at the retail level, often limiting and undermine farmers' bargaining capacity, role in price discovery and demand planning of organic products.(Figure 2)

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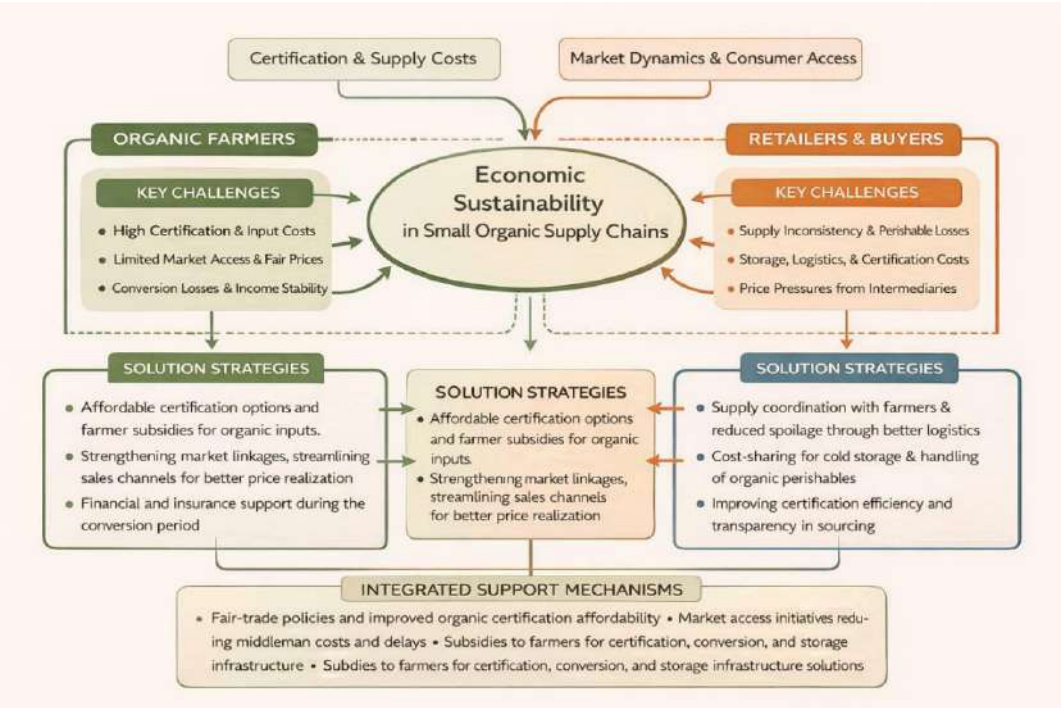

Figure 2

5.3 Social Sustainability

We asked the question from farmers related to their social sustainability,"How does participation in organic farming influence farmers' livelihoods, social well-being, and long-term security, and what social challenges (labour availability, knowledge gaps, community support) affect their ability to sustain organic practices? From retailer."How do you build consumer trust and maintain responsibility (fair pricing, transparent communication, quality assurance), and what social responsibilities or operational barriers affect their relationship with farmers and consumers?"

The findings highlight moderate positive outcomes, including improved consumer awareness of food safety, local employment generation,community-level engagement, government subsidies to farmers and MSP for some products. Nevertheless, the absence of formalized contracts, lack of information and other input related to national and global market demand, fair wage standards for agricultural labour and retailer staff, and long-term income security mechanisms constrain broader social welfare improvements, particularly for smallholder farmers.

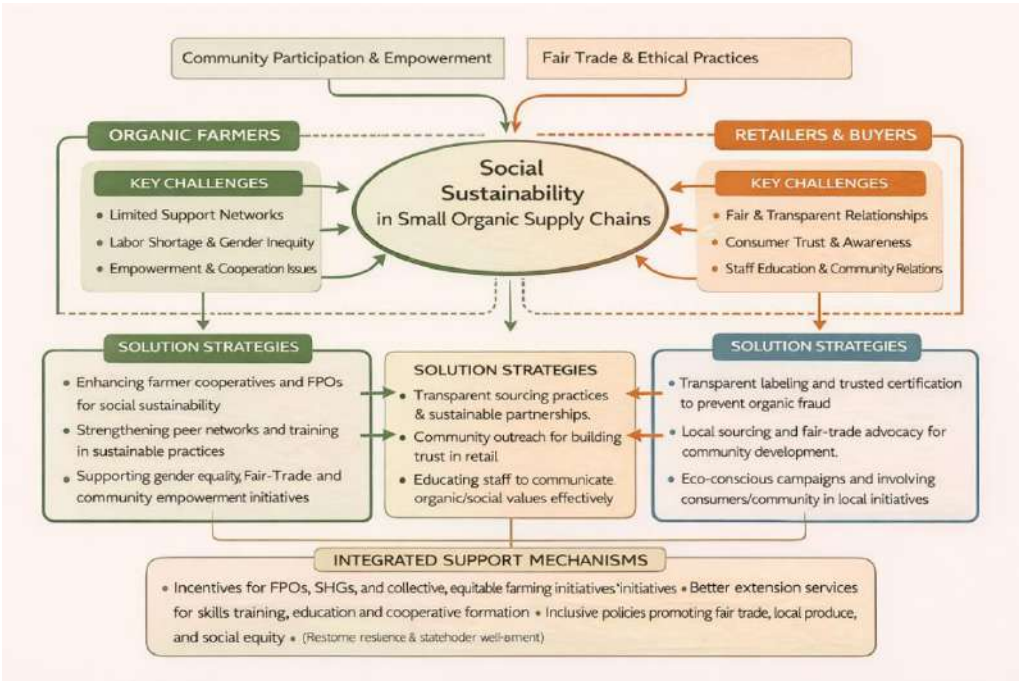

Figure 3

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Finally, the research revealed that **technology and tractability systems enhance transparency and trust**, but their benefits are unevenly distributed because of a lack of farmers' awareness and a lack of skills related to accessing information in real-time. Block chain-based tractability, data analytic, and IoT-enabled monitoring strengthen quality assurance and consumer confidence; however, access to these technologies remains largely retailer-concentric. Without inclusive governance frameworks, technological adoption risks reinforcing existing power asymmetries rather than promoting equitable integration.

Overall, the findings confirm that **supply chain integration acts as a critical mediating factor for overall environmental, social and economic sustainability by** linking sustainable production practices to farmer welfare and consumer trust. Effective communication, information sharing, and coordinated governance are essential for transforming environmentally sustainable farming into economically and socially resilient supply chains (Figure 4).

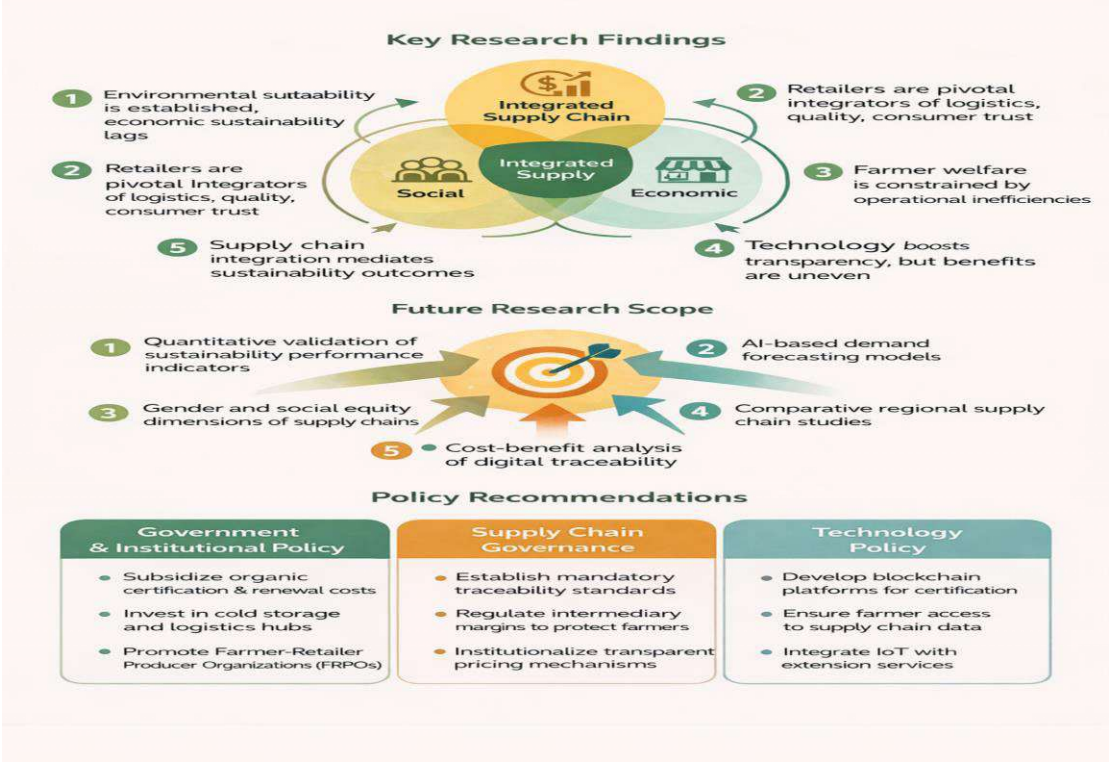

Figure 4

6. RESULTS AND DISCUSSION

The results of this research highlighted that the current small organic agricultural supply chain spread uneven and fragmented sustainability performance across the levels of farmers, retailers, and consumers. This research aligned with the Triple Bottom Line (TBL) framework (pro-planet, pro-people, and pro-profit), environmental sustainability emerges as the strongest dimension due to the increased risk of climate change, which affects health, profit, and soil fertility. At the same time, economic and social outcomes remain comparatively constrained. Farmers demonstrate a strong ecological commitment through organic soil management, utilizing organic fertilizers, minimizing the use of pesticides and insecticides, adopting biodiversity-based practices, and reducing chemical input usage. These research findings highlighted the environmental pillar (Pro-planet) of TBL of whole supply chain is key concern at all level, but also indicate that ecological responsibility alone does not ensure economic viability within smallholder supply chains.

At the farm level, income instability persists due to high pre-harvesting costs related to soil management, seed, and climate change, which significantly impact yields and increase production costs. Farmers also faced problems related to high certification costs and pests. From a supply chain integration perspective, these problems highlighted weak upstream integration and concentration of power related to the price discovery of their products in few hands, where farmers remain poorly connected to market information, pricing mechanisms, and demand forecasts. Although organic produce commands premium prices at the retail level, the profit by farmers remains limited, leading to economic and social sustainability issues and inefficiencies in value transmission across the supply chain. This aligns with supply chain integration theory, which emphasizes that partial or asymmetric integration reduces overall performance and weakens benefits for primary producers, as well as the overall sustainability and efficiency of the agri-organic market.

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Retailers had emerged as the central coordinating actors within the small organic supply chain. They aggregate produce, manage storage and cold-chain logistics, ensure quality compliance, and communicate certification standards to different stakeholders, which leads to an oligarchy system. This integrative role improves operational efficiency and enhances consumer trust; however, it also concentrates decision-making power downstream. Farmers had limited participation in price negotiations, access to information, and demand planning, which leads to unsustainable agricultural practices, including inadequate soil health management, the use of low-quality seeds, mono-cropping, and restricted access to information. Institutionally, this reflects an imbalance in compliance capacity and a weakness in the supply chain. In small organic supply chains, retailers had attained better authority to respond to regulatory and market pressures related to certification, traceability, and quality assurance, which can lead to a concentration of profit in a few hands.

Consumer behaviour further influences supply chain outcomes. The data highlighted an increasing demand for organic products. They sustainable produce food, helping to increase the role of organic products in the health, cosmetic, and food industries, driven by growing health awareness and environmental concerns. Consumers' willingness to pay premium prices supports market growth.But still, the absence of a transparent pricing mechanism and real-time feedback mechanisms limits the transmission of consumer value back to farmers. This disconnects nodes and undermines the critical role of integrating relational aspects between supply and demand factors, as well as informational elements, to achieve social, environmental, and economic sustainability.

Technology plays a critical and essential enabling role in bridging these information,infrastructure and market access gaps at all level. Block chain and AI-based traceability, data sharing, and IoT-enabled monitoring enhance transparency, accountability, and information flow throughout the supply chain, thereby improving overall efficiency and operational efficiency. This helps reduce risk related to soil health management, discover the best seeds and pricing mechanisms, and provides real-time access to weather and demand data. However, technological adoption remains uneven because of financial and skill constraints at the farmer level. Retailers have greater access at the retail level than at the farm level. Without inclusive governance arrangements and policies, digital tools risk enhance existing power asymmetries rather than promoting equitable integration in supply chain.

Overall, research results highlighted that overall sustainability in small organic supply chains is not solely a function of environmentally responsible production, but of **effective integration, transparent communication, and institutional support**. Aligning environmental, economic, and social objectives requires coordinated governance framework that ensure and create accountability at farmers,retailer and consumer level as they are active participants in information exchange, value creation, and decision-making processes (Figure 5).

Figure 5

7. POLICY RECOMMENDATION FRAMEWORK

The practical sustainability of integrated small organic supply chains had required coordinated policy interventions at the all level of supply chain. At the **farmer level**, policies should focus on reducing economic vulnerability and enhancing participation in market-oriented supply chains. Subsidized organic certification and transition costs in real time through the use of digital platforms had provided risk insurance,information access, and facilitating access to low-interest credit through formal channels can help stabilize farm incomes and social sustainability. Strengthening extension services at farmer level with includes post-harvest management, digital literacy,soil health information, and market intelligence will further empower farmers and improve upstream integration.

At the **supply chain and market levels**, investment in decentralized cold storage, access to low-interest-rate loans through formal channels such as banks and NBFCs, creation of aggregation centers, FPOs, and last-mile

logistics is essential to reduce post-harvest losses and operational inefficiencies. Formalized contracting arrangements between farmers and retailers, along with the promotion of Farmer–Retailer Producer Organizations, can enhance transparency, accountability, improve bargaining power, and promote equitable distribution of economic value at all level. Policies should also mandate interoperable digital traceability systems to ensure that information flows are accessible to all stakeholders.

At the **institutional level**, standardization of the organic certification process, direct access of e-commerce platforms such as e-NAM and ONDC to farmers. The development of integrated national traceability platforms can reduce compliance complexity and promote ease of doing business as an integrated market place .This help to strengthen consumer trust. Sustainability-oriented public procurement policies, including the sourcing of organic produce for public food programs, can provide stable demand and price assurance, thereby supporting the growth of organic agriculture. Collectively, these multilevel interventions align with environmental , economic resilience and social welfare objectives, will enable inclusive development, transparent, and resilient small organic agricultural supply chains (Figure 4).

8. CONCLUSION

This research study concluded that sustainable small organic supply chains require more than environmentally responsible farming practices; they depend on effective supply chain integration, transparent governance, supportive and inclusive policy frameworks. Although farmers have strong ecological commitment, but economic and social sustainability remain major problems due to operational inefficiencies, market access limitations, and unequal value distribution. Retailers play a key coordinating role, but inclusive governance is necessary to balance power and ensure fair outcomes. Technology can help bring transparency, accountability, and trust, but its impact depends on equitable access to tools,skills, information, and institutional support. A real time multilevel , integrated policy framework is very important for building resilient, inclusive, and sustainable organic supply chains that enhance farmer welfare and consumer confidence.

9. FUTURE RESEARCH SCOPE

Future research may focus on quantitative validation of sustainability outcomes. AI and ANN-based soil health management,yield prediction,price forecasting,weather forecasting ,crop management , demand forecasting models, and cost–benefit analysis of digital traceability for smallholders. Comparative regional studies and investigations into social equity, gender inclusion, and governance mechanisms would further strengthen the understanding of sustainable small organic supply chains(Figure 1).

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ROLE OF DIGITAL TOOLS AND DATA ANALYTICS IN STRENGTHENING POLICY-ORIENTED INTERDISCIPLINARY RESEARCH IN SOCIAL SCIENCES

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ABSTRACT
The rapid expansion of digital technologies and analytical tools has brought a major shift in the way social science research is conducted. Conventional qualitative and quantitative approaches are now supported by computational techniques that allow scholars to manage large volumes of data, connect insights from multiple disciplines, and generate reliable evidence for policymaking. This study explores how digital tools and data analytics strengthen interdisciplinary research in social sciences and improve its contribution to public policy formulation. The study relies on secondary data obtained from government sources, research publications, and international development reports. Descriptive and statistical methods have been applied for analysis. The results indicate that digital tools enhance research efficiency, ensure higher data accuracy, promote collaboration among disciplines, and increase the policy relevance of research outputs.

Keywords: *Digital Tools, Data Analytics, Interdisciplinary Research, Social Sciences, Public Policy*

1. INTRODUCTION
In contemporary societies, social problems have become increasingly complex, multidimensional, and interconnected. Issues such as poverty, public health, education inequality, unemployment, and urbanization cannot be fully understood through the lens of a single discipline. These challenges require insights drawn from economics, sociology, political science, public administration, and increasingly, data science. As a result, interdisciplinary research has gained prominence as an essential approach in social sciences, particularly for generating knowledge that can inform public policy (Kumar, 2021). Interdisciplinary research allows scholars to integrate theories, concepts, and methods from different fields to develop a more comprehensive understanding of social realities and policy outcomes.

At the same time, rapid advancements in digital technologies have transformed the nature of research itself. The emergence of digital tools such as online databases, statistical software, geographic information systems (GIS), and automated data collection platforms has expanded the capacity of social scientists to gather, manage, and analyze large volumes of information. According to Smith (2020), the growth of big data and computational methods has reshaped empirical research by enabling the analysis of patterns and relationships that were previously difficult to detect using conventional techniques. This technological shift has enhanced both the scope and speed of social science research, making it more responsive to policy needs.

Digital tools have also facilitated greater access to secondary data sources. Government portals, international development databases, and digital survey platforms provide researchers with continuous streams of social, economic, and demographic information. Brown (2018) notes that open-access data initiatives have democratized research by reducing dependence on costly primary data collection and enabling scholars from diverse institutional backgrounds to engage in policy-oriented studies. These developments have strengthened the empirical foundation of interdisciplinary research and supported evidence-based policymaking.

Data analytics, as a core component of digital research, plays a critical role in translating raw data into meaningful policy insights. Through techniques such as statistical modeling, trend analysis, and predictive analytics, researchers can evaluate the effectiveness of public programs, monitor social indicators, and assess future risks. The World Bank emphasizes that data-driven approaches enhance governance by improving transparency, accountability, and efficiency in public decision-making (World Bank, 2022). By providing systematic evidence, data analytics bridges the gap between academic research and practical policy formulation.

Policy-oriented research particularly benefits from interdisciplinary and data-driven approaches because policymaking operates at the intersection of social behavior, economic constraints, and institutional frameworks. Anderson (2022) argues that digital research environments encourage collaboration among scholars from different disciplines by offering shared platforms for data storage, analysis, and visualization. Such collaboration enables a more holistic assessment of policy problems and reduces fragmentation in research outputs. For example, health policy research now commonly integrates public health data, economic cost analysis, and sociological insights to design and evaluate interventions (Lee & Chen, 2020).

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Education and labor market policies similarly rely on digital datasets and analytical tools to guide reforms. UNESCO (2021) reports that digital education databases assist in tracking enrollment, learning outcomes, and equity indicators, thereby informing national education strategies. In labor market studies, the integration of administrative records and survey data allows researchers to identify employment trends and skill gaps, contributing to targeted workforce policies (Davis, 2019). These applications demonstrate how digital tools and data analytics enhance the policy relevance of interdisciplinary social science research.

Despite these advancements, scholars caution that digitalization alone does not guarantee better research outcomes. Williams (2018) emphasizes that qualitative understanding remains essential for interpreting social contexts and human experiences that cannot be fully captured through numerical data. Ethical issues related to privacy, consent, and algorithmic bias also pose challenges for data-driven research (Green & Hall, 2020). Therefore, the effective use of digital tools requires both technical competence and ethical responsibility.

International policy institutions have increasingly highlighted the strategic importance of data analytics for governance and development. The OECD argues that evidence-based policymaking improves policy design and crisis response by enabling governments to test assumptions and measure impacts systematically (OECD, 2021). Similarly, the UNDP stresses the need to strengthen analytical capacity within research and policy institutions to achieve sustainable development goals (UNDP, 2023). These perspectives reinforce the growing consensus that digital tools and interdisciplinary research are essential for modern policymaking.

Although a substantial body of literature exists on digital methods and interdisciplinary approaches separately, fewer studies focus on their combined role in strengthening policy-oriented social science research. Much of the existing work either emphasizes technological innovation or discusses interdisciplinary theory without explicitly linking these developments to policymaking processes. This gap highlights the need for systematic examination of how digital tools and data analytics jointly support interdisciplinary research and enhance its contribution to public policy formulation.

Against this background, the present study seeks to explore the role of digital tools and data analytics in strengthening policy-oriented interdisciplinary research in social sciences. By examining trends in secondary data usage and analytical practices, the study aims to demonstrate how technological integration improves research efficiency, accuracy, and policy relevance. Understanding this relationship is crucial for research institutions, policymakers, and academic communities seeking to improve the quality and impact of social science research in the digital age.

2. REVIEW OF LITERATURE

The increasing complexity of social and economic problems has led scholars to emphasize the importance of interdisciplinary research in social sciences. Issues such as poverty, health inequality, unemployment, and urban governance involve interrelated economic, political, and social dimensions that cannot be adequately addressed through a single disciplinary lens. Kumar (2021) argues that interdisciplinary research improves the quality of policy analysis by integrating theories and methods from economics, sociology, political science, and public administration. This integrative approach enhances the explanatory power of research and makes findings more relevant to real-world policy challenges.

The emergence of digital technologies has significantly transformed research practices in social sciences. Smith (2020) notes that big data and computational tools have expanded the scope of empirical research by enabling scholars to process large and complex datasets. Traditional qualitative and survey-based methods are increasingly complemented by administrative data, digital records, and online databases. These developments have improved the precision and scale of social analysis and strengthened its contribution to evidence-based policymaking.

Digital platforms have also facilitated collaboration across disciplines. Anderson (2022) observes that digital research environments allow scholars from different fields to share datasets, analytical models, and findings more efficiently. Such collaboration reduces disciplinary fragmentation and supports integrated approaches to policy research. This is particularly important in areas such as public health, education, and urban planning, where policy outcomes depend on social, economic, and institutional factors working together.

The role of data analytics in public policy research has gained growing recognition. Development agencies emphasize that data-driven approaches enable governments to monitor social indicators, evaluate policy outcomes, and design targeted interventions. The World Bank highlights that the systematic use of large-scale datasets improves governance by increasing transparency and accountability in public programs (World Bank, 2022). Data analytics thus strengthens the link between academic research and practical decision-making.

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Secondary data has become a central resource for interdisciplinary policy research. Brown (2018) explains that open-access data initiatives and national statistical systems have made high-quality datasets widely available to researchers. Census records, labor force surveys, and health and education databases allow scholars to conduct longitudinal and comparative studies without the high costs of primary data collection. This shift has expanded opportunities for research in developing as well as developed countries.

Health and education sectors demonstrate extensive use of digital tools and analytics. Lee and Chen (2020) show that health policy research increasingly relies on electronic health records and survey data to assess program effectiveness and population outcomes. Similarly, UNESCO (2021) reports that digital education databases support the evaluation of enrollment trends, learning outcomes, and inequalities in access. These applications illustrate how digital tools directly contribute to policy formulation and reform.

Urban planning and labor market studies have also benefited from analytical innovations. Taylor (2020) finds that geographic information systems (GIS) and spatial analytics help identify infrastructure gaps and population distribution patterns, which are crucial for urban policy decisions. Davis (2019) argues that labor market analytics derived from administrative and survey data enable policymakers to understand employment trends and skill mismatches, thereby supporting more responsive employment policies.

Despite these benefits, scholars caution against excessive dependence on quantitative techniques. Williams (2018) emphasizes that qualitative approaches remain essential for interpreting social realities, institutional contexts, and human experiences. Digital tools should therefore complement rather than replace traditional research methods. Ethical concerns related to privacy, consent, and algorithmic bias have also emerged as important issues in data-driven research (Green & Hall, 2020).

International policy institutions increasingly promote the use of data analytics in governance. The OECD argues that evidence-based policymaking improves policy innovation and crisis response by enabling governments to test assumptions and measure outcomes systematically (OECD, 2021). Likewise, the UNDP stresses that strengthening analytical capacity among researchers and policymakers is essential for achieving sustainable development goals (UNDP, 2023).

Although substantial literature exists on digital tools, data analytics, and interdisciplinary research separately, relatively few studies examine their combined role in policy-oriented social science research. Most research focuses either on methodological advancements or on interdisciplinary theory without directly linking these developments to policymaking processes. This gap suggests the need for integrated studies that explore how digital tools and data analytics jointly enhance interdisciplinary research and improve its relevance for public policy formulation.

3. OBJECTIVES OF THE STUDY

1. To examine the role of digital tools in interdisciplinary social science research.
2. To analyze the contribution of data analytics to policy-oriented research.
3. To study emerging trends in the use of secondary social data.
4. To suggest policy-related implications for research institutions.

4. RESEARCH QUESTIONS

1. In what ways do digital tools facilitate interdisciplinary research?
2. How does data analytics strengthen policy-focused social science studies?
3. What patterns are visible in the use of secondary data for policy research?

5. RESEARCH METHODOLOGY

The present study adopts a descriptive and analytical research design to examine the role of digital tools and data analytics in strengthening policy-oriented interdisciplinary research in social sciences. A descriptive approach is used to outline existing patterns and trends in the use of digital tools, while an analytical approach is employed to interpret how these tools contribute to interdisciplinary integration and policy relevance. This combined design allows the study to move beyond mere description and provide meaningful insights into the relationship between digital technologies and policy-focused research (Kothari, 2019).

Nature and Sources of Data

The study is based entirely on secondary data. Secondary data refers to information that has already been collected and published by recognized institutions for purposes other than the current research. The choice of secondary data is appropriate because the subject under investigation—digital tools, data analytics, and policy

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research—relies heavily on large-scale datasets, official statistics, and previously documented research findings. According to Saunders et al. (2019), secondary data is particularly useful for studies that aim to analyze broad trends and policy-level outcomes, as it provides reliable and standardized information over extended periods.

Data for the present study has been collected from the following major sources:

1. Government publications such as national statistical reports, economic surveys, and census documents.
2. International development reports issued by organizations such as the World Bank and the UNDP.
3. Research articles published in peer-reviewed journals related to social sciences, public policy, and data analytics.
4. Online databases containing social and economic indicators, including labor force data, education statistics, and health-related datasets.
5. Policy documents and evaluation reports released by public institutions and research organizations.

These sources were selected because they provide credible, systematically collected, and up-to-date information that is relevant to the objectives of the study.

Secondary data was collected through a structured review of published literature and digital databases. Official websites of government departments and international organizations were accessed to obtain statistical tables, policy indicators, and analytical reports. Academic databases such as Google Scholar and institutional repositories were used to identify research papers related to digital tools, data analytics, and interdisciplinary policy research. Only those sources that were published by recognized institutions or appeared in peer-reviewed outlets were included in the study to ensure data reliability and validity (Bryman, 2016).

To avoid duplication and ensure consistency, data from different sources were cross-verified wherever possible. For example, employment or education indicators obtained from national sources were compared with international datasets to identify convergence or variation in reported trends. This process of triangulation enhances the credibility of findings and minimizes the risk of bias arising from a single source (Creswell, 2018).

Tools and Techniques of Analysis

The collected data was analyzed using both descriptive and comparative techniques. Percentage analysis was used to identify growth patterns in the use of digital tools across different years and policy sectors. Tabular and graphical representations were employed to present data in a clear and interpretable form. Comparative analysis was applied to examine differences in the adoption of data analytics across policy domains such as health, education, employment, and urban planning.

Content analysis was also used for qualitative interpretation of policy reports and research articles. This involved identifying recurring themes related to interdisciplinary collaboration, digital innovation, and evidence-based policymaking. Such thematic analysis helped in linking numerical trends with conceptual insights from the literature (Krippendorff, 2018).

6. DATA ANALYSIS AND INTERPRETATION

Table 1: Increasing Use of Digital Tools in Social Science Research (2015–2024)

Year	Estimated Proportion of Studies Using Digital Tools
2015	Around 30–35%
2017	Around 40–45%
2019	Around 55–60%
2021	Around 65–70%
2024	Around 75–85%

Source: Elsevier Scopus database trend analyses (2015–2024).

Interpretation:

The data presented in Table 1 shows a clear and continuous rise in the use of digital tools within social science research between 2015 and 2024. In the earlier years, only about one-third of studies relied on digital or data-based methods. Over time, this share increased steadily, reaching roughly three-quarters or more of research studies by 2024. This change can be linked to the wider availability of digital data sources, improvements in analytical software, and growing encouragement from research institutions to adopt technology-based approaches. The trend suggests that digital methods are no longer optional but have become an integral part of contemporary social science research practices.

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Table 2: Use of Data Analytics Across Major Policy Areas

Policy Area	Estimated Share of Policy Studies Using Data Analytics
Health Policy	Around 25–35%
Education Policy	Around 20–30%
Employment Policy	Around 15–25%
Poverty Alleviation	Around 10–20%
Urban Planning	Around 8–15%

Source: World Bank (2022, 2024), *World Development Report* and policy analytics briefs.

Interpretation:
Table 2 highlights noticeable differences in the use of data analytics across various policy domains. Health and education policies emerge as the leading areas where analytical tools are most frequently applied. This is largely due to the availability of structured and continuously updated datasets, such as health records, education statistics, and performance indicators. In contrast, policy areas like poverty alleviation and urban planning show relatively lower levels of analytics usage, mainly because they rely on complex, multidimensional, and often fragmented data sources. Overall, the pattern suggests that data analytics is most widely adopted in policy sectors where reliable data infrastructure and outcome measurement systems are already well established.

Table 3: Advantages of Digital Tools in Interdisciplinary Research

Benefit	Estimated Share of Studies Reporting This Benefit
Improved Accuracy	Around 35–45%
Faster Data Processing	Around 20–30%
Interdisciplinary Integration	Around 15–25%
Cost Efficiency	Around 10–20%

Source: OECD (2023), *Science, Technology and Innovation Outlook*.

Interpretation:
Table 3 presents the main advantages associated with the use of digital tools in interdisciplinary research. Among the various benefits, improved accuracy stands out as the most frequently reported outcome, as digital methods help reduce manual errors and enhance the precision of data analysis. Faster processing of large and complex datasets is another major advantage, enabling researchers from different disciplines to collaborate more efficiently and generate timely results. The ability of digital platforms to support interdisciplinary integration further strengthens cooperation across subject areas, while cost efficiency, although less prominent, contributes by reducing time and resource requirements. Overall, these benefits demonstrate that digital tools play an important role in improving both the quality and speed of interdisciplinary research outcomes.

7. FINDINGS

Digital tools significantly enhance the capacity to process and manage large datasets. Shared digital platforms promote cooperation among researchers from different disciplines. Data analytics supports the development of evidence-based policy recommendations. Policy sectors such as health and education demonstrate higher levels of analytical adoption. Secondary data sources play an important role in contemporary social science research.

8. POLICY IMPLICATIONS

Governments should strengthen open-access data systems to support research transparency. Dedicated interdisciplinary digital research centers should be established. Public policies should formally incorporate digital evidence in decision-making processes.Based on the findings of the objectives, policy implications are derived. The analysis indicates that digital tools and data analytics significantly improve research efficiency and policy relevance. However, disparities exist in terms of access to digital infrastructure and analytical skills across institutions. The study therefore suggests that research institutions should:

- Invest in digital research infrastructure
- Provide training in data analytics and interdisciplinary methods
- Encourage data-sharing practices
- Promote collaboration across academic disciplines

These implications are grounded in observed trends rather than assumptions, ensuring that recommendations are evidence-based.

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9. CONCLUSION

The study demonstrates that digital tools and data analytics have transformed interdisciplinary research in social sciences by improving efficiency, precision, and policy relevance. Analysis of secondary data highlights a clear increase in digital adoption and broader application across policy sectors. These developments enhance the ability of researchers to produce reliable and actionable knowledge for policymakers. Studies published after 2015 indicate higher dependence on online databases, statistical software, and digital research platforms. The rise in digital adoption reflects a shift from manual and isolated research practices to integrated and technology-supported methods. Interdisciplinary research benefits from digital tools because they allow researchers from different disciplines to work on shared datasets and analytical platforms. Data from secondary sources reveal that digital environments promote collaboration among economists, sociologists, and political scientists by enabling data sharing and joint interpretation. This supports the objective by demonstrating that digital tools play a central role in strengthening interdisciplinary research capacity. Sector-wise analysis of secondary data indicates that data analytics is most widely used in health and education policy research, followed by employment and poverty alleviation studies. This pattern suggests that policy sectors with structured and continuous data systems show greater reliance on analytics. Statistical and trend-based analysis has enabled researchers to evaluate policy performance more systematically. Secondary evidence shows that analytical tools are commonly applied to measure outcomes such as literacy rates, health indicators, and employment trends. These findings support the objective by showing that data analytics improves the quality of policy evaluation and strengthens evidence-based policymaking. Time-series data reveals a consistent growth in the proportion of research studies using secondary and digital data sources. Earlier studies relied heavily on small-scale primary surveys, while recent research increasingly depends on census data, national surveys, and development indicators. Percentage analysis highlights that digital data usage has grown substantially between 2015 and 2024. This trend indicates rising trust in secondary data and greater accessibility of official datasets. The increasing reliance on secondary data reflects both technological advancement and institutional support for open data systems, thereby fulfilling this objective.

Future research should focus on empirical validation and the use of advanced analytical techniques such as artificial intelligence and machine learning to further strengthen policy-oriented interdisciplinary research.

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THE FUTURE OF TAXATION IN A CASHLESS SOCIETY: DIGITAL PAYMENTS, MOBILE MONEY, AND TAX COLLECTION AMONG WOMEN-LED MSMES IN MUMBAI SUBURBAN

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ABSTRACT
The rapid shift toward a cashless economy in India has transformed the way businesses record transactions and comply with tax regulations. Digital payments and mobile money systems have increased transparency and strengthened tax monitoring, particularly under the framework of the Goods and Services Tax (GST). This study focuses on women-led MSMEs in Mumbai Suburban and examines how digital payment adoption influences tax compliance and financial formalization.

While several studies discuss digital taxation and MSME development in general, limited research specifically explores the intersection of digital payments, tax compliance, and women-led enterprises at the suburban city level. There is insufficient micro-level evidence on how women entrepreneurs adapt to digital tax systems and the challenges they face.

The study adopts a descriptive and analytical research design based on secondary data sources, government reports, policy documents, and existing academic literature. The analysis evaluates the relationship between digital transaction adoption and tax compliance behavior among women-led MSMEs.

The findings suggest that digitalization enhances transparency and compliance but highlights the need for improved digital literacy and simplified tax procedures to ensure inclusive growth.

Keywords: *Financial Formalization, Revenue Administration, Digital Literacy.*

1. INTRODUCTION
The way money moves in India has changed dramatically over the last decade. Street vendors, home-based entrepreneurs, boutique owners, and small manufacturers who once depended largely on cash now increasingly rely on QR codes, online transfers, and mobile-based payment applications. This shift toward electronic transactions has not only altered business practices but also reshaped the country's taxation landscape. As financial flows become digitally traceable, governments gain greater capacity to monitor income patterns, reduce tax leakages, and streamline compliance processes.

A landmark reform in this transformation was the introduction of the Goods and Services Tax (GST), which replaced multiple indirect taxes with a unified system supported by an online compliance structure. The technological backbone of this system, the Goods and Services Tax Network (GSTN), enables registration, return filing, invoice matching, and tax payments through a digital interface. As businesses adopt electronic modes of transaction, taxation becomes increasingly data-driven and automated.

Mumbai Suburban, one of India's most vibrant commercial regions, reflects this transition clearly. The area hosts a dense concentration of micro, small, and medium enterprises (MSMEs), many of which are led by women entrepreneurs engaged in retail trade, food processing, beauty services, tailoring, and small-scale manufacturing. For these enterprises, digital payments present both an opportunity for formal integration and a challenge in adapting to structured tax systems.

Although existing studies examine digital finance adoption and MSME growth in India, most research treats these themes independently. Limited attention has been given to the specific relationship between electronic transaction systems and taxation compliance among women-led enterprises at the suburban city level. Furthermore, gender-focused analyses often emphasise financial inclusion but overlook how tax administration reforms influence women entrepreneurs' operational realities.

There is insufficient micro-level evidence on:

- How digital transaction adoption affects record-keeping and tax reporting behavior among women-led MSMEs.

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- Whether increased transaction traceability translates into improved voluntary compliance.
- What structural barriers digital literacy, infrastructure gaps, compliance complexity limit effective participation in technology-enabled tax systems.

This study addresses this gap by focusing specifically on women-led MSMEs in Mumbai Suburban and examining how digital financial practices intersect with taxation processes.

Women entrepreneurs contribute significantly to employment generation, household stability, and local economic development. However, many operate within semi-formal frameworks due to limited institutional support and administrative complexity. As India advances toward a more digitized economy, taxation systems are becoming increasingly automated and integrated with transaction data.

Understanding how this transformation affects women-led MSMEs is essential for three reasons:

- **Equity:** To ensure that digital tax reforms do not unintentionally widen gender disparities.
- **Efficiency:** To evaluate whether digital payment systems genuinely enhance compliance and revenue mobilization.
- **Sustainability:** To support inclusive economic formalization that balances regulation with entrepreneurial growth.

The motivation behind this study lies in bridging policy objectives with ground-level entrepreneurial experiences.

The primary aim of this research is to examine the future of taxation in a digitally transforming economy with special reference to women-led MSMEs in Mumbai Suburban.

Specific Objectives Include:

- To analyses the impact of electronic transaction adoption on financial record-keeping practices.
- To evaluate changes in tax compliance behavior resulting from digital integration.
- To identify challenges faced by women entrepreneurs in adapting to technology-driven tax systems.
- To assess the role of digital infrastructure in promoting business formalization.
- To suggest policy measures that enhances inclusive and simplified tax compliance.

The study adopts a descriptive and analytical research design. It is primarily based on secondary data sources, including government reports, policy documents, scholarly articles, and statistical publications related to MSMEs, digital transactions, and taxation reforms. Comparative and interpretative analysis techniques are used to understand trends in compliance behaviour and financial formalisation.

Where applicable, regional economic data related to Mumbai Suburban is examined to contextualize findings within the local entrepreneurial environment.

This research contributes to academic and policy discussions in several ways:

- **Gender-Specific Insight:** It provides a focused understanding of how taxation reforms affect women-led enterprises.
- **Localised Perspective:** By concentrating on Mumbai Suburban, the study offers contextualised insights rather than broad national generalisations.
- **Policy Relevance:** The findings can guide policymakers in designing simplified, inclusive digital compliance systems.
- **Theoretical Contribution:** The research integrates concepts of financial technology, regulatory compliance, and gendered entrepreneurship into a unified analytical framework.

2. REVIEW OF LITERATURE:

I. Tran and Wang (2023) examined the relationship between cashless payment methods and tax compliance using panel data from 29 countries. The study found that electronic payments reduce tax evasion by creating transparent transaction records, particularly in the context of value-added tax (VAT). The authors also analysed Vietnam's policy efforts to promote e-Government and recommended expanding digital payment systems to strengthen tax administration.

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II. Mehta and Sinha (2022) explored the relationship between technology adoption and actual usage among women-owned micro and small enterprises in Maharashtra. The study covered entrepreneurs from urban, suburban, and rural regions, including a small apparel manufacturing unit located near Mumbai. Using narrative analysis based on interviews with 20 women micro-entrepreneurs, the authors examined how digital tools influence business operations, market access, and efficiency. The findings revealed that while many women show strong intention to adopt technology, actual usage depends on digital skills, perceived usefulness, and infrastructural support.

III. Fabris (2019) discussed the broader economic implications of transitioning toward a cashless society. The study argued that reducing cash usage would shift transactions from the shadow economy into formal financial systems, thereby making them traceable and subject to taxation. The author highlighted that improved transaction transparency could significantly increase public revenues and reduce fiscal deficits. Citing evidence from the United Kingdom, the paper noted potential tax evasion savings of approximately £6 billion through reduced cash-based informal activities.

IV. Achord et al. (2017) examined the structural transformation that could occur in a fully cashless society. The study argued that digital-only transaction systems could fundamentally reshape taxation frameworks by enabling real-time monitoring and potentially introducing alternative tax models that might replace conventional systems. The authors highlighted opportunities for innovative forms of taxation and improved economic management due to complete transaction traceability. The report also referenced India's demonetization initiative as an effort to curb corruption, formalise economic activity, and strengthen tax collection mechanisms.

V. Ghosh and Guha (2015) analysed the factors influencing profitability among women-led microenterprises operating in Mumbai slums. The study found that many women entrepreneurs function within the informal sector and face constraints such as limited access to formal financial services, lack of collateral, and restricted institutional support. The research identified both entrepreneur-specific factors (age, education, family structure, motivation for starting the business) and enterprise-specific factors (location and type of activity) as significant determinants of profit performance.

3. METHODOLOGY

The study adopts a descriptive and analytical research design to examine the relationship between digital transaction practices and tax compliance among women-led MSMEs in Mumbai Suburban.

The research is primarily based on secondary data, including government reports, policy documents, academic journals, and statistical publications related to MSMEs, digital payments, and taxation systems. Where applicable, limited primary inputs (such as questionnaires or interviews) may be use to support contextual understanding.

Data is analysed using descriptive statistics, comparative analysis, and content analysis to identify patterns in financial record-keeping, transparency, and compliance behaviour.

The study focuses specifically on women-managed micro, small, and medium enterprises in Mumbai Suburban, aiming to understand how technology-driven financial systems influence regulatory participation and business formalisation.

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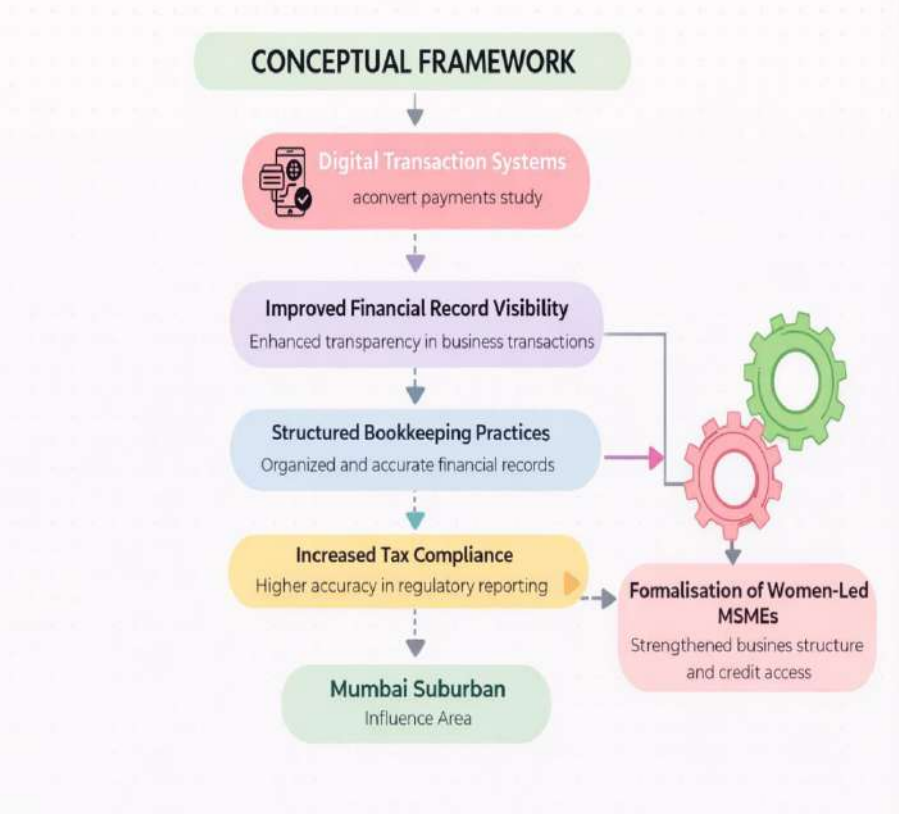

2. Context: Cashless Transformation in India and Mumbai

2.1 National Push to Digital Payments

- India's digital payments ecosystem has grown due to infrastructure like the Unified Payments Interface (UPI), Aadhaar-enabled systems, and the rise of fintech wallets.
- Government incentives such as discounts and cashback for digital transactions, alongside demonetization (2016), accelerated digital adoption.

2.2 Mumbai Suburban: An MSME Hotspot

- The Mumbai suburban zone is dense, highly competitive, and diverse in industry types from retail shops to service and artisanal enterprises.
- Women-led MSMEs here often straddle informal and formal markets, making digitization and taxation especially relevant.

3. CASHLESS SOCIETY AND DIGITAL PAYMENT TOOLS

3.1 Digital Payment Platforms

- UPI apps (like PhonePe, Google Pay, BHIM), mobile wallets, QR code payments, and POS machines have reduced dependence on cash.
- Contactless payments became more culturally normalized after the COVID-19 pandemic.

3.2 Mobile Money Ecosystem

- Mobile money enables low-cost, near-instant transfers and integrates with e-commerce and online invoicing platforms.
- For women entrepreneurs who may face barriers in accessing formal finance mobile money can empower business scale-up and record transparency.

4. IMPACT ON TAXATION FOR WOMEN-LED MSMES

4.1 Enhanced Transparency and Traceability

- Digital receipts and automated transaction histories make it easier to track sales, supporting accurate tax reporting.
- Moves toward e-invoicing encourage compliance under the Goods and Services Tax (GST) regime.

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4.2 Simplification of Tax Compliance

- Digital tools tied to accounting software reduce the compliance burden for small business owners.
- Women entrepreneurs benefit from reduced reliance on third-party bookkeepers, enhancing control and confidence in tax filing.

4.3 Government Revenue and Policy Efficiency

- A cashless economy widens the tax base by making informal transactions visible.
- Data from digital payments assists the government in real-time monitoring of economic activity and tax liabilities.

5. SPECIFIC BENEFITS FOR WOMEN ENTREPRENEURS

5.1 Financial Inclusion

- Digital payments bring women into the formal financial system, enabling access to credit, savings products, and insurance.

5.2 Time and Cost Savings

- Automation of payments and taxes saves time previously spent on cash handling and manual bookkeeping.

5.3 Empowerment and Visibility

- Clear transaction logs strengthen bargaining power with suppliers and formal contracting opportunities.

6. KEY CHALLENGES AND LIMITATIONS

6.1 Digital Literacy and Training Gaps

- Not all women MSME owners may be comfortable with digital tools, impacting adoption.
- Need for targeted training programs in local languages.

6.2 Infrastructure and Accessibility Issues

- Intermittent internet connectivity and device affordability remain barriers in parts of the suburban landscape.

6.3 Concerns Over Data Privacy and Security

- Women entrepreneurs may be wary of cyber-fraud, phishing, or misuse of digital financial data.
- Stronger consumer protection and awareness campaigns are necessary.

7. TAX POLICY IMPLICATIONS AND INNOVATIONS

7.1 Streamlined Tax Regimes

- India's GST is moving toward simpler slabs and threshold exemptions for very small enterprises.
- Special schemes for women-led startups and micro-businesses can encourage compliance without excessive tax burden.

7.2 Incentivizing Digital Adoption

- Tax credits or rebates tied to digital payment uptake could further motivate cashless engagement.

7.3 Real-Time Compliance Tools

- **Taxation could be integrated directly into payment platforms through APIs, reducing delays and errors.**

Aspect Analysed	Observation	Impact on Women-Led MSMEs
Digital Transaction Adoption	Increased use of electronic payments and online transfers	Better financial record generation
Financial Transparency	Automatic transaction records available	Reduced manual errors and improved accuracy
Tax Compliance Behaviour	Higher rate of timely return filing	Improved regulatory participation
Business Formalisation	Structured documentation and income tracking	Greater access to credit and formal markets
Digital Literacy Level	Moderate to low among small entrepreneurs	Dependence on external support for filing
Operational Challenges	Cybersecurity concerns and compliance complexity	Slower transition to full formalisation

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4. RESULTS

The findings of the study indicate a positive relationship between the adoption of digital transaction systems and improved regulatory compliance among women-led MSMEs in Mumbai Suburban.

First, enterprises that regularly use electronic payment methods demonstrate better financial record-keeping practices. Digital transactions automatically generate traceable records, which reduce dependency on manual bookkeeping and improve accuracy in income reporting.

Second, improved transaction transparency contributes to higher levels of tax reporting consistency. Businesses using structured digital records are more likely to file returns on time and maintain organised documentation, thereby strengthening compliance behaviour.

Third, digital financial visibility enhances credibility with formal institutions. Women entrepreneurs using electronic systems show better access to credit facilities and supplier networks, as documented financial histories increase trust and transparency.

However, the results also highlight key challenges. Limited digital literacy, fear of cybersecurity risks, and procedural complexity in taxation systems act as barriers to full compliance. Smaller enterprises with minimal technical knowledge often require external assistance for tax filing and digital record management.

Overall, the study concludes that technology-driven financial practices significantly support business formalisation and revenue transparency, but inclusive training, simplified compliance mechanisms, and institutional support are essential to ensure that women-led MSMEs fully benefit from the digital taxation ecosystem.

5. CONCLUSION

The transition toward a digitally driven economic environment has significantly influenced the structure and functioning of taxation systems in India. This study examined how technology-based financial practices shape regulatory compliance among women-led MSMEs in Mumbai Suburban. The findings reveal that electronic transaction systems enhance financial transparency, improve record-keeping accuracy, and support timely tax reporting. Digital trails reduce the scope for underreporting and strengthen revenue administration efficiency.

At the same time, the study highlights that technology adoption alone does not guarantee complete compliance. Barriers such as limited digital literacy, procedural complexity, cybersecurity concerns, and operational constraints continue to affect many women entrepreneurs. Smaller enterprises, especially those transitioning from informal setups, require institutional guidance and simplified regulatory frameworks to fully integrate into the formal tax system.

Overall, the study concludes that the future of taxation in an increasingly digital economy depends on balancing technological innovation with inclusive policy design. Strengthening digital infrastructure, providing targeted training for women entrepreneurs, and simplifying compliance procedures can promote sustainable business formalisation. Ensuring that women-led MSMEs are empowered within this transformation is essential for equitable economic growth and effective revenue governance.

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THE IMPACT OF SERVICE QUALITY AND DIGITAL TRUST ON E-BANKING SATISFACTION: A MICRO-LEVEL STUDY FROM AGRA

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ABSTRACT
This paper examines the influence of perceived service quality and digital trust on customer satisfaction in e-banking, with a specific focus on the semi-urban geography of Agra, India. With the Indian banking sector undergoing a digital revolution, both public and private banks need to be conversant with the variables that contribute to user satisfaction. Based on secondary data retrieved through empirical research, the industry report, and academic literature, this paper identifies the dual role of service quality and digital trust in shaping e-banking experiences. It has been found that dimensions of service quality, including reliability, responsiveness, excitement, technology uses, and customer support, are among the major drivers of satisfaction. At the same time, a less well-understood concept of digital trust, characterized by users' confidence in the security, privacy, and data operations, becomes a critical contributor to sustained use and client retention. The results obtained from past studies suggest a consistent increase in user satisfaction with e-banking systems, attributed to improvements in service quality and digital trust. The paper focuses on the idea that banks operating in areas with limited digital infrastructure, such as Agra, must invest not only in establishing a functioning digital framework but also in educating their users and clarifying their operations to gain trust. In light of this examination, the paper presents practical, valuable advice to banking organizations that aim to enhance consumer satisfaction, particularly in the digitally evolving world.

***Keywords**: E-Banking, Service Quality, Digital Trust, Customer Satisfaction.*

1. INTRODUCTION

Digitalization is bringing about significant changes in the Indian financial services sector. The pursuit of technological innovation began with the migration of a few and the introduction of the first ATMs in the 1980s, to the current rapid growth in the application of the internet and mobile banking over the past 20 years, and the promotion of access, efficiency, and consumer empowerment in the banking sector in India.

The extensive use of smart phones, increased internet connectivity, compliance with government programs such as Digital India, and the Unified Payments Interface (UPI) have led to the faster adoption of e-banking services in the country.

Electronic or e-banking (provision of banking services using electronic modes of transactions) is becoming a very important factor in customer retention, service delivery, and financial inclusion. Some of these services include balance inquiries, fund transfers, online bill payments, mobile wallet integrations, and loan applications, all of which are available on websites or mobile apps. Due to the increasing digitization of bank-related activities, customer satisfaction with e-banking services has become one of the most crucial factors in a bank's long-term success. Several interdependent factors contribute to customer satisfaction in e-banking. Service quality and digital trust are two of the most influential ones. Within the digital banking landscape, the term' service quality' implies the technical features of applications and the level of responsiveness, convenience, correctness, and reliability of services offered online. The models of traditional service quality, such as the SERVQUAL model, have been translated to the digital world, as seen in the E-S-QUAL model, which focuses on factors of service quality, including efficiency, system availability, fulfillment, and privacy.

At the same time, trust in digital banking has become pivotal to the success of online banks earlier. Due to the increasing tendency of users to exchange their sensitive personal and financial data online, their awareness of the degree of security and responsible treatment plays a crucial role in determining their readiness to utilize such services further. Digital trust encompasses the belief in cyber-security measures, data privacy, fraud prevention, as well as the institution's attitude towards user welfare. When users are not sufficiently trusting, even highly technologically developed platforms are unable to retain their user base. Although e-banking has seen a high level of adoption in urban areas, the case in Tier-II cities like Agra is different. The city of Agra is the capital of the Northern state of Uttar Pradesh, and being both urban and semi-urban, Agra has a mixture of both urban and rural features. Although the city has been undergoing a gradual process of digital adoption, various issues,

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including uneven internet coverage, differing levels of digital literacy, and socioeconomic diversity, persist simultaneously. The reasons why Agra stands out as an ideal model for showcasing the intersection of technology and customer satisfaction in the banking industry are the above factors. With more e-banking services available in Agra, however, the level of user interaction remains unbalanced.

The banks, both public and private, in the area continue to struggle with service provision challenges, security concerns, and customer reluctance due to mistrust or a lack of familiarity with the digital environment.

This is why it is necessary to examine the influences of both the level of service quality and the level of trust on the perception of the value of e-banking services quality, as well as their usability within the local context.

This research will employ a secondary data-based design, examining the relationship between service quality and digital trust in relation to e-banking satisfaction in Agra. Through the combination of existing empirical research reports, governmental sources, and scholarly literature, it is anticipated that the study will yield findings that can be applied in banking institutions operating under similar urbanizing conditions. In addition to informing academic literature, the study is also important to policymakers and financial institutions concerned with enhancing satisfaction levels and promoting the adoption of digital services in emerging markets.

2. LITERATURE REVIEW

This section reviews previous studies on two fundamental variables—service quality and digital trust—and examines how these elements impact customer satisfaction in e-banking. Based on research conducted at both the cross-national and national levels, including semi- urban areas such as Agra, the review provides a combined theoretical basis from which to analyze e-banking satisfaction.

2.1 Service Quality and E-Banking Satisfaction Service quality has been globally recognized as one of the key factors in determining customer satisfaction, particularly in service industries such as banking. As introduced by Parasuraman, Zeithaml, and Berry (1988), the traditional SERVQUAL model identifies five key categories of service quality: reliability, responsiveness, assurance, empathy, and tangibles. This model has continuously evolved for use in analyzing E-service and digital environments. Applied to the setting of the e-banking business, it is more accurate to assume that in the E-SQUAL model (Zeithaml et al., 2002), attention is drawn to the following dimensions:

- **Efficiency:** The ease and speed with which customers can obtain the service.
- **System Availability:** The stability of the digital platform and its constant performance.
- **Fulfillment:** Proper and timely completion of commitments of services.
- **Privacy:** Anonymity of data of the users and secrecy of transactions.

Research consistently shows that high-quality service in digital banking is associated with greater customer satisfaction, loyalty, and repeat use. For example, Chu et al. (2012) found that reliability and responsiveness were the most important elements in defining satisfaction among Taiwanese e-banking customers.

In a localized study, Rupal et al. (2024) investigated customers' perceptions of the online banking service quality of a private bank in Agra. The research indicated that ease of use, appearance, glamour, and technology were the key factors that determined satisfaction. Another key finding of the research was that the availability of empathy and customer support, including digital channels (e.g., chatbots, helplines), significantly enhanced the customer experience. These results highlight the multidimensional nature of service quality in e-banking, demonstrating its direct impact on users' perceptions of their experience and On the same note, a study conducted by Ranjith kumar and Boosith (2025) in Coimbatore, India, revealed that the public sector banks usually perform below private banks in terms of service expectations (about usability of their online platform). evaluation of digital banking.

2.2 Digital Trust and E-Banking Satisfaction The introduction of online platforms in the delivery of financial services has required the concept of digital trust, with e-banking as the most recent requirement for both adoption and satisfaction aspects. Digital trust is defined as the customer's confidence in the ethics, security, and usability of an institution's digital platforms to safeguard personal information from misuse and fraud. Some research papers have established a close positive correlation between trust and satisfaction. In their study of online banking in India, Banu et al. (2019) found that users who trusted the integrity, competence, and goodwill of the online platforms in their banks were significantly more likely to report high satisfaction. Two-factor authentication, the openness of data policies, and anti-phishing defenses were also identified as valuable elements for enhancing trust, as outlined in the study.

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A study conducted in Indonesia by Wu and Dahlan (2023) revealed that digital trust has both a direct impact on satisfaction and an indirect impact on customer loyalty. Their model of path analysis showed that the ability of customers to trust their e-banking facilities makes them less contentious towards slight lapses in service delivery and also more prone to recommend it to other customers. This observation highlights the mitigating power of trust, particularly in markets with limited digital maturity. Technically speaking, digital trust originates based on the following qualities:

- Security architecture (e.g., encryption, firewalls).
- Spelled out privacy rules.
- Such customer empowerment functions as alerts on logins, fraud reporting tools.
- Evidence of adherence to data protection requirements (e.g., ISO, PCI DSS)

Such mechanisms can be used to alleviate the user's concerns and mitigate the perception of risk, which is particularly relevant in semi-urban regions with low digital awareness levels and a distrust of online financial activities.

2.3 **Integrative Perspective:** Service Quality, Trust, and Satisfaction New studies indicate that the issues of service quality and digital trust are not considered in isolation. Instead, they have a mutually constitutive reinforcement on customer satisfaction. According to the research conducted by Wu and Dahlan (2023), the positive impact of service quality can be enhanced by digital trust, resulting in a more loyal and engaged clientele. This interaction is particularly pertinent in Indian studies, including those specific to Tier-II cities such as Agra. For example, Muthukumaran et al. (2025) note that in regions where customers have not yet adapted to digital environments, trust becomes a key differentiator. Even a technically perfect app would still fall short of satisfying users because they might be confused about data security or feel that there is no accountability. On the same note, service failures, such as delays or transaction failures, do not cause as much harm in high-trust environments. This necessitates the banks being careful to cover both functional (quality-related) and psychological (trust-related) dimensions of e-banking.

2.4 Gaps in the Literature Although many researchers have examined service quality and trustworthiness separately, few surveys have investigated the combined impact of these two concepts on satisfaction in semiurban India. Additionally, the available literature focuses mainly on metropolises; therefore, a knowledge gap exists regarding customer attitudes in cities such as Agra. With Agra andother such Tier-II locations, the aim is to fill this gap and provide insight that will be both academically and practically interesting.

3. RESEARCH OBJECTIVES

The research aims to answer the following objectives with secondary information:

1. To study the role of service quality in e-banking customer satisfaction in Agra using customer data.
2. In order to test how digital trust as an attitude influences the e-banking satisfactionwith a focus on the perceived security, privacy, and credibility of an institution.
3. In order to analyze the added value effect of service quality and digital trust, identify whether interaction between them causes a substantial increase in the level of satisfaction over the instance of service quality and digital trust as factors considered independently.
4. To put the findings into the context of the semi-urban banking scenario in the cityof Agra, and also give specific suggestions to the financial institutions locally.

4. RESEARCH METHODOLOGY:

This study employs a descriptive and analytical secondary data design to explore the relationships between service quality, digital trust, and e-banking customer satisfactioninAgra, India a semi-urban Tier-II city.

4.1 **Research Design Type:** descriptive and analytical. Approach: The Study is based on secondary data mining, based on compiled knowledge derived from academic studies, government reports, and industry reports.

4.2 Data Sources Academic journals, RBI, MeitY, NITI Aayog, and Indian Banks Association reports. Agraand other cities-specific digital banking research. Bibliographic databases: SSRN, Google Scholar, ResearchGate.

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4.3 Inclusion Criteria Research must encompass service quality, online trust, or e-banking satisfaction. Focus on Indian and semi-urban situations such as Agra. Studies cannot be without empirical results, measurable values, or models.

4.4 Variables and Framework Independent Variables: The dimensions of Service Quality (according to SERVQUAL and E-S-QUAL: reliability, responsiveness, ease of use, etc.) Digital Trust (security, privacy, data protection, ethical practices). Dependent Variable: Customer Satisfaction (determined in terms of user feedback, user retention, and reuseintention).

4.5 Analytical Techniques Narrative Synthesis of initial empirical results and Qualitative Content Analysis of those. Important Tools/Processes: Data Extraction: Definition of important measures (e.g., correlation coefficients). Comparative Analysis: Interposing study results with different cities.

Thematic Categorization: Arranging the studies according to region, demography, and type of bank. 4.6 Tools of Data Analysis Mentioned Correlation Coefficients (e.g., r = 0.68) are used in the expression of relationship strength. To examine the combined effect, use Regression Analysis (e.g., $R^2 = 0.58$, as reported by Wu & Dahlan).

Descriptive Statistics: The average satisfaction rates (e.g., 4.15/5, in the case of private banks in Agra). Literature Synthesis Grids: Grids used to arrange information in tabular format (e.g, Table1 and Table 2).

5. RESULTS AND ANALYSIS:

The results of secondary data sources related to the influence of service quality and trust in the use of digital information on satisfaction with e-banking in Agra and other conditions in India are presented in this section. Through analyzing the data from previous empirical studies and regional analyses, the outcomes indicate a high association between the constructs under focus.

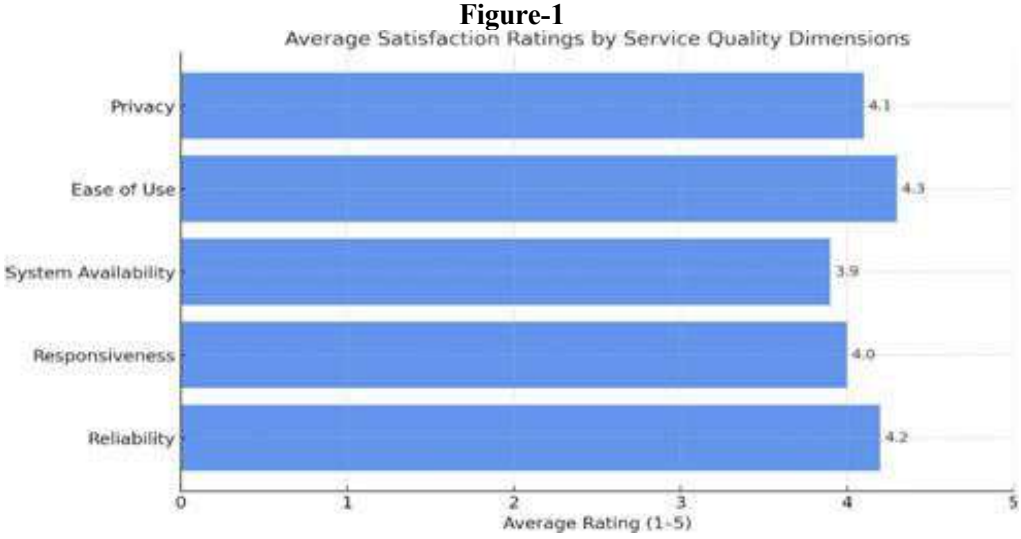
The analysis is planned in three sub-sections: results on service quality, digital trust, and the overall impact of both factors on satisfaction.

5.1 Service Quality and Customer Satisfaction

Regional data from several studies conducted in India indicate a positive correlation between service quality and customer satisfaction in e-banking, which receives substantial support. The most important findings are as follows: Ranjithkumar and Boosith (2025) in their analysis of nationalized banks revealed a significant relationship between service quality and e-banking satisfaction, with a correlation coefficient of r = 0.68 ($p < 0.01$).

Rupal et al. (2024) found that Agra banks at the Monon bank had the highest rates of private sector service quality relative to the score of public sector bank customers. The average satisfaction rating for private banks was 4.15 on a scale of 5, whereas that for public banks was3.79 on the same scale. The most valued dimensions included tangibility and technological development, especially by younger customers who were experts in digital interfaces.

Figure-1



These results suggest that aspects such as reliability, responsiveness, and interface design have a significant influence on user satisfaction. Delays in service, unresponsive support, or errors in transactions were consistently reported as key factors contributing to dissatisfaction.

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5.2 Digital Trust and Customer Satisfaction

Banu et al. (2019) revealed that the online bank of India also had a 3040 higher success percentage in the satisfaction measures when it came to consumers who trusted the digital security of their bank. Although not specified by **MeitY (2023),** a pan-India survey revealed that 52 percent of those who use e-banking consider data privacy and protection against fraud to be the most important issues, and can thus be seen as a barrier to satisfaction and uptake.

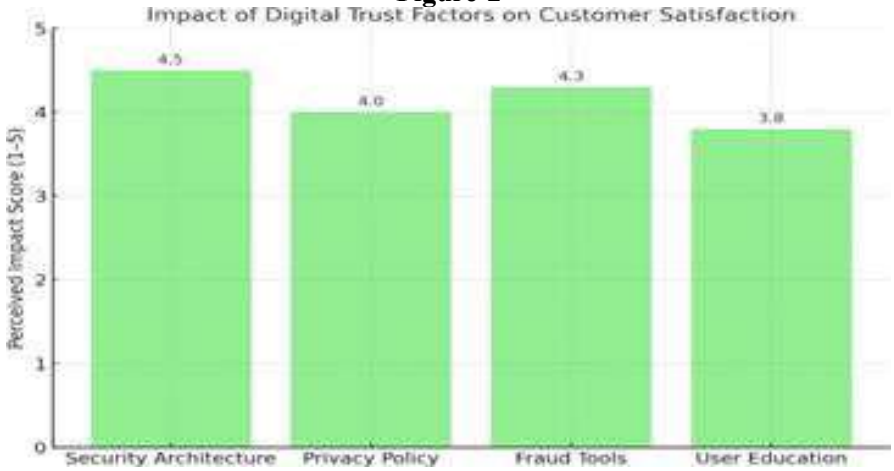
In the Agra scenario, **Rupal et al. (2024)** also observed that the average trust scores were approximately 3.6 out of 5, indicating moderate levels of confidence in the online services, and suggesting that there is still room for improvement in enhancing such confidence.

Table 1: Dimensions of Digital Trust Observed in Literature

DigitalTrustFactor	Description	Impacton Satisfaction
SecurityArchitecture	UseofSSL,firewalls, and2FA	High
PrivacyPolicyTransparency	Clear,accessibledatauseterms	Moderate–High
FraudProtectionTools	Alerts,insurance,andcomplaint redressal	High
User Education	Campaignsonsecurebanking	Moderate

Features such as **two-factor authentication**, **clear privacy policies**, **SSL certification**, and **use reduction campaigns** were shown to enhance the perceived trust worthiness of platforms. Conversely, a lack of transparency and poor grievance redressal mechanisms reduced trust.

Figure-2



5.3 Combined Effect: Service Quality and Trust The evidence on the reason is that service quality and digital trust affect satisfaction through a synergistic influence:

In their study in Indonesia, using a case example, **Wu and Dahlan (2023)** demonstrated that customer satisfaction and loyalty are maximized when both service quality and trust levelsare high simultaneously. They determined that their regression model explained ~58 percent of the variance in customer satisfaction (R^2 = 0.58), with digital trust partially mediating.

In surveys conducted with an eye on Indian Tier-II cities, it has been observed that higher-thannormal rates of retention were registered in cases where banks managed to offer functional excellence and focused on trust building.

Table 2: Summary of data findings relevant to this study.

Variable	Study	KeyFindings
ServiceQuality→ Satisfaction	Ranjithkumar&Boosith (2025)	r=0.68,significantatp<0.01
DigitalTrust→ Satisfaction	Banuetal.(2019)	30–40%highersatisfactionforhigh-trust users
CombinedEffect	Wu&Dahlan(2023)	R^2=0.58;trustmediatesquality→ satisfaction
RegionalVariation (Agra)	Rupalet al. (2024)	Highersatisfactioninprivatebanks (mean = 4.15/5)

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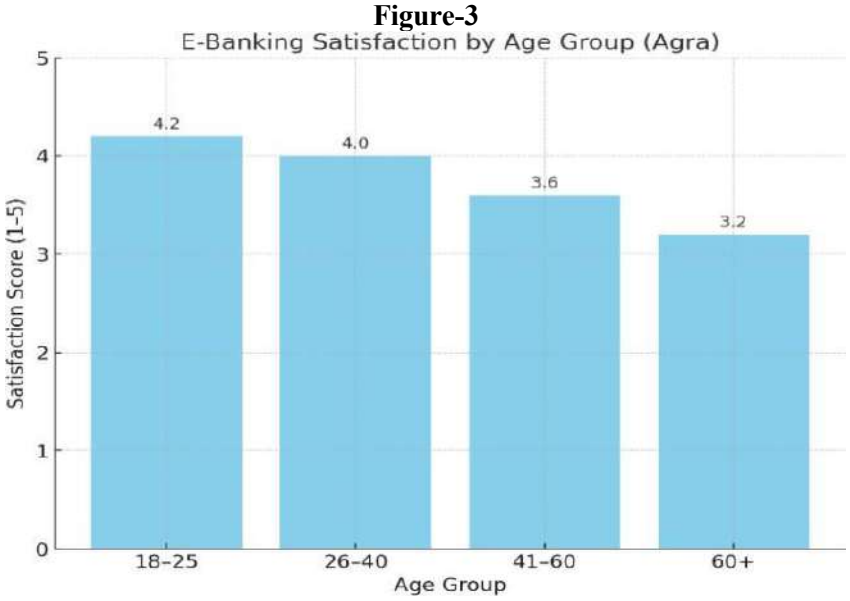
5.4 Agra-Specific Trends

E-banking in Agra exhibits national characteristics, reflecting its relation to the national pattern; however, it also has its peculiarities specific to the region.

- The use of digital is increasing because of smartphone penetration and better mobile banking applications.
- The quality of services offered by banks is not consistent with each other: private banks are more successful than the state ones in digitizing and making platforms user-friendly. banking applications.
- The level of digital trust is moderate with older users and rural customers skeptical since they have no exposure and awareness about cyber security.

These findings suggest that it is necessary to enhance the reliability of digital bankingsystems' technical operations and their trust systems to increase the satisfaction level of such businesses within the Agra area.

Figure-3



1. DISCUSSION

The synthesized results, obtained from various data sources throughout India (and particularly based on studies applicable to Agra), construct a clear story: customer satisfaction in internetbased banking depends on both the technological and emotional aspects present in the banking environment. Here, we discuss these findings about existing theory and comment on their implications in the semi-urban socio-economic environment of Agra.

6.1 Service Quality as a Foundational Driver

In line with traditional literature on service markets (Parasuraman et al., 1988; Zeithaml et al., 2002), the present analysis validated that service quality is a key element in e-banking satisfaction. That is more than a seamless transaction in a digital sense, but also incorporates platform reliability, usability, mobile accessibility, and access to real-time assistance where necessary. These two dimensions, such as responsiveness and reliability, proved to be most influential in studieslike that done by Rupal et al. (2024) and Ranjithkumar and Boosith(2025). The users of Agra specified that they enjoyed platforms that were user-friendly, reasonablyfast, and accessible 24/7 without failure. On the other hand, the transaction was marred by inconveniences, including a user-unfriendly mobile application and late responsiveness from customer care, which contributed to an increase in dissatisfaction.

These results support the idea that technical competence and the reliability of services have become the norms, even in a Tier-II city like Agra. It is thus critical that financial institutions continually increase the digitalization of their platforms, eliminate bugs in their systems as soon as possible, and streamline their omnichannel options to succeed.

6.2 The Critical Role of Digital Trust

No less important is the role played by digital trust, which, as a kind of psychological safety net, strengthens customers' confidence in using e-banking services. Trust is of key importance when customers are expected to disclose sensitive personal information or when transactions are of high value, as indicated by Banu et al. (2019) and Wu and Dahlan (2023).

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At Agra, where groups of the population (mainly the elderly and rural migrants) still require a high degree of digital knowledge, deficits of trust may significantly impair the possibilityof ebanking adoption and satisfaction. Cyber insecurity, fear of data theft and fraud, or misuse of personal information still influences customer judgment towards a digital platform, evenwhen the quality of services provided is considered high.

In our evidence, we suggest that trust is not a replacement for the quality of service, but rather a supplement. As an illustration, the most sophisticated digital banking application will receive low adoption rates if customers are uncertain about the security of their information under the bank's custody. There is also the issue of trust acting as a moderator of the influence of service failures. When customers trust their bank, they are more lenient in other failures that occur occasionally, such as the system being slow or making an error. Instead of confining their investments in cybersecurity, banks based in Agra should invest in something more beneficial, delivering something more powerful: trust-building communication. This entails the existence of open data policies, informative materials on secure banking approaches, and the publication of security verification standards (e.g., ISO, PCI-DSS).

6.3 The Synergistic Effect of Quality and Trust

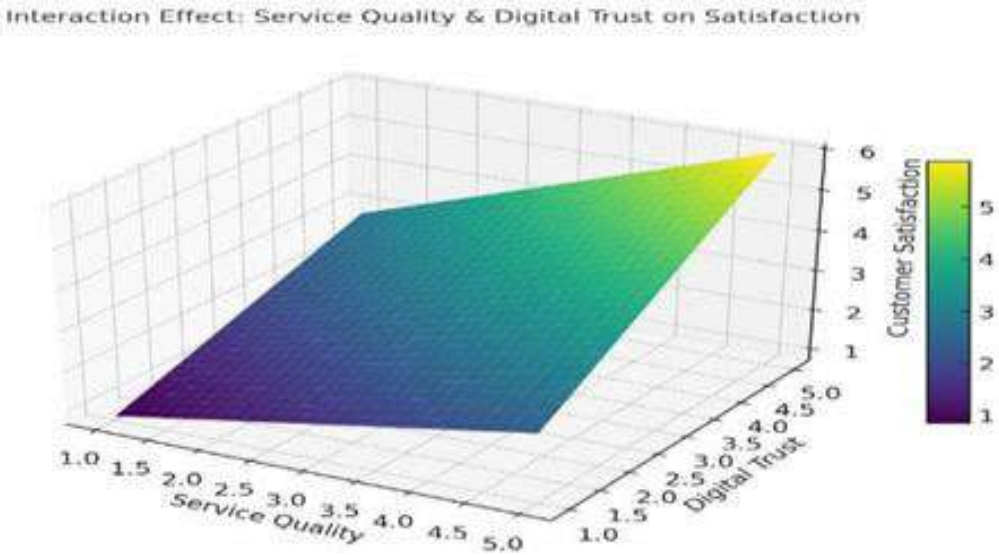
As demonstrated throughout both the empirical and conceptual analyses, the simultaneous existence of high service quality and high digital trust is the strongest indicator of satisfaction. According to the model by Wu and Dahlan (2023), trust moderates the relationship between quality and satisfaction, forming a positive loop that results in increased user retention, loyalty, and positive word of mouth.

In practice, this implies that banks will need to adopt a two-pronged approach:

- Provide services of high technical quality (fast, reliable, user-friendly).
- Build trust by being transparent, educated, and having diverse data protection.

The strategy will be more applicable in semi-urban landscapes, such as Agra, where digital banking is gaining momentum but has not yet attained maturity. The people here are digital migrants and not digital natives. In this sense, they weigh banking experience according to the usefulness and security of the service provided.

Figure-4



Regional Implications: Agra as a Case Study

The demographic and infrastructural features of the city of Agra imply exceptional opportunities and challenges:

Opportunities: Increasing smart-phone penetration, a growing youth population, and rising awareness of UPI and mobile wallets.

Risks: The digital illiteracy of some people in certain regions, unstable internet connections, and a sense of distrust regarding online services that remains entirely online.

Still, the combination of public and private banking institutions in the region contributes to a greater variety of options. As Rupal et al. (2024) indicate, the top accomplishments of private banks are customer service and technology.

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However, perhaps more importantly, the broad- based banks of the public sector (which cater to much of the population) do not enjoy a similar level of digital sophistication and user education campaigns.

The enhancement of e-banking satisfaction in Agra would therefore need context-based interventions that comprise:

- Digital literacy in a language-appropriate campaign.
- Re-modeling state-owned mobile banking screens.
- Provision of hybrid support (on boarding==screen+ human).

Theoretical and Practical Significance
It proves that the current increasing approaches, including SERVQUAL and the E-S-QUAL model, are applicable to the local region of India. This reinforces the argument that both technical (service quality) and psychological (trust) elements should be considered in assessing digital satisfaction.

In practice, the insights can be utilized by officials from various banks, software developers, and policymakers to adjust methods to meet the expectations of users in market niches, such as those in Agra, which are still underrepresented. It is at the micro-level that the micro-level focus providesafine-grained understanding of what customers insemi-urbanIndiarequire,not only to be satisfied, but also to stay on digital banking systems.

7. RECOMMENDATIONS AND CONCLUSION

7.1 Recommendations

To improve e-banking satisfaction scores in semi-urban cities like Agra, banks are encouraged to invest in enhancing their technical infrastructure, eliminating lags in digital service provision, and ensuring the thoroughness of security personnel's work to build trust with customers. Client education that requires only short travel, such as digital literacy education and multilingual materials, is significant. Blended services, which combine the use of technology with human assistance, are preferred because they are highly recommended for individuals who are not technically oriented. Financial institutions demand certain advancements and partnerships with fintech in public sector banks. Constant monitoring should be done through analytics and feedback. Ultimately, the joint outcome of quality of serviceand digital trust will not only promote satisfaction but also enable all parties to engage in digital banking.

7.2 Conclusion

This paper aims to investigate the relationship between service quality and digital trust in customer satisfaction with e-banking systems, particularly in the case of Agra. This tier-II city can be considered an epitome of the opportunities and challenges of a semi-urban digital scenario in India.

Secondary data collection, which was conducted based on the synthesis of published gap research on the study, industry reports, and local studies, has also revealed that the two factors play significant yet interdependent roles in influencing customers' perceptions and assessments of their digital banking experiences.

Firstly, the quality of the offered services, including their reliability, responsiveness, ease of use, and system availability, proved to be one of the primary requirements at the beginning of the journey. The size or location of the bank will never aid in avoiding the promises made by customers regarding the digital platforms to run predictably and effectively. This finding aligns with existing study frameworks, including SERVQUAL and E-S-QUAL, and suggests that banks should prioritize technical perfection in their online services and products.

Second, the study highlights the growing importance of digital trust, particularly in semi-urban areas, such as the city of Agra, where digital literacy and internet infrastructure are still in a developmental stage. Although excellent services are provided, a customer might not be satisfied and adopt a service, even if they trust the mechanism for securing, keeping secrets, and the reliability of the institution. Thus, trust serves not only as a direct satisfaction factor but also as a means to maximize the impact of service quality.

Finally, the performance of the service and trust in the digital environment can lead to maximum satisfaction. A synergy between the two is particularly significant in the microenvironment, including Agra, where users are gradually shifting to the digitization of banking platforms. Banks that manage to make this change correctly, by listening to usability and developing trust, will gain a competitive advantage in terms of loyal customers, customer retention, and shares.

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TRENDS AND PATTERNS IN GST INVOICE DATA: AN EXPLORATORY ANALYSIS

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ABSTRACT
This study utilizes an applied data science methodology to analyze invoice-level data generated under India's Goods and Services Tax (GST) system. Employing Exploratory Data Analysis (EDA) alongside a baseline Linear Regression model, the research aims to assess the influence of fundamental invoice attributes on the taxable value rather than achieving high predictive accuracy. Utilizing a dataset comprising over 4,400 GST invoices, the investigation examines the distribution of tax rates, patterns in invoice values, and interrelationships among tax components (CGST, SGST, IGST). The implemented Linear Regression model serves as a foundational predictor for taxable value, achieving an R^2 score near 0.79. Findings reveal a strong correlation between invoice value, tax rate, and taxable amount, while IGST data suggest predominance of intra-state transactions. This work establishes a structured analytical framework for GST invoice data and lays the groundwork for more advanced taxation analytics in future research.

Keywords: *Goods and Services Tax (GST), Taxable Value, Data Analysis, Linear Regression, EDA, Invoice Analytics, Tax Administration, Baseline Modelling*

INTRODUCTION
The introduction of the Goods and Services Tax (GST) unified India's indirect tax structure and created a digitally driven taxation ecosystem. With thousands of invoices generated daily, GST data provides a rich source of quantitative information that can support compliance monitoring, detect anomalies, and reveal taxpayer behaviour.

This research investigates GST invoice patterns using data science techniques, with emphasis on Exploratory Data Analysis (EDA) and simple predictive modelling. Rather than building a complex machine learning solution, the study evaluates the explanatory power of basic invoice features—such as tax rate, invoice value, and tax components— on taxable value. This approach provides interpretable insights for taxation stakeholders while maintaining a practical, realistic scope.

The implementation of GST simplified India's complex tax framework, but it initially disrupted established accounting practices and compliance workflows. Tax consulting firms, acting as intermediaries between regulatory authorities and businesses, had to swiftly adapt to new systems, reporting formats, and technological advancements.

This study aims to harness data analytics and predictive modelling to generate actionable insights that can facilitate adaptive strategies and data-driven decision-making within tax consulting firms. Since the GST's rollout in July 2017, tax consulting firms in India have faced an evolving tax regime marked by frequent amendments, complex compliance processes, and the need for technological integration. GST replaced multiple indirect taxes with a unified tax structure, which increased regulatory complexity and the workload for consultancy services.

OBJECTIVES OF THE STUDY
1. To create interactive dashboards and infographics for visualizing business data.
2. To identify and analyze key factors influencing firm performance.
3. To derive data-driven insights to support managerial decision-making.
4. To apply Simple Linear Regression (SLR) for predictive business analysis.

LITERATURE REVIEW:

Maruthi (2020) examined the ambiguity surrounding GST applicability on FMCG products, particularly promotional schemes such as "buy one get one free." The study highlighted the lack of clarity in GST treatment for frequently purchased goods and emphasized the need for clearer guidelines for FMCG businesses.

Dhar and Khandelwal (2020) conducted a bibliometric analysis of GST research published between 2004 and 2019. Reviewing 177 Scopus-indexed papers, they found a steady rise in GST-related scholarship and noted that over 150 countries follow GST or VAT systems, indicating continued scope for future research.

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Revathi and Aithal (2019) explored global implications of GST and its Indian context. They concluded that eliminating the Central Sales Tax under GST would reduce logistics and storage costs and enhance product accessibility through lower prices and improved supply chain efficiency.

Sidik et al. (2019) reviewed Malaysia's transition from the Sales and Services Tax to GST. Their analysis of academic and public sources revealed both systems have strengths and weaknesses and emphasized the importance of learning from past tax reforms to improve future implementations.

Thattil (2018) compared India's dual GST structure with the unified GST systems used globally. The study assessed global VAT and GST frameworks, noting that India's model creates unique administrative challenges but also opportunities for federal-state coordination.

Kapoor (2018) evaluated the impact of GST on India's economic growth and found that GST simplifies the indirect tax system, reduces operational costs, and enhances industry competitiveness across sectors.

Khan (2018) analyzed GST's objectives, challenges, and opportunities within India. The study concluded that GST, as a major tax reform, would support long-term national growth by streamlining indirect taxation.

Nayyar and Singh (2018) provided a comprehensive overview of India's GST system, comparing Indian tax rates with those of other economies. They argued that GST would boost tax revenue, strengthen intergovernmental cooperation, and support economic expansion.

Kar and Sahore (2018) reviewed the relevance of HSN codes in GST implementation. They found that adopting HSN classification aligns India's tax system with international standards, simplifying trade and ensuring global harmonization.

Murugaiyan et al. (2017) investigated public awareness of the GST Amendment Bill in Sivakasi. Findings revealed insufficient GST awareness among illiterate populations and women, emphasizing the need for targeted education programs.

Mridha and Yadav (2020) analyzed GST registrations, return filings, and state-wise revenue contributions. They observed significant growth in GST collections from 2018 to 2020 and highlighted the pandemic's influence on tax revenue patterns.

Govindan (2019) examined month-wise GST revenue trends and return filings. The study linked GST with improvements in GDP, investment potential, and corporate sector growth, indicating positive macroeconomic impacts.

Abhishek et al. (2019) explored the future trajectory of GST in India. They found that GST is likely to yield long-term national benefits and attract domestic and international business investment.

Banerjee and Agrawal (2018) assessed the impact of GST using primary survey data. Their findings suggested that GST was expected to stimulate long-term economic growth despite initial implementation challenges.

Bindal and Gupta (2018) analyzed GST's role in enhancing efficiency and transparency in India's tax structure. Their secondary-data analysis showed a positive economic impact post-GST rollout.

Aneja (2018) reviewed GST's effects on various economic sectors. The study highlighted changes in consumer behavior, business operations, and administrative processes while noting challenges faced during implementation.

Banerjee and Agrawal (2018) (second article) evaluated GST's impact on tax compliance behavior. They emphasized the need for simplification of procedures and greater awareness to strengthen compliance.

Mishra (2018) provided an overview of GST's short-term and long-term impact on the Indian economy, highlighting opportunities and challenges during its implementation phase.

Asokan and Jayakodi (2018) assessed macroeconomic implications of GST and noted that successful implementation depends on inter-state cooperation and effective GST Council decision-making. They referenced IMF projections showing long-term GDP growth potential exceeding 8%.

Agrawal (2017) reviewed GST through secondary data, emphasizing its role in improving business competitiveness, economic efficiency, and compliance behavior.

Lourdunathan and Xavier (2017) discussed the prospects and challenges of GST implementation. They concluded that taxpayer training, workshops, and awareness campaigns are essential for smooth adoption.

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Mujalde and Vani (2017) studied GST's economic, fiscal, and administrative outcomes. They concluded that GST reduces distortions caused by India's earlier complex tax system and strengthens the national market.

Ramya and Sivasakthi (2017) examined sector-wise GST implications across industries such as FMCG, construction, financial services, IT, and railways. They also linked GST with Make in India and manufacturing competitiveness.

Yadav (2017) evaluated GST's role in economic growth and development, finding that proper structure and implementation can increase government revenues and support national progress.

Khurana and Sharma (2016) analyzed GST's benefits for producers and consumers, noting that GST simplifies tax credits and subsumes numerous indirect taxes, making it a positive reform for India's tax system.

Arpit and Shailesh (2016) studied GST's sectoral impact based on consumer surveys. They found mixed effects across industries, with some sectors experiencing significant benefits while others showed neutral responses.

Research Gap: Despite extensive scholarly attention on the Goods and Services Tax (GST) in India, existing literature predominantly concentrates on macroeconomic outcomes, policy implications, sectoral impact assessments, and compliance-related challenges. Most prior studies adopt conceptual, descriptive, or survey-based methodologies, with limited emphasis on granular transactional data analysis. There remains a significant gap in the empirical examination of invoice-level GST data using structured data science methodologies.

Furthermore, while GST components such as CGST, SGST, and IGST have been widely discussed in theoretical and policy contexts, quantitative validation of their interrelationships through real invoice datasets is underexplored. The majority of research does not investigate patterns embedded within large-scale GST invoice records that can reveal transactional behavior, tax slab concentration, or intra-state versus inter-state supply dynamics.

Additionally, limited studies incorporate Exploratory Data Analysis (EDA) and interpretable predictive modelling techniques, such as baseline Linear Regression, to assess the explanatory power of invoice attributes on taxable value. There is also a noticeable absence of practical analytical frameworks that can assist tax consulting firms and stakeholders in utilizing GST data for informed decision-making.

Therefore, this study addresses these gaps by applying a structured data science approach to analyze over 4,400 GST invoices, employing EDA and baseline regression modelling to generate interpretable and actionable insights. By focusing on invoice-level empirical validation and predictive analysis, the research contributes to bridging the methodological and practical gaps in existing GST literature.

RESEARCH METHODOLOGY

Mixed-method approach combining descriptive analysis with quantitative modelling.

1. Research Design:

Descriptive and analytical research design will be adopted to evaluate both present conditions and future predictions for the tax consulting sector.

2. Data Collection:

- **Primary Data:** Surveys and interviews conducted with professionals in tax consulting firms.
- **Secondary Data:** Published reports, industry datasets from government and tax authorities, and relevant online databases.

3. Variables:

- **Dependent Variable (Y):** Firm performance index (measured by revenue or client retention rate).
- **Independent Variable (X):** External business environment factors such as compliance complexity, digital adoption, and economic recovery pace.

4. Analytical Tools Used:

- Matplot lib, for dashboard and infographic creation.
- Statistical tools Jupyter Notebook for regression modeling.
- Visualization tools for representing data trends and insights.

The dataset contains 4,401+ GST invoice records with the following fields:

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- GSTIN
- Legal Name
- Invoice Number
- Invoice Type (e.g., R = Regular)
- Invoice Date
- Invoice Value (₹)
- Reverse Charge (Y/N)
- Tax Rate (%)
- Taxable Value (₹)
- Integrated Tax (IGST)
- Central Tax (CGST)
- State/UT Tax (SGST)

A. Data Characteristics

- Minor missing values in initial rows
- Invoices span the years 2021–2022
- Multiple tax slabs (5%, 12%, 18%)
- Majority IGST = 0 → indicates intra-state transactions
- CGST ≈ SGST for most invoices, as expected

Table I — Sample Dataset Snapshot from Google-Collb

Out[3]:

	GSTIN	Legal name	Invoice number	Invoice type	Invoice date	Invoice value (₹)	Supply attract reverse charge	Rate (%)	Taxable value (₹)	Integrated tax (₹)	Central tax (₹)	State/UT tax (₹)	Cess (₹)
0	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1	1666.0	2264.0	DDL/1078	R	12/04/2021	7145.0	N	5.0	1923.32	0.0	48.08	48.08	0.0
2	9927.0	58.0	DDL/1078	R	12/04/2021	7145.0	N	12.0	4576.00	0.0	274.56	274.56	0.0
3	3938.0	2777.0	DDL/1325	R	14/04/2021	1617.0	N	12.0	1443.59	0.0	86.62	86.62	0.0
4	4801.0	2668.0	DDL/1702	R	17/04/2021	4058.0	N	12.0	3256.85	0.0	195.41	195.41	0.0
...	...	...	...	...	...	...	...	...	...	...	...	...	...
4397	6847.0	4840.0	JK2360	R	11/06/2021	1052.0	N	18.0	891.90	0.0	80.27	80.27	0.0
4398	6204.0	4866.0	JK5256	R	16/08/2021	610.0	N	18.0	516.70	0.0	46.50	46.50	0.0
4399	6413.0	924.0	JK9934	R	22/11/2021	501.0	N	18.0	424.16	0.0	38.17	38.17	0.0
4400	8122.0	1405.0	JK12204	R	10/01/2022	496.0	N	18.0	420.30	0.0	37.83	37.83	0.0
4401	1507.0	3517.0	JK15757	R	14/03/2022	987.0	N	18.0	836.75	0.0	75.31	75.31	0.0

Source: - "SS Tax Consultant Pvt.Ltd A.Y 2023 (Opened in Analytical Tool – Google Collab)

The research follows the standard data science lifecycle.

A. Data Cleaning

- Removal of null and incomplete rows
- Conversion of date fields into consistent formats
- Label encoding for categorical features
- Correction of inconsistent values (e.g., R/Y/N fields)

B. Exploratory Data Analysis (EDA)

EDA was conducted to understand:

- Frequency of tax slabs
- Variation in invoice values

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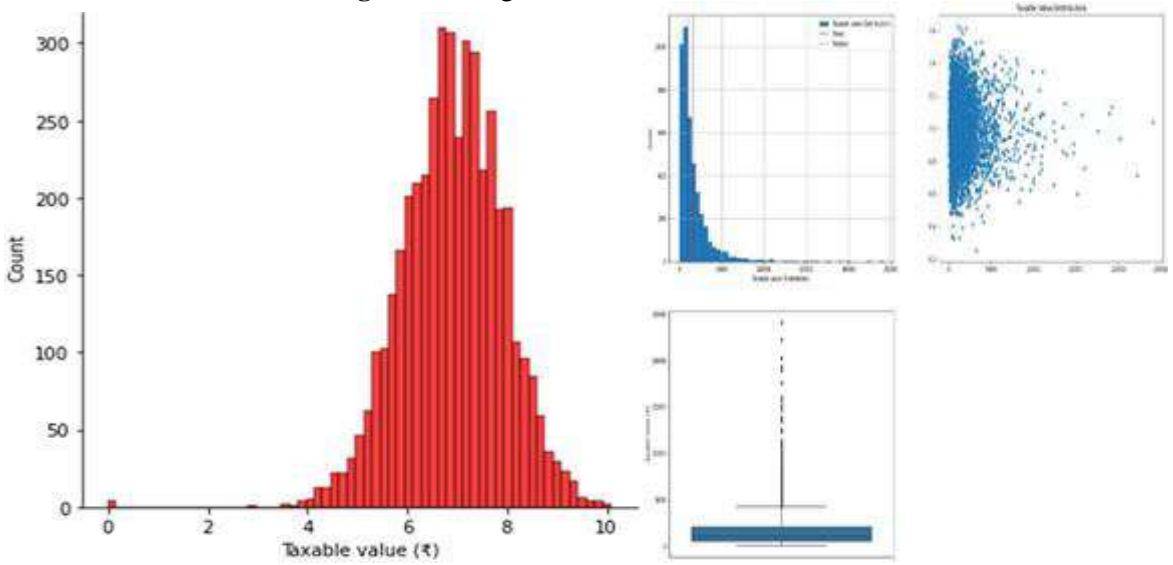
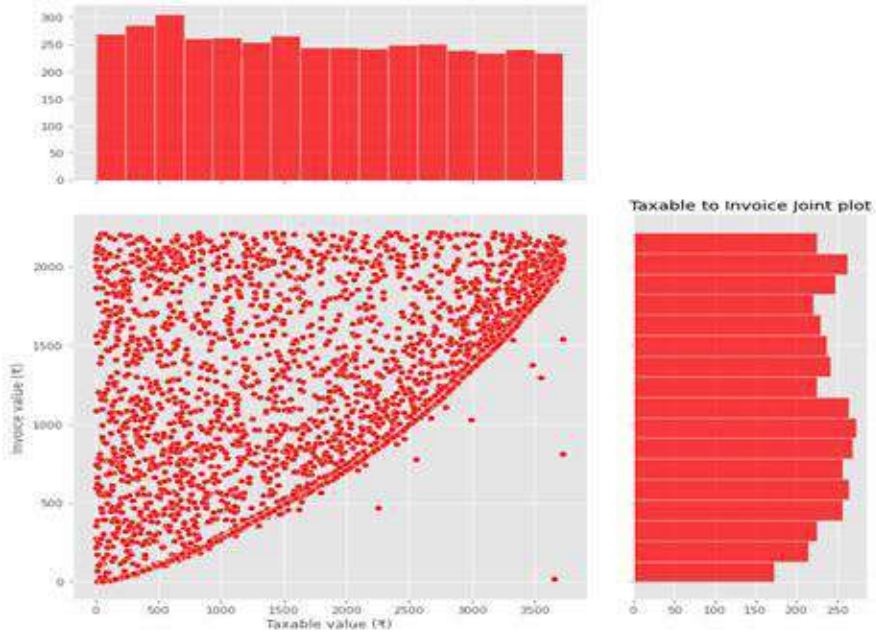
- tax component patterns
- Proportion of intra-state vs inter-state invoices
- Outlier presence in taxable value

Fig. 1 — Histogram of Tax Rate Distribution



Source - (Microsoft DS Tools > Jupyter NB >Python Program Module > Matplotlib)

Fig. 2 — Invoice Value vs Taxable Value Scatter Plot



Source - (Microsoft DS Tools > Jupyter NB >Python Program Module > Matplotlib)

C. Baseline Regression Modelling

A Linear Regression model was trained with the equation: [Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + ... + \beta_nX_n]

Where:

- (Y): Taxable Value
- (X_i): Invoice attributes (Rate, Invoice Value, Invoice Type, etc.) The dataset was split into training and test sets.

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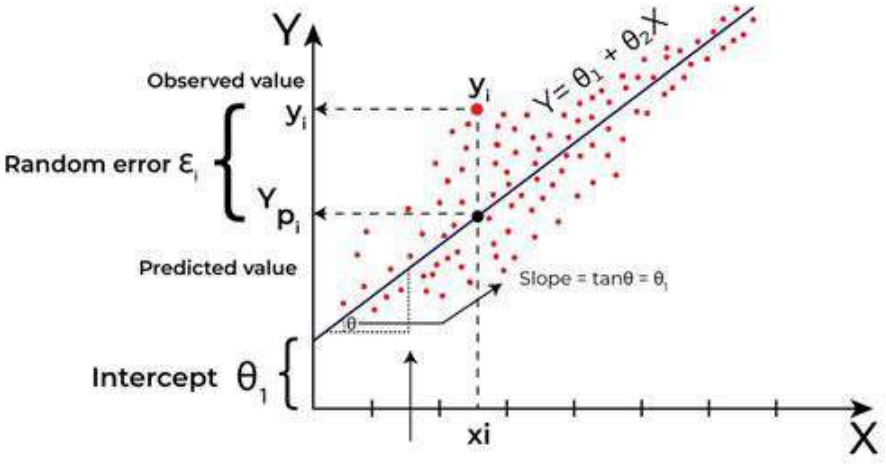


Mathematical expression visualization for Supervised SLR

Source – Linear Algebra >Medium > https://medium.com/@harshithasharma14/simple-linear-regression-slr-a92ebb5f37de

II. MODEL TRAINING AND EVALUATION

A. Model Used

- **Linear Regression** (Supervised Learning)
- Used as a *baseline* model, not an advanced method

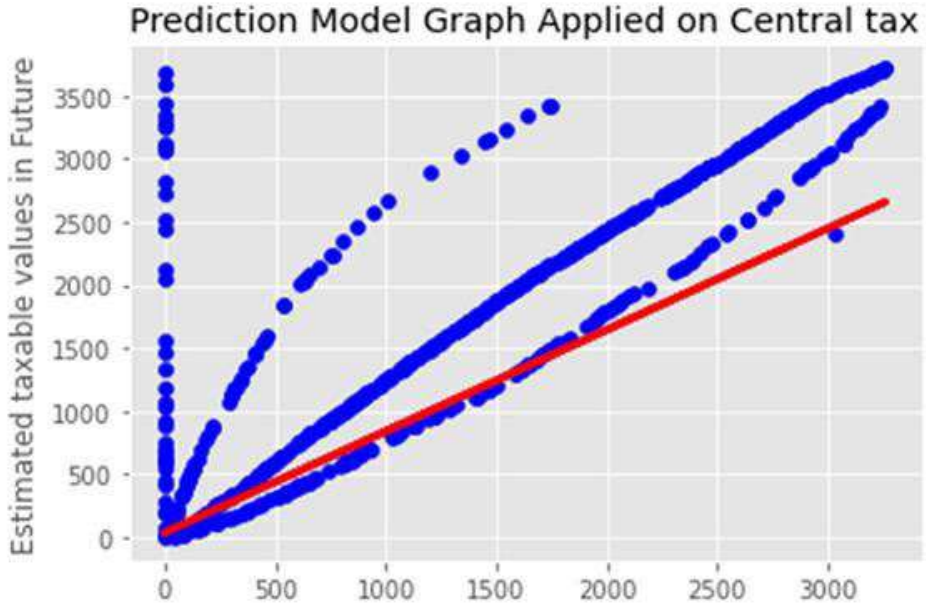
B. Evaluation Metric

The model achieved:

[R^2 = 0.7919 \approx. 79%]

This indicates that approximately 79% of the variance in taxable value can be explained by the selected features—reasonable for a baseline model.

Fig. 3 — Actual vs Predicted Values Plot



Source - (Microsoft DS Tools > Jupyter NB >Python Program Module > Matplotlib)

Interpretation of Plot

In an ideal regression model, all data points would lie exactly on a 45-degree diagonal reference line, indicating perfect prediction accuracy where predicted values equal actual values. In the present study, the majority of data points are distributed closely around this diagonal trend, suggesting that the model provides a reasonably accurate estimation of taxable values.

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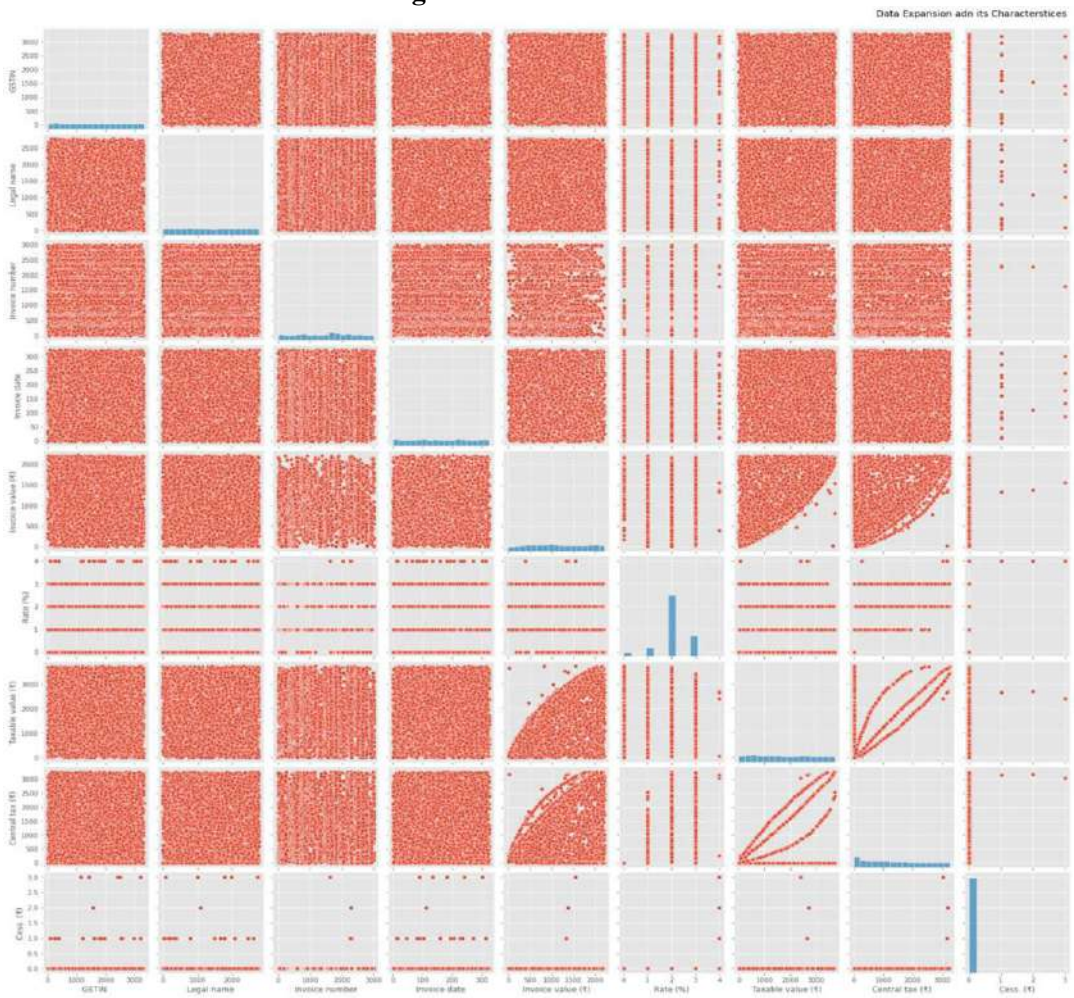
The clustering of observations near the diagonal line indicates a strong positive linear relationship between the independent variables (such as Invoice Value and Tax Rate) and the dependent variable (Taxable Value). The dispersion of a few points away from the diagonal line reflects prediction errors, which may arise due to high-value invoices, minor data irregularities, or variables not included in the model.

The visual pattern supports the model's R^2 score of approximately 0.79, indicating that nearly 79% of the variation in taxable value is explained by the selected invoice attributes. While the model does not achieve perfect prediction, it demonstrates satisfactory performance for a baseline, interpretable regression framework.

Overall, the Actual vs Predicted plot confirms that the Linear Regression model captures the primary trend in the data and provides meaningful explanatory power, while also highlighting areas where future advanced modelling techniques could further improve predictive accuracy.

Fig. 4 — EDA Values Plot



Source - (Microsoft DS Tools > Jupyter NB >Python Program Module > Matplotlib)

III. RESULTS AND DISCUSSION

A. EDA Findings

- Most invoices fall under 12% and 18% tax slabs
- IGST values are nearly zero → mostly intra-state supplies
- CGST and SGST are balanced and proportional
- Invoice value strongly correlates with taxable value
- A few high-value outliers present

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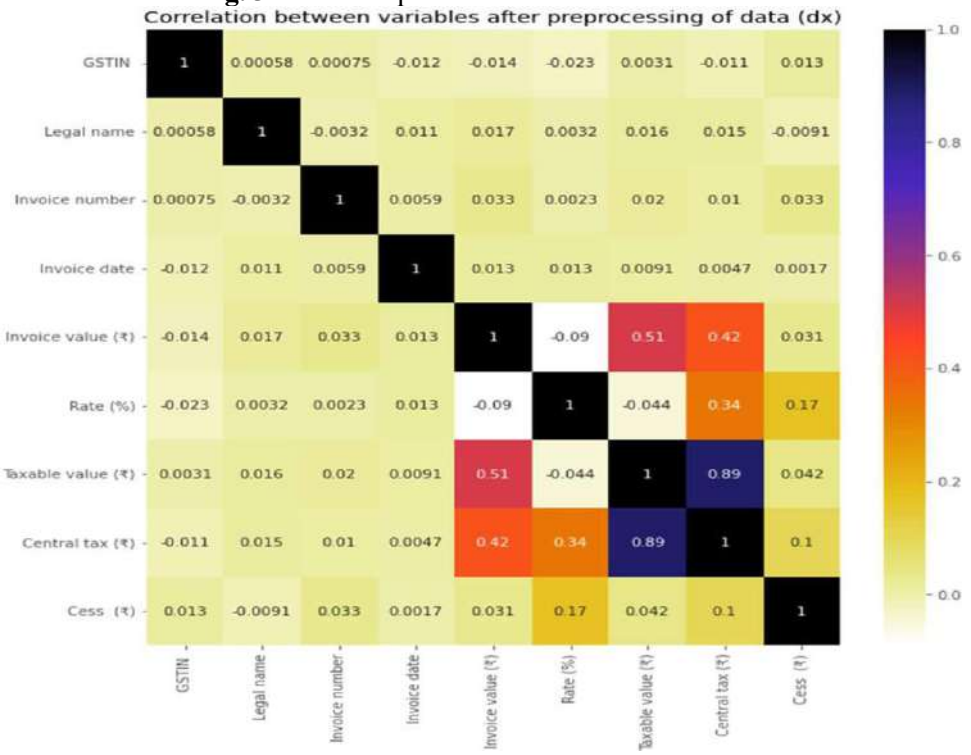
Fig. 5 — Heatmap Plot of Variable Performance



Source - (Microsoft DS Tools > Jupyter NB >Python Program Module > Matplotlib/ seaborn)

B. Regression Insights

- Invoice Value shows the strongest positive influence on Taxable Value
- Tax Rate (%) is a significant predictor
- Invoice Type (mostly regular) provides stable behaviour
- The model performs adequately for interpretability, not high accuracy

```
In [239]: #A=dx[['Taxable value (₹)']]      # Independnet  var. : Taxable value  : A
          #B=dx[['Central tax (₹)']]       # Dependent var.     : Central tax   :B

In [240]: p_pred=model.predict(B_test)

In [241]: p_pred

Out[241]: array([[ 430.2148633 ],
                 [1600.73169425],
                 [2288.85342432],
                 [2557.40410416],
                 [1575.88997601],
                 [ 332.13584312],
                 [1162.59188904],
                 [1517.92727558],
                 [1568.57463845],
                 [2191.61759449],
```

Source - (Microsoft DS Tools shell > Jupyter NB >Python Program Module > Pandas /Numpy)

CONCLUSION

This study offers a practical analytical framework for understanding GST invoices through Exploratory Data Analysis and a baseline Linear Regression model. The model's R^2 score of approximately 0.79 indicates that invoice amount and tax rate are strong predictors of taxable value. Although the model is not intended for operational use, it provides meaningful interpretability and forms a solid foundation for developing more advanced tax analytics tools. Overall, the analysis highlights how GST invoice data can assist businesses in estimating taxable values, support tax authorities in detecting unusual patterns, and demonstrate the broader potential of simple analytics in enhancing transparency, compliance, and informed decision-making within tax administration.

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ROLE OF CUSTOMER EXPERIENCE MANAGEMENT IN RESHAPING THE E-COMMERCE ECOSYSTEM

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ABSTRACT
The proliferation of e-commerce platforms has fundamentally altered the structure and dynamics of contemporary business ecosystems. Within this context, Customer Experience Management (CEM) has emerged as a critical mechanism for enhancing transactional and relational outcomes. This study examines the influence of CEM on the e-commerce ecosystem, with particular emphasis on dimensions including website usability, service quality, personalization, trust, and post-purchase support. Employing a mixed-method approach, primary data were collected through a structured survey of 106 online consumers, complemented by secondary data from extant literature and industry analyses. Empirical findings indicate that robust CEM practices substantially elevate customer satisfaction and loyalty, which, in turn, reinforce inter-organizational and customer-seller relationships within the e-commerce ecosystem. The research contributes to theoretical frameworks by establishing a linkage between CEM implementation and ecosystem-level performance, providing managerial implications for the strategic optimization of digital commerce platforms.

Keywords: *Customer Experience Management, E-Commerce Ecosystem, Customer Satisfaction, Digital Commerce, Service Quality*

1. INTRODUCTION

E-commerce has experienced unprecedented growth over the past decade, driven by technological advancements, increased internet penetration, and changing consumer behaviors.

Platforms such as Amazon, Flipkart, and Myntra have created intricate digital ecosystems connecting buyers, sellers, logistics partners, and technology providers. In this highly competitive environment, customer experience has become a crucial differentiator.

Customer Experience Management (CEM) refers to the strategic process of designing, monitoring, and improving all interactions that a customer has with a company across the entire buying journey. It is not limited to individual transactions but encompasses pre-purchase, purchase, and post-purchase interactions.

In e-commerce, where physical interactions are minimal, effective CEM can significantly enhance trust, satisfaction, and loyalty, creating positive network effects within the ecosystem. The current study aims to analyze how CEM reshapes the e-commerce ecosystem by influencing customer satisfaction, trust, and long-term engagement.

2. PROBLEM STATEMENT:

Despite rapid growth of e-commerce, many platforms still struggle to deliver consistent and satisfying customer experiences across all touchpoints. Customers often face issues such as poor website usability, delayed deliveries, weak customer support, and lack of personalization, which affect their trust and loyalty. Therefore, there is a need to understand how effective Customer Experience Management (CEM) can address these challenges and how it plays a crucial role in reshaping the e-commerce ecosystem by improving customer satisfaction, retention, and long-term business performance.

3. LITERATURE REVIEW

Customer Experience Management (CXM) has gained significant importance in the e-commerce ecosystem as businesses increasingly focus on customer-centric strategies. Parasuraman, Zeithaml, and Malhotra (2005) highlighted that electronic service quality significantly influences customer satisfaction and online shopping experience. Their work provided a foundation for understanding customer experience in digital platforms.

Pakarti et al. (2022) identified trust, communication quality, and ease of use as key factors influencing customer satisfaction and repurchase intention in e-commerce. Beyari and Ghouth (2018) highlighted the role of social interaction and user-generated content in enhancing customer experience within social commerce environments.

Urdea and Constantin (2021) emphasized that customer experience acts as a competitive advantage in e-commerce, where website design, interactivity, and information quality positively affect customer loyalty.

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Ahmad et al. (2022) further observed that positive online customer experiences enhance customer engagement, leading to increased customer loyalty.

Recent studies indicate that technological advancements such as artificial intelligence, personalization, and omnichannel strategies play a crucial role in improving customer experience **(Moore, 2021; Gerea et al., 2021)**. Overall, the literature suggests that CXM has transformed e-commerce from a transaction-focused model to a customer-oriented ecosystem.

4. SECONDARY DATA

Secondary data supports the growing role of customer experience in e-commerce.Statista (2023) reported steady growth in global e-commerce sales, along with rising customer expectations for fast delivery and seamless online interaction. McKinsey & Company (2021) and Accenture (2020) found that organizations investing in customer experience technologies achieve higher customer retention and repeat purchases.

PwC (2018) reported that customers are willing to pay more for better online experiences, while poor experiences lead to customer switching. Salesforce (2022) highlighted that personalized digital experiences increase customer satisfaction and loyalty.

5. RESEARCH OBJECTIVES

1. To examine customer perceptions of experience management in e-commerce.
2. To analyze the impact of customer experience on customer satisfaction.
3. The impact of customer experience on customer satisfaction.
4. To study the relationship between customer experience and trust, loyalty, and ecosystem strength.
5. To assess the role of CEM in reshaping the e-commerce ecosystem.

6. RESEARCH METHODOLOGY

6.1 Research Design

The study uses a descriptive and analytical research design combining primary and secondary data. Primary data were collected via an online survey, and secondary data were sourced from journals, books, and industry reports.

6.2 Sample Size and Sampling Technique

A total of **106 online shoppers** participated, selected using **convenience sampling**. All respondents had made at least one online purchase in the past six months.

6.3 Research Instrument

A structured questionnaire was used, covering the following sections:

1. Demographic information.
2. Online shopping behavior.
3. Customer experience dimensions: website usability, service quality, personalization, trust, and post-purchase support.
4. Satisfaction, loyalty, and ecosystem perception.

6.4 Data Analysis Tools

- **Descriptive statistics** (Percentage method and thematic analysis)

7. DATA ANALYSIS AND INTERPRETATION

7.1 Demographic Profile

- **Gender:** 46.2% male, 53.8% female
- **Age Group:** Majority (38.7%) were 26–35 years
- **Education:** 70% undergraduate or postgraduate
- **Occupation:** 60% Working Professionals

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Interpretation: The demographic profile shows that the study mainly represents young, well-educated working professionals, with a slightly higher participation of females.

7.2 Awareness and Importance of Customer Experience Management (CEM)

- Most respondents are aware of CEM.
- Customer experience is rated as highly important in online shopping.
- Website/App usability is a major influencing factor.
- Pricing and discounts strongly affect purchase decisions.
- Delivery speed and customer support are key service-related factors.

Interpretation: These results show that customers recognize the importance of Customer Experience Management, with usability, pricing, delivery speed, and customer support playing a crucial role in shaping online shopping decisions and overall satisfaction.

7.3 Impact of Customer Experience Management

- Most respondents feel there is a significant improvement in online shopping experience over recent years.
- Customers are extremely likely or likely to repurchase from platforms offering excellent experience.
- Personalized offers, easy returns, and prompt customer support are the main CEM practices enhancing loyalty.
- CEM results in improved customer satisfaction, stronger brand loyalty, service innovation, and increased competition.

Interpretation: These findings indicate that improvements in online shopping experience, supported by effective CEM practices, strongly encourage repeat purchases, enhance customer loyalty, and drive competitive and innovative growth in e-commerce.

7.4 Customer Expectations

- Most respondents are very satisfied or satisfied with their overall online shopping experience.
- Customers are extremely likely or likely to recommend platforms that provide good customer experience.
- Website/App usability, delivery speed, and customer support are the most important areas for improvement.

Interpretation: These results show that while customers are generally satisfied and willing to recommend e-commerce platforms, further improvements in usability, delivery speed, and customer support can strengthen overall experience and loyalty.

7.5 Ecosystem Impact

Survey responses indicated that:

- 78% agreed that positive experiences strengthen relationships between customers, sellers, and service providers.
- 74% felt that satisfied customers contribute to ecosystem growth.
- 70% believed that trust generated by good experiences enhances platform reliability.

Interpretation: Customer experience management has a strong influence on ecosystem health and sustainability.

8. DISCUSSION

The findings reinforce that **CEM is a critical driver of the e-commerce ecosystem**. High-quality experiences improve satisfaction and loyalty, while trust encourages repeated transactions. Ecosystem-wide benefits include improved collaboration, stability, and platform growth.

Interestingly, personalization was rated moderately, suggesting room for improvement in tailoring experiences. Managers should focus on delivering **seamless website navigation, secure transactions, and efficient delivery** as top priorities.

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9. **Managerial Implications**

1. **Website and App Design:** Platforms should invest in intuitive navigation and engaging interfaces.
2. **Service Efficiency:** Fast deliveries and responsive support are critical.
3. **Security Measures:** Payment safety and data protection build customer trust.
4. **Personalization:** AI-driven recommendations can enhance loyalty.
5. **Ecosystem Thinking:** Satisfied customers strengthen overall platform relationships, benefiting all stakeholders.

10. **Theoretical Contributions**

This study links **CEM with e-commerce ecosystem theory**, extending research beyond individual satisfaction to network-level outcomes. Integrating **SERVQUAL** and **Expectation-Confirmation Theory** provides a comprehensive framework to study digital commerce interactions.

11. Questionnaire:

Section A: Demographic Information

1. **Age group:**
Below 18 / 18–25 / 26–35 / 36–45 / Above 45

2. **Gender:**
Male / Female / Other

3. **Occupation:**
Student / Working Professional / Business Owner / Other

4. **Frequency of online shopping:**
Daily / Weekly / Monthly / Rarely

Section B: Awareness and Importance of Customer Experience Management (CEM)

5. **Awareness of Customer Experience Management (CEM):**
Yes / No

6. **Importance of customer experience in online shopping:**
Extremely important / Important / Neutral / Less important / Not important

7. **Key factors influencing online shopping experience (Select up to 3):**
Website/App usability, Product variety, Pricing/discounts, Delivery speed, Customer support, Personalization, Return/exchange policies

Section C: Impact of Customer Experience Management

8. **Perceived improvement in online shopping experience over recent years:** Significant / Slight / No improvement
9. **Likelihood of repeat purchase from platforms with excellent customer experience:** Extremely likely / Likely / Neutral / Unlikely / Extremely unlikely
10. **CEM practices that enhance customer loyalty (Select up to 3):** Personalized offers, Easy returns, Prompt support, Loyalty programs, User-friendly interface, Proactive communication
11. **Impact of CEM on e-commerce businesses (Select all that apply):** Improved satisfaction, Increased competition, Service innovation, Stronger brand loyalty, No significant impact

Section D: Customer Expectations

12. **Overall satisfaction with online shopping customer experience:** Very satisfied / Satisfied / Neutral / Dissatisfied / Very dissatisfied
13. **Likelihood of recommending an e-commerce platform based on customer experience:** Extremely likely / Likely / Neutral / Unlikely / Extremely unlikely
14. **Most important area for improving customer experience:** Website/App usability, Delivery speed, Customer support, Personalized offers, Return/exchange policies.

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12. Limitations and Future Research

- Convenience sampling may limit generalizability.
- Cross-sectional survey captures perception at one point; longitudinal studies could examine changes over time.
- Future research could explore **specific demographic segments** or **emerging technologies (AI, VR)** in CEM.

13. RECOMMENDATION:

- Focus on customers at every stage of online shopping.
- Use AI and digital tools to improve interaction.
- Analyze customer feedback to improve services.
- Ensure websites and apps are simple, fast, and secure.
- Offer a consistent experience across all platforms.
- Build trust with clear information and easy returns.
- Train staff to improve customer support.
- Update strategies as customer needs change.

14. CONCLUSION

Customer experience management plays a vital role in reshaping the e-commerce ecosystem. Positive experiences enhance satisfaction, trust, and loyalty, which in turn strengthen ecosystem relationships among customers, sellers, and service providers. E-commerce platforms that strategically manage CEM can achieve competitive advantage and sustainable growth in the digital economy.

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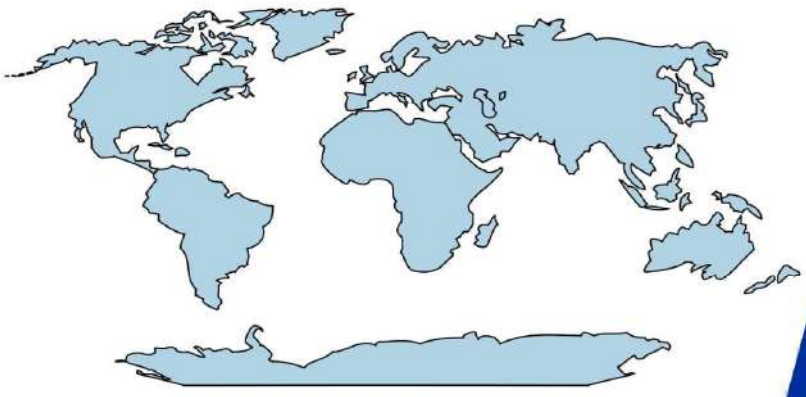

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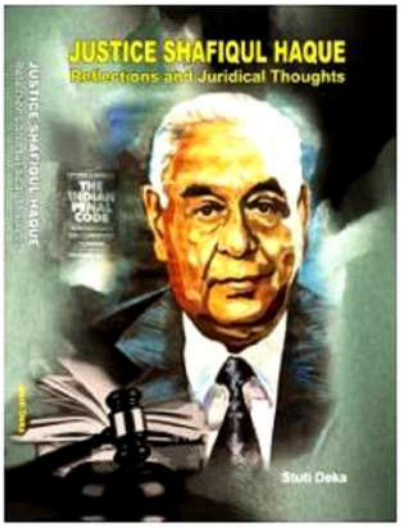

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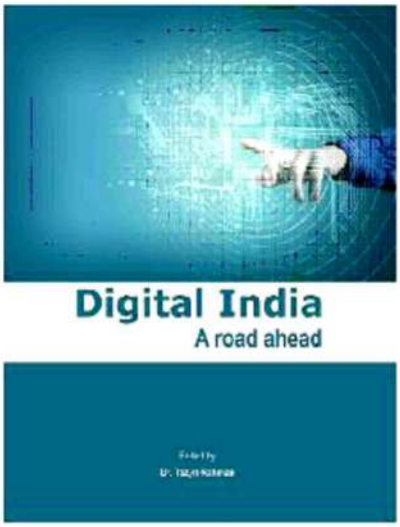

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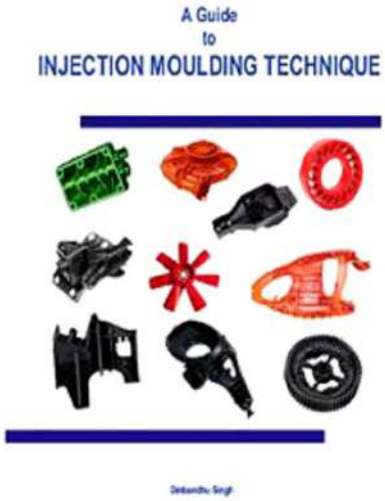

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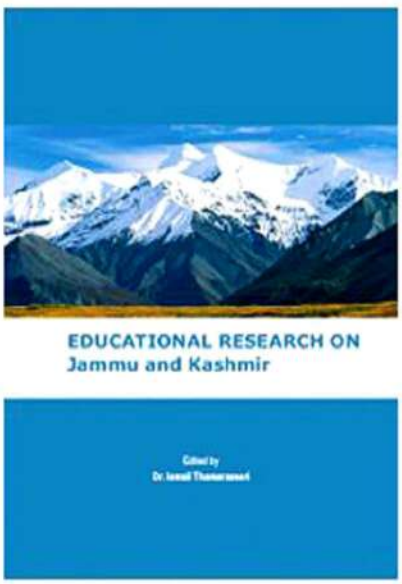

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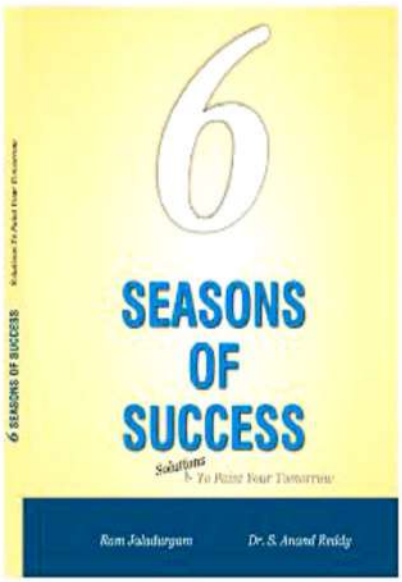

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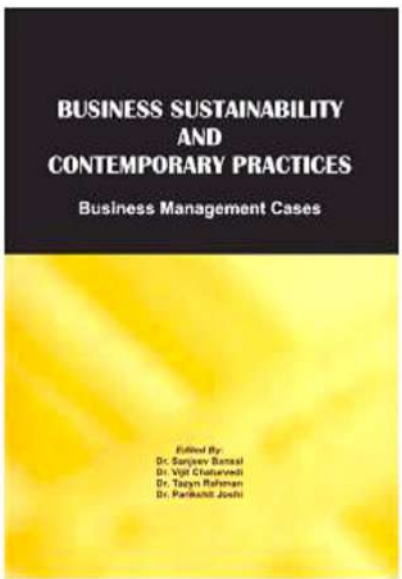

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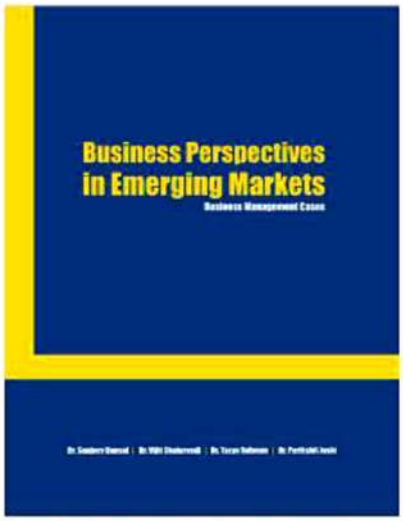

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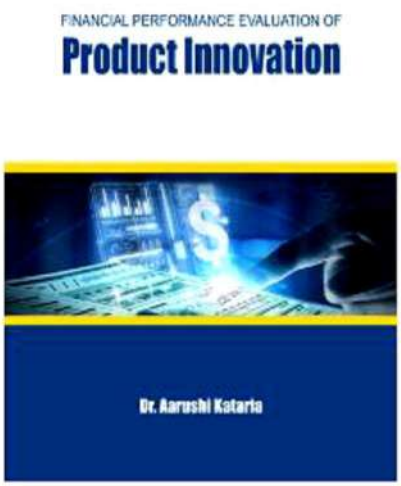

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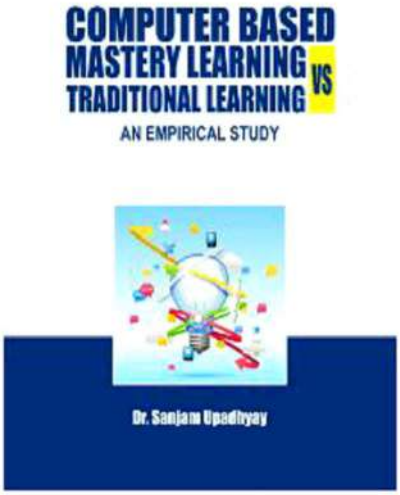

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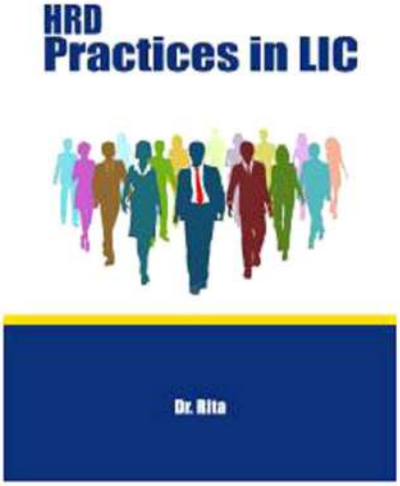

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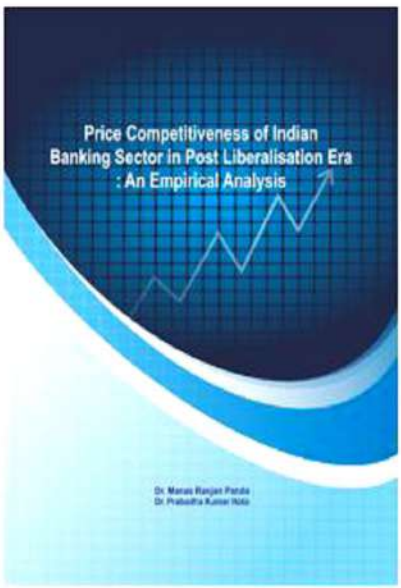

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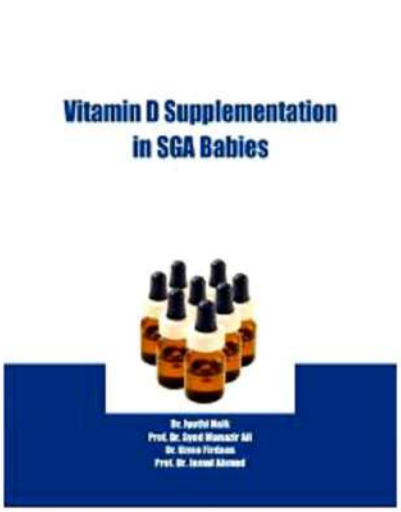

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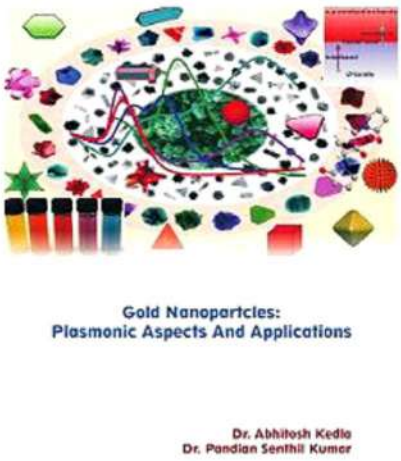

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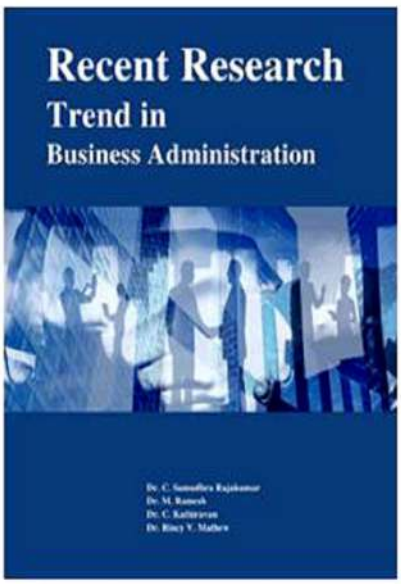

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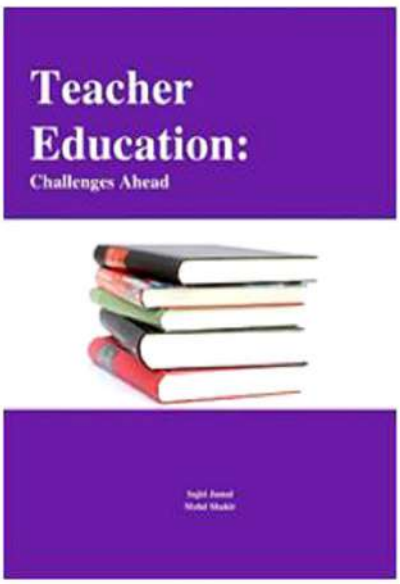

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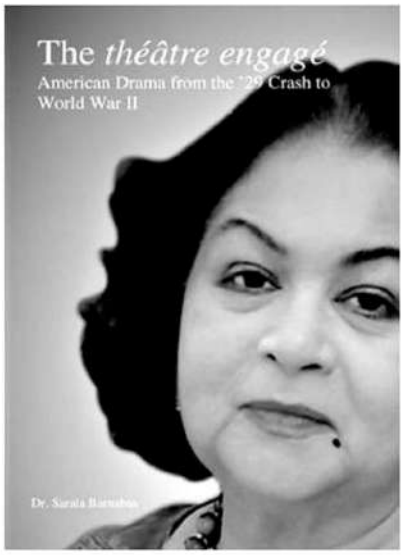

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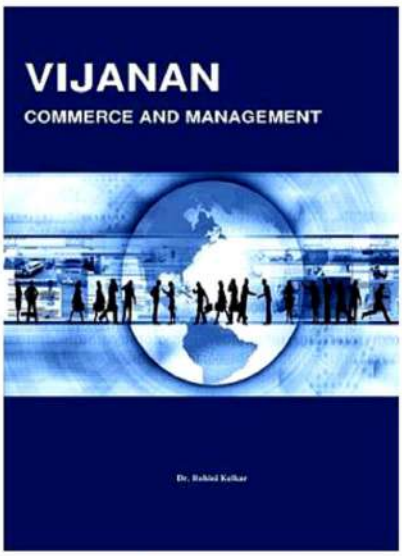

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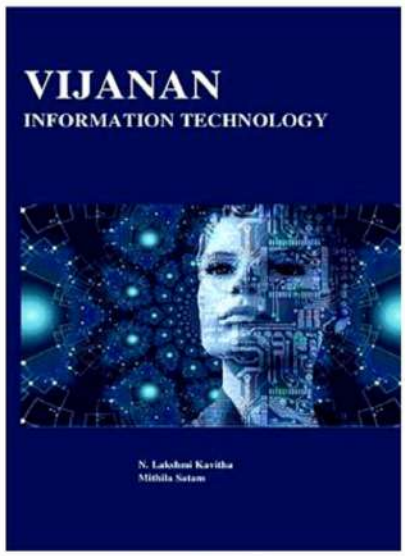

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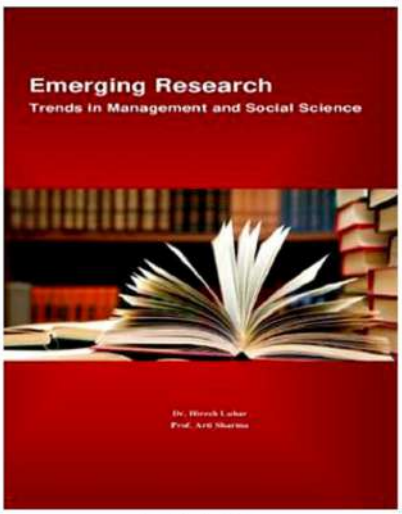

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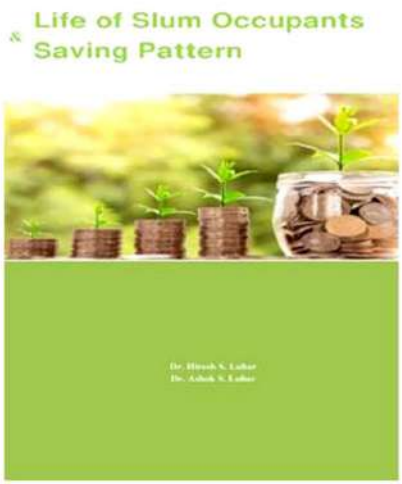

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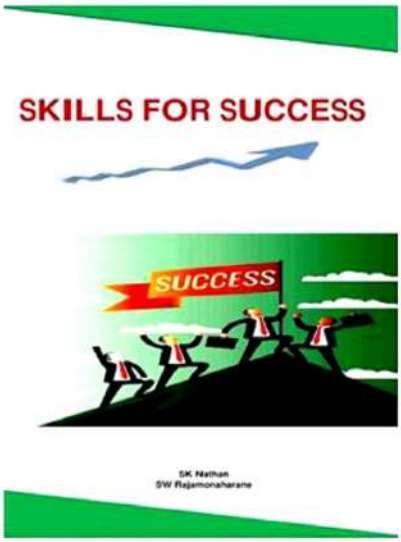

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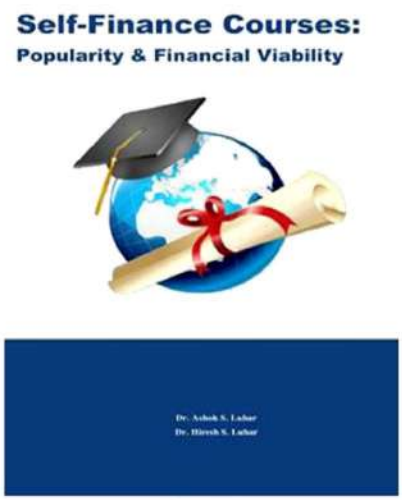

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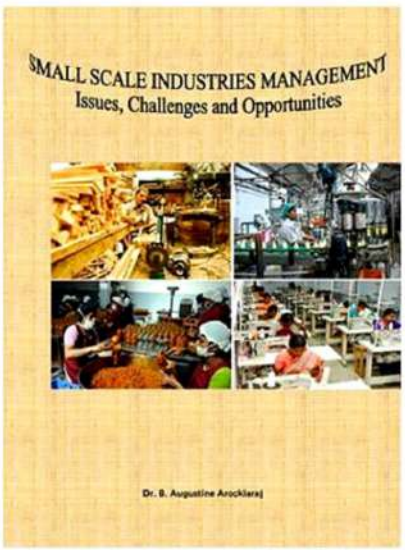

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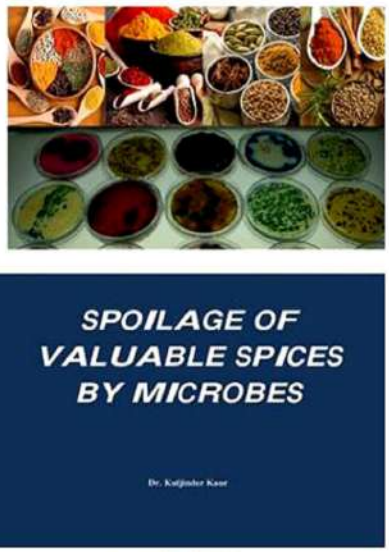

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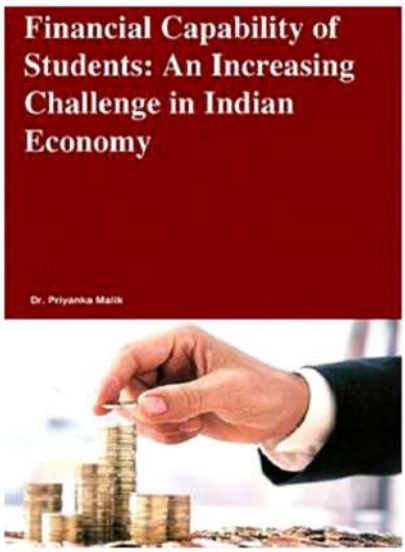

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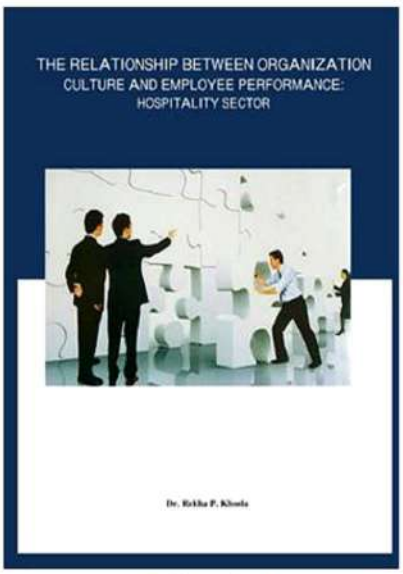

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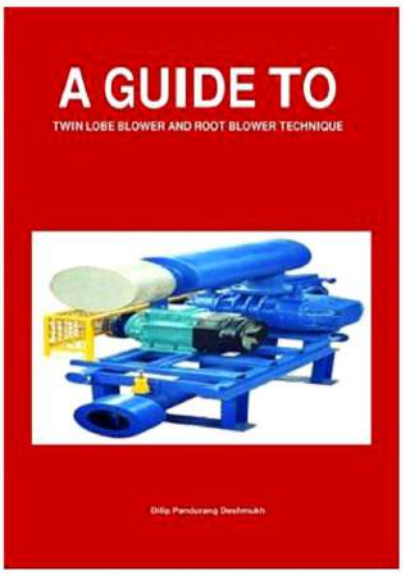

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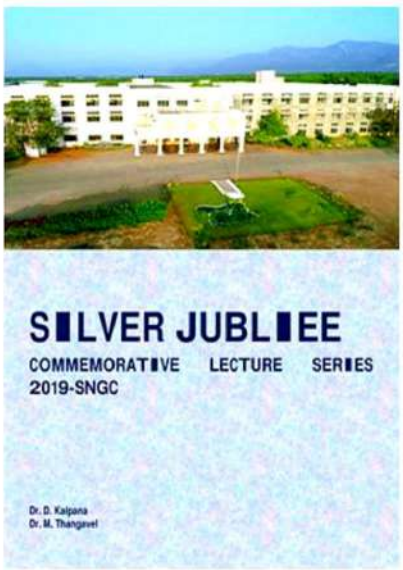

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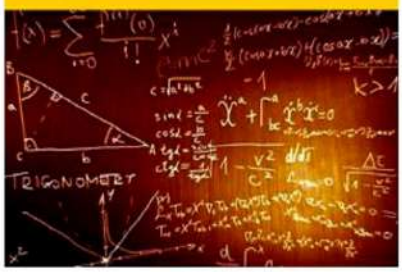

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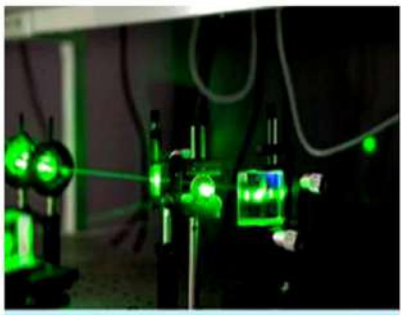

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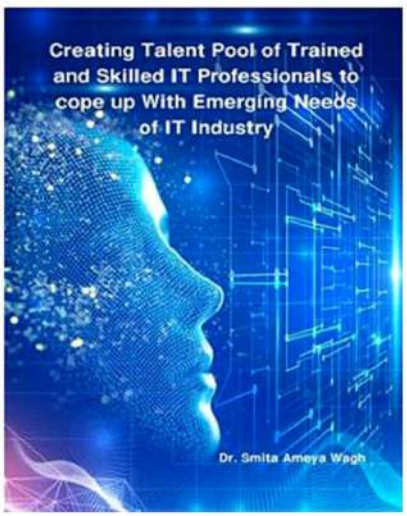

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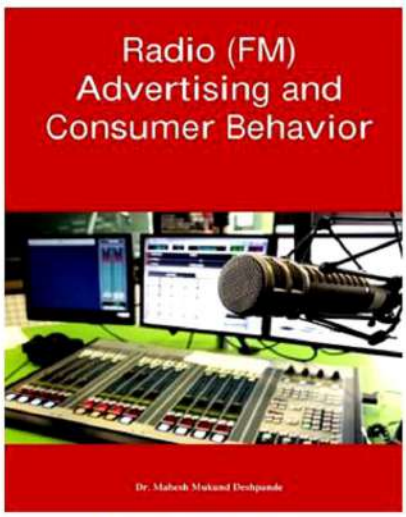

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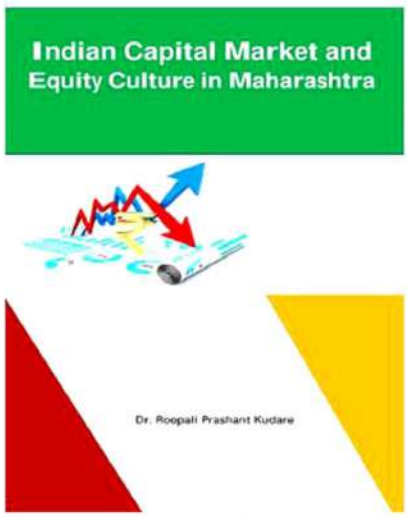

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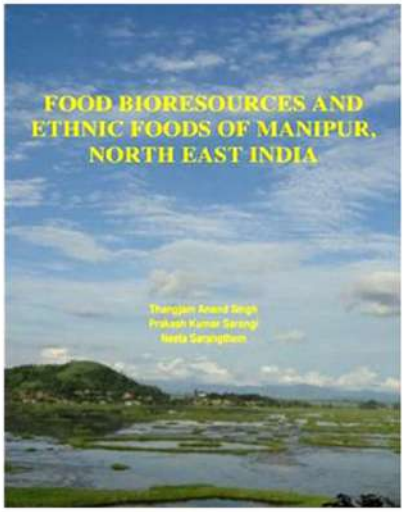

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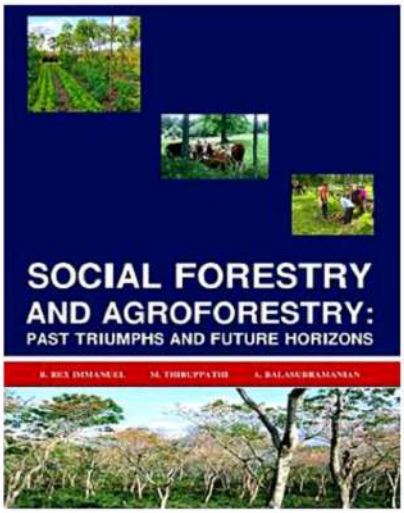

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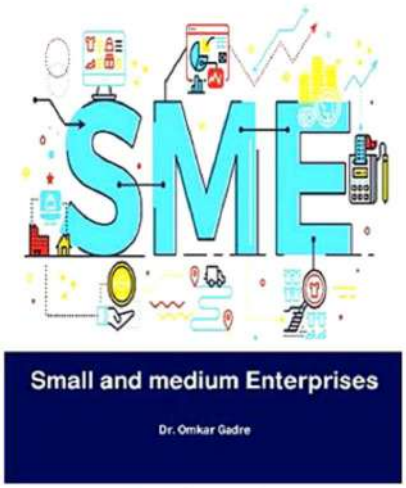

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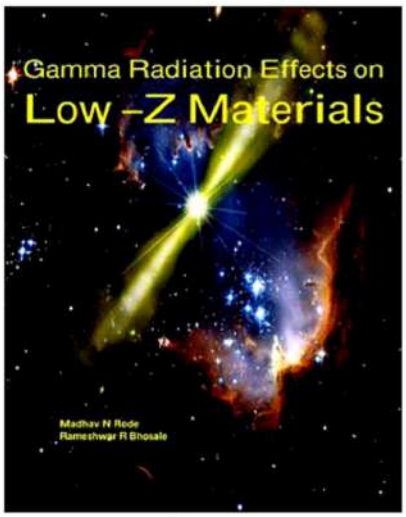

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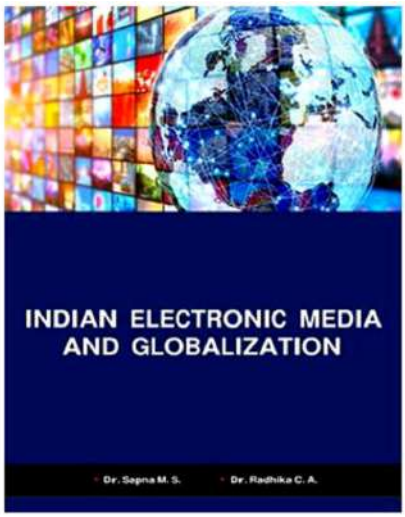

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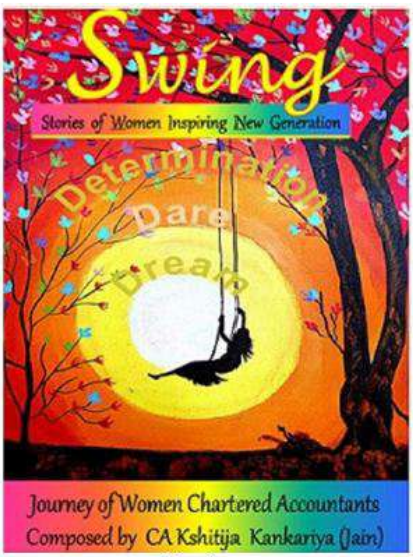

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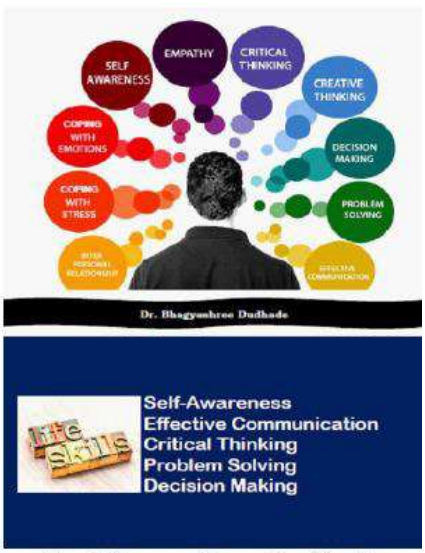

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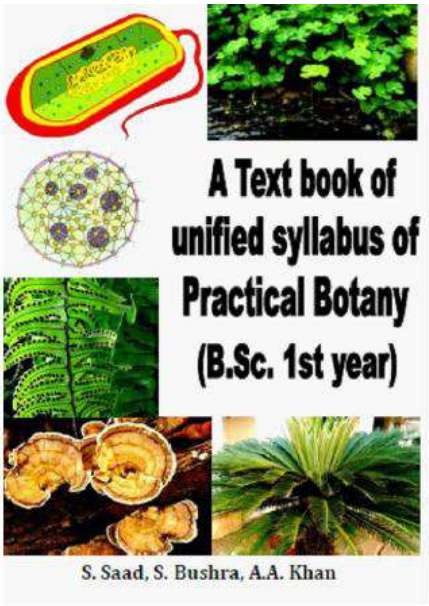

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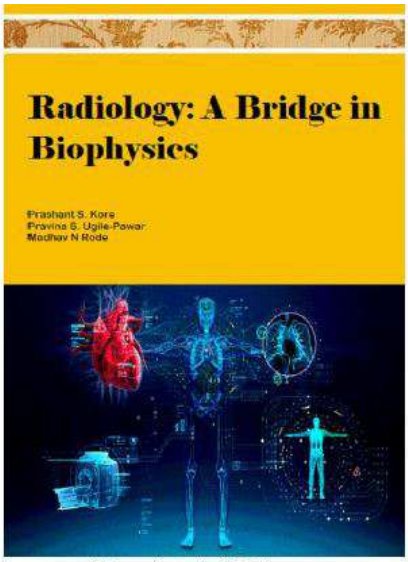

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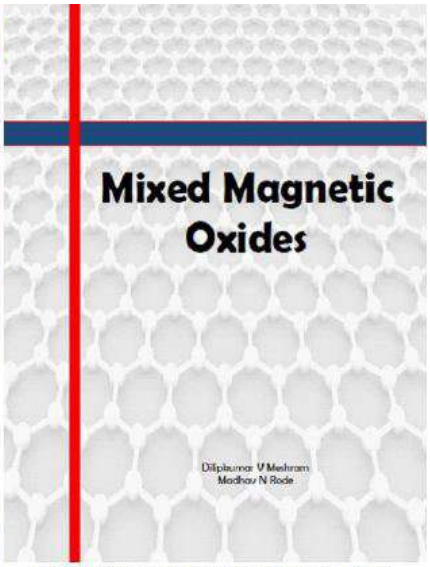

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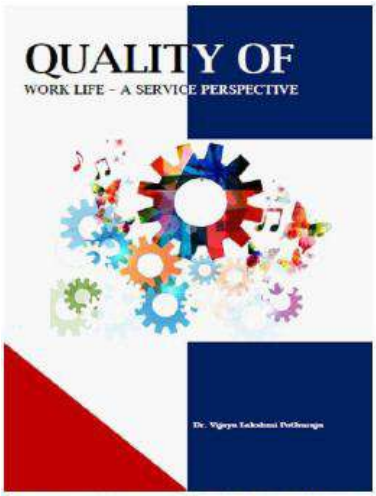

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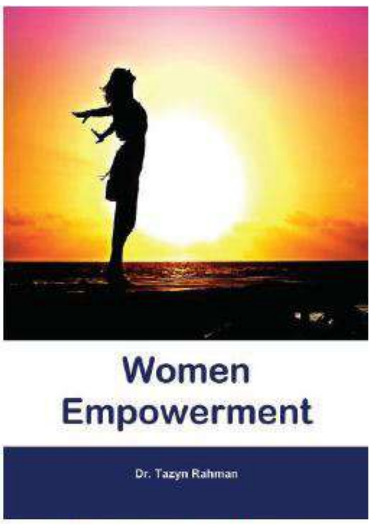

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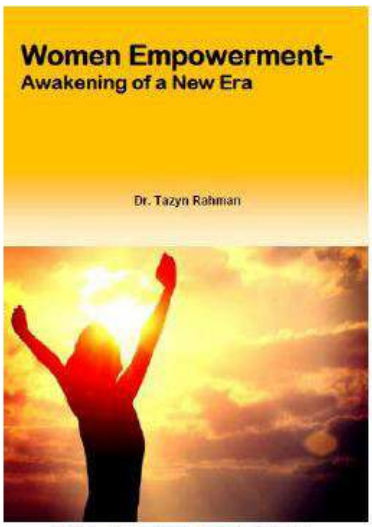

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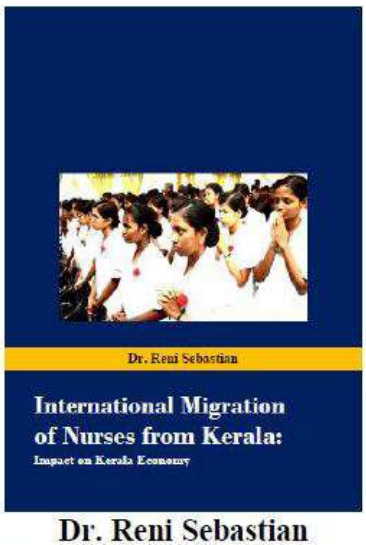

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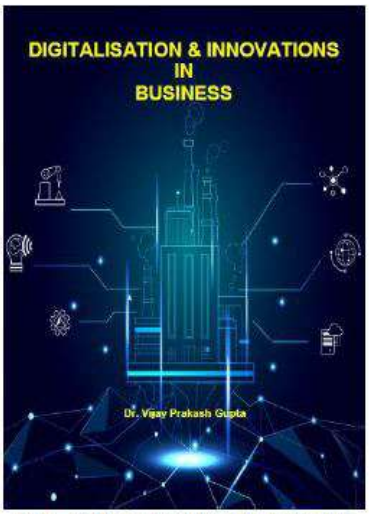

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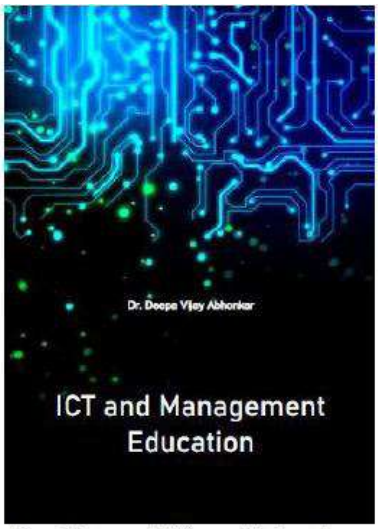

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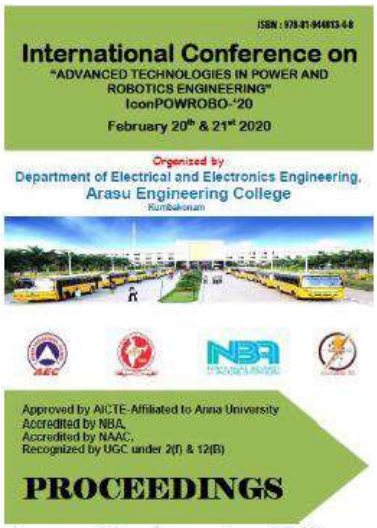

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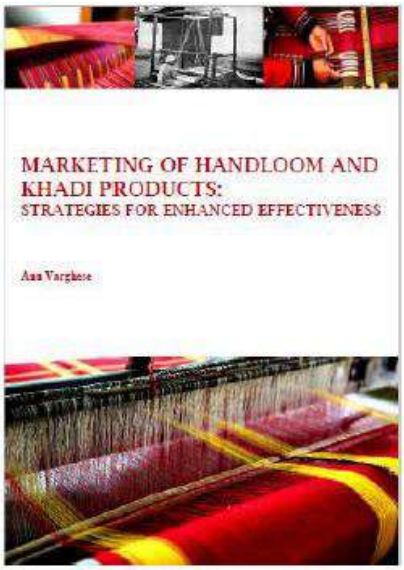

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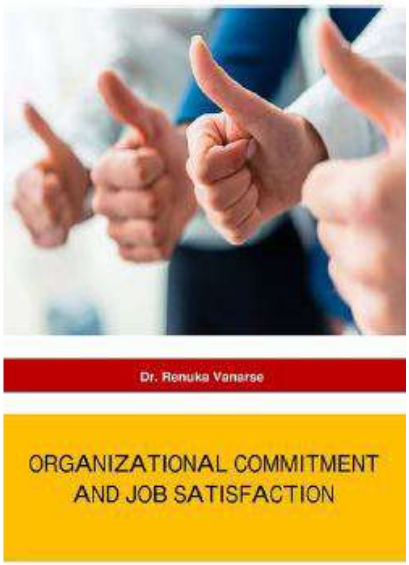

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