ISSN - 2347-7075
Impact Factor - 8.26

INTERNATIONAL JOURNAL OF ADVANCE AND APPLIED RESEARCH

Double-Blind Peer Reviewed / Bi-Monthly / Referred / Open Access Research Journal

Special Issue
Vol. 7 No. 56
September - October – 2026

Young Researcher Association, Kolhapur (Maharashtra)

International Journal of Advance and Applied Research

(IJAAR)

A Multidisciplinary International Level Referred and Peer Reviewed Journal

ISSN–2347-7075 **Impact Factor–8.26**

September - October - 2026

Volume - 7 Issue – 56

Published by:
Young Researcher Association, Kolhapur, Maharashtra, India
Website: *https://ijaar.co.in*
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ISSN – 2347 -7075 (DOUBLE-BLIND Peer Reviewed) (Bi-Monthly Research Journal)
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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Review on Sustainable Materials through Green Chemistry: Innovations in Synthesis, Applications, and Environmental Impact

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DOI - 10.5281/zenodo.24334366

Abstract:

Sustainable materials are increasingly important as societies seek to reduce resource depletion, hazardous chemical use, greenhouse-gas emissions, and persistent waste. Green chemistry offers a preventive approach by designing chemical products and processes to minimize or eliminate hazardous substances at source. This review discusses the relationship between green chemistry and sustainable materials, focusing on renewable and waste-derived feedstocks, safer solvents, catalysis, energy-efficient synthesis, bio-based polymers, functional nanomaterials, and design for circularity. Applications in packaging, water treatment, construction, agriculture, energy technologies, and healthcare are considered from chemical and environmental perspectives. Potential benefits include improved atom utilization, lower solvent demand, reduced dependence on fossil resources, and opportunities for reuse or recycling. However, sustainability cannot be inferred from a material's natural or bio-based origin alone. Agricultural inputs, processing energy, toxicity, product durability, additives, degradation products, and actual end-of-life infrastructure can alter the overall environmental outcome. Green chemistry metrics—including atom economy, E-factor, and process mass intensity—are useful for comparing synthesis routes, while life-cycle assessment (LCA) helps evaluate impacts across raw-material extraction, production, use, and disposal. The review concludes that material selection should integrate chemical performance, human and ecological safety, resource efficiency, and realistic end-of-life management. Combining green chemistry with circular-economy strategies and transparent life-cycle evidence can support materials that deliver functional value while reducing environmental burdens.

Keywords: Green Chemistry; Sustainable Materials; Green Synthesis; Biopolymers; Catalysis; Circular Economy; Life-Cycle Assessment.

Introduction:

Materials support nearly every sector of modern life, including packaging, buildings, transport, electronics, agriculture, medicine, and renewable energy. Conventional material production can depend on finite fossil resources, energy-intensive processing, hazardous reagents, and complex formulations. Products that are difficult to reuse or separate may become persistent waste, while additives and degradation products can introduce additional environmental concerns (Geyer et al., 2017; Hahladakis et al., 2018). These challenges have encouraged researchers to design materials with sustainability considered from the earliest stages.

Green chemistry is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances (Anastas & Warner, 1998). Rather than treating pollution only after it is produced, it emphasizes prevention through molecular design, safer reagents, efficient transformations, and reduced

waste. Its principles are relevant to materials chemistry because feedstock selection, reaction selectivity, solvent choice, energy demand, and end-of-life behavior all influence environmental performance (Anastas & Eghbali, 2010; Clark, 2006).

A sustainable material should meet its intended function while reducing total impacts relative to realistic alternatives. Bio-based does not necessarily mean biodegradable, and biodegradable does not necessarily mean that degradation will occur rapidly in every environment. Durability may be desirable in construction, whereas controlled degradation may be useful for selected agricultural or packaging applications. Thus, chemical design should be connected to performance testing, hazard assessment, and life-cycle evaluation.

Innovations in Synthesis:

1. Renewable and waste-derived feedstocks:

Cellulose, starch, lignin, plant oils, sugars, and other biomass components can serve as renewable carbon sources for fibers, coatings, composites, and polymer intermediates. Agricultural residues and food-processing by-products can also be converted into adsorbents, fillers, and functional chemicals, potentially creating value from waste. The environmental benefit depends on responsible sourcing, collection distance, pretreatment, water use, and energy demand. Biomass use should avoid land-use change and excessive competition with food, biodiversity, or soil-carbon needs.

2. Bio-based polymers and polymer design:

Polylactic acid (PLA), polyhydroxyalkanoates (PHAs), starch blends, and cellulose-based materials illustrate routes to polymers using renewable carbon. PLA can be produced from lactic acid generated by fermentation, while PHAs are synthesized by microorganisms under suitable conditions. These polymers may replace selected fossil-derived materials, but their full impact depends on cultivation, fermentation, purification, performance, and waste management. Reviews emphasize that biodegradability, compostability, and recyclability are distinct properties and should be supported by appropriate testing (Mülhaupt, 2013; Narancic et al., 2020; Rosenboom et al., 2022).

3. Safer solvents and solvent reduction:

Solvents can account for a substantial share of process mass and hazard. Water, ethanol, selected bio-derived solvents, solvent-free reactions, and mechanochemical methods may reduce the use of hazardous organic solvents where chemically suitable. Solvent selection should consider toxicity, persistence, flammability, recovery, and production impacts—not merely whether the solvent is renewable. Solvent recovery and process redesign can often be as important as substitution.

4. Catalysis and energy-efficient processing:

Catalysts can improve selectivity, reduce reagent demand, and enable reactions under milder conditions. Enzymes and other biocatalysts may offer high selectivity in aqueous or moderate-temperature systems; heterogeneous catalysts can sometimes be recovered and reused. Microwave-assisted, continuous-flow, and mechanochemical processes may improve heat or mass transfer for selected reactions. Their claimed benefits should be confirmed using comparable yields, full energy balances, catalyst lifetime, and purification requirements.

5. Green synthesis of functional materials:

Plant extracts, enzymes, and microorganisms are being investigated as reducing or stabilizing agents for selected metal and metal-oxide nanomaterials. Such approaches may reduce reliance on some conventional reagents, but natural mixtures can vary between batches and complicate reproducibility.

Applications in sensors, coatings, catalysis, and water treatment require assessment of particle release, transformation, ecotoxicity, and recovery. Immobilizing active particles on reusable supports can limit dispersal and support safer operation.

6. Measuring synthesis efficiency:

Atom economy estimates how efficiently reactant atoms enter the desired product; E-factor measures waste mass per mass of product; and process mass intensity measures total material input per product output. These metrics are valuable but incomplete: they do not independently capture toxicity, climate impact, water stress, or long-term persistence. Sheldon (2017, 2018) recommends using green metrics as part of a broader assessment rather than as stand-alone proof of sustainability.

Applications of Sustainable Materials:

1. Packaging and consumer goods:

Cellulose films, molded fibers, starch-based materials, and bio-based or compostable polymers are used or investigated for packaging. Their potential benefits include renewable feedstocks and, under appropriate conditions, alternative end-of-life routes. Critical chemical and engineering properties include moisture and oxygen barriers, mechanical strength, food-contact safety, and shelf life. Multilayer packaging can be difficult to recycle, and compostable products may not deliver benefits where suitable collection and treatment facilities are absent. Reuse, reduction of unnecessary packaging, and recyclability should be assessed alongside material substitution (United Nations Environment Programme [UNEP], 2023).

2. Water and wastewater treatment:

Biochar, cellulose, chitosan, modified clays, membranes, and porous materials can remove selected dyes, metals, nutrients, and organic contaminants through adsorption, filtration, or catalytic transformation. Performance depends on surface functional groups, pore structure, pH, charge, and contaminant speciation. Sustainable treatment requires more than high removal percentages: spent adsorbents must be regenerated, recovered, or disposed of safely, otherwise pollution may simply be transferred from water to solids. Regeneration efficiency and performance over repeated cycles should be reported.

3. Construction and infrastructure:

Recycled aggregates, supplementary cementitious materials, low-carbon binders, natural-fiber composites, and bio-based insulation may reduce embodied emissions or demand for virgin resources in selected applications. The benefits depend on strength, fire and moisture behavior, local supply, service life, and compatibility with building codes. Long-lasting materials can prevent repeated replacement, while designs that enable repair, component reuse, and end-of-life separation can improve circularity.

4. Agriculture:

Biodegradable mulch films, plant-derived coatings, and controlled-release carriers may help manage water, nutrients, or agrochemicals. Their use should be based on evidence of performance and degradation under real field conditions, including soil temperature, moisture, microbial activity, and exposure time. Incomplete degradation or harmful additives could create unintended impacts. Materials should be designed to reduce unnecessary chemical release while preserving crop productivity and soil health.

5. Energy technologies:

Sustainable materials can support batteries, fuel cells, solar devices, and hydrogen technologies through membranes, electrode binders, catalyst supports, and protective coatings. Green chemistry can reduce solvent use and improve synthesis efficiency, but the overall assessment must also consider critical-mineral

extraction, material scarcity, manufacturing energy, durability, and recycling. Material recovery and design for disassembly are particularly important as clean-energy technologies scale.

6. Healthcare and biomedical uses:

Biocompatible polymers, hydrogels, absorbent materials, and selected bio-derived compounds can serve in wound care, controlled release, and medical devices. Chemical purity, sterilization compatibility, leachables, degradation products, and infection control are essential constraints. In healthcare, single-use items may be justified by safety requirements; sustainability improvements should focus on safe material choice, efficient manufacture, reduced packaging, and appropriate regulated waste management.

Environmental Impact and Sustainability Assessment:

1. Potential benefits:

Green chemistry can prevent waste at source, reduce hazardous exposures, improve raw-material efficiency, and reduce the need for energy-intensive separations. Renewable feedstocks may diversify supply, while recovered feedstocks can support circular material flows. Catalysis and improved process control can reduce by-products, and materials designed for reuse or recycling can retain value for longer. These benefits are most credible when demonstrated with measured data and comparisons against functionally equivalent alternatives.

2. Trade-offs and environmental risks:

Bio-based materials can require land, fertilizer, irrigation, and processing energy; poorly managed biomass production can affect biodiversity and soil carbon. Some biodegradable polymers degrade only under specific industrial composting conditions and may persist in soil or aquatic environments. Recycled materials may contain legacy additives, while nanomaterials may be released or transformed during use and disposal. A process that reduces solvent use may consume more heat or electricity. These trade-offs demonstrate why terms such as “natural,” “green,” and “eco-friendly” should not substitute for evidence.

3. Role of life-cycle assessment:

LCA evaluates environmental burdens across raw-material extraction, manufacturing, transport, use, and end of life. Standards ISO 14040 and ISO 14044 describe key principles, framework, requirements, and guidance for such studies (International Organization for Standardization [ISO], 2006a, 2006b). Comparisons should use a meaningful functional unit—for example, packaging needed to protect a defined quantity of food for a specified duration—rather than comparing equal masses of materials that perform differently. Assumptions about energy mix, recycling rates, transport, degradation, and allocation should be transparent.

4. A practical assessment checklist:

A credible assessment should define the material’s function and system boundary; document feedstock origin; quantify mass, water, and energy inputs; identify hazards of reagents, additives, and degradation products; test performance and durability; evaluate realistic reuse, recycling, composting, or disposal routes; and report uncertainty. Laboratory-scale improvements should not be described as industrial sustainability without scale-up evidence. Standardized methods and transparent reporting make results more reproducible and comparable.

Research Challenges and Future Directions:

Priorities include developing selective and recoverable catalysts, improving biomass-feedstock consistency, designing polymers for efficient recycling, replacing hazardous additives,

and verifying degradation products and ecological effects. Process intensification and digital monitoring may reduce energy and material use, while computational methods can help predict material properties and identify safer chemical alternatives. Collaboration among chemists, engineers, ecologists, manufacturers, and waste-management authorities is necessary to align material design with actual infrastructure and user behavior.

Conclusion:

Green chemistry provides a practical framework for sustainable materials through safer molecular design, efficient synthesis, renewable or recovered feedstocks, and planned end-of-life pathways. Bio-based polymers, waste-derived adsorbents, greener catalysts, and recyclable functional materials offer opportunities in packaging, water treatment, construction, agriculture, energy, and healthcare. However, sustainability is context-dependent: toxicity, performance, resource demand, durability, and disposal must be assessed together. Combining green chemistry metrics with LCA and circular-economy principles can help distinguish genuine environmental improvements from burden shifting.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

From Ideas to Impact: Empowering Women Through Innovation and Entrepreneurship

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Abstract:

Empowering women through innovation and entrepreneurship can foster inclusive economic development, job creation, gender equality, and sustainable progress. Women entrepreneurs create businesses, launch new products and services, utilize digital technologies, and generate income. However, their potential may be hindered by factors such as restricted access to finance, gender biases, insufficient business education, weak networking opportunities, market obstacles, digital disparities, and disproportionate family duties. This paper explores the opportunities and challenges facing women entrepreneurs, with a particular focus on India. It employs a descriptive and analytical methodology, utilizing secondary data from scholarly articles, government documents, and institutional reports. The discussion encompasses digital entrepreneurship, e-commerce, rural businesses, financial inclusion, skills enhancement, and institutional backing. It advocates for a collaborative approach involving government entities, educational institutions, financial institutions, industries, and communities. The paper concludes that entrepreneurship extends beyond mere self-employment; it has the potential to enhance women's economic autonomy, leadership, innovation, and involvement in development.

Keywords: Women Empowerment, Women Entrepreneurship, Innovation, Digital Entrepreneurship, Financial Inclusion, Gender Equality, Sustainable Development.

Introduction:

Economic and social advancement depend on the empowerment of women. Women can become financially independent, acquire new skills, find work, and support national growth through innovation and entrepreneurship. In industries like education, healthcare, fashion, food processing, and technology, new business prospects have been made possible by digital platforms, e-commerce, and online payments. However, women entrepreneurs are still constrained by a lack of funding, technology, training, and market access. The potential, difficulties, and tactics for advancing sustainable women-led enterprises in India are examined in this essay.

Problem Description and Objectives:

Finance, training, technology, market access, and family obligations are among the difficulties faced by female entrepreneurs.

The Objectives are to:

1. Analyze how entrepreneurship and innovation contribute to women's empowerment.
2. Determine business prospects for women.
3. Examine the main obstacles that female entrepreneurs must overcome.
4. Examine institutional and governmental assistance. Make recommendations on ways to support women-owned businesses.

Methods of Research:

Based on secondary data, such as scholarly articles, official documents, policy papers, and institutional reports, the study employs a descriptive and analytical research design. To comprehend potential, obstacles, institutional support, and policy recommendations, the data is subjected to a thematic analysis.

Literature Review:

- The significance of removing gender-related obstacles to women's involvement in innovation, technology, and entrepreneurship is emphasized by Chatterjee et al. (2018).
- The Women Entrepreneurship Platform of NITI Aayog provides knowledge, tools, mentorship, and business support to women.
- For female entrepreneurs, Jaitly and Thangallapally (2022) stress the significance of funding, training, mentorship, and market access. It's also crucial to understand schemes and basic application processes.

Women's entrepreneurship is supported by banking, credit, savings, and digital payments, according to research on financial inclusion. For sustainable growth, however, market awareness, financial literacy, and business acumen are equally crucial.

Innovation and Entrepreneurship as Means of Empowerment:

1. Economic and Social Empowerment:

Entrepreneurship has the ability to generate income, to increase women's control over resources and to strengthen their involvement in both household and business decisions. Women who run businesses can develop confidence, leadership, negotiation and management abilities. They may also serve as role models and thus challenge the assumptions regarding who can lead a business.

2. Employment and Community Development:

Businesses that are run by women are able to provide jobs for their employees, their suppliers and their service providers. Small businesses in particular are important in rural and semi-urban areas since formal employment might be scarce there. Businesses with strong local ties can make use of the skills and materials available in the region at the same time as keeping income circulating within the community.

3. Innovation and Financial Inclusion:

Innovation has the effect of improving the quality of products, decreasing waste, allowing companies to reach customers and meet changing demand. For instance, a home-based food producer could enhance its packaging, take digital payments and make use of online marketing. Moreover, engaging in formal business operations can lead to the use of banking, credit and insurance. Knowing something about finance enables entrepreneurs to keep accurate records, plan their cash flow and assess the cost of borrowing.

Opportunities for Women Entrepreneurs:

1. Digital and E-commerce Businesses:

Women can promote products and services through websites, online marketplaces, social media, and digital payment systems without having to depend completely on physical shops. The kinds of opportunities available are in the fields of online education, design, consulting, digital marketing, clothing, jewelry, handicrafts and processed foods. In order to be successful it is necessary to have digital literacy, branding skills, good customer service, an awareness of cybersecurity and reliable delivery.

2. Rural and Agriculture-Based Enterprises:

Rural and agriculture-based businesses play a big role in local economies. These businesses include small farms, food processing

units, and craft workshops. They often use local resources and create jobs in farming communities. Many people rely on this work for their income. These businesses also help reduce poverty and slow down migration to cities. By supporting rural enterprises, we can improve food security and boost rural development. Rural women have the opportunity to get involved in food processing, the production of dairy products, poultry farming, beekeeping, handicrafts and agricultural services. If processing, storage, packaging and branding are improved, then the value of the products can be increased. Self-help groups and producer cooperatives can combine their resources, share their facilities and enhance their bargaining power.

3. Education, Health Care and Professional Services:

Women who have the necessary qualifications are able to set up coaching centers, vocational training programmes, online learning initiatives, wellness services and professional consultancies. Further opportunities are available in the fields of accounting, design, software, research, translation and human-resource services. Those engaging in regulated healthcare activities must satisfy the applicable qualification, licensing and safety requirements.

4. Green Entrepreneurship and Start-Ups:

Environmental awareness offers opportunities in the areas of recycling, sustainable packaging, reusable products, waste management and energy-efficient services. Start-ups based on technology can come up with solutions in the fields of education, agriculture, logistics and business services. Incubators, innovation competitions, mentorship and investor networks can all assist women in turning their ideas into viable businesses.

Important Challenges:

1. **Financial Access:** Due to a lack of collateral, credit history, and financial literacy, women may have trouble getting loans. Transparent funding, financial awareness, and advice are crucial.
2. **Family Responsibilities and Social Preconceptions:** Women's entrepreneurial endeavors may be limited by household responsibilities, caregiving, and gender preconceptions. Childcare, flexible training, and family assistance can all be beneficial.
3. **Digital Inequality and Skills:** Growth may be impacted by a lack of digital access and business expertise. It is crucial to have training in cybersecurity, accounting, e-commerce, marketing, and taxation.
4. **Regulation, Mentorship, and Market Access:** Difficulties arise from complex legal processes, constrained networks, and market rivalry. Regulatory advice, market ties, and mentoring can all be beneficial.
5. **Sustainability and Scaling:** Finance, technology, qualified staff, and management support are all necessary for business expansion.

Governmental and Institutional Support:

The Women Entrepreneurship Platform at NITI Aayog offers assistance and networking. Through funding programs, MUDRA and Stand-Up India assist qualified business owners. Eligible MSMEs can formalize their enterprises with the aid of Udyam Registration. Business groups, banks, incubators, and colleges can offer market contacts, money, training, and mentorship.

Findings and Conversation:

Women's economic engagement, leadership, and financial independence can all be enhanced by innovation and entrepreneurship. But having access to financing is not enough on its own. Building and growing successful women-led enterprises need digital skills, market opportunity, mentorship, family support, and ongoing institutional support.

Suggestions:

1. In schools and universities, offer hands-on instruction in entrepreneurship that Covers Company planning, accounting, marketing, and innovation.
2. Expand the availability of appropriate financing and provide advice on financial records, repayment obligations, and credit preparedness.
3. Increase knowledge of digital payments, cybersecurity, online marketing, e-commerce, and business software.
4. Establish mentorship networks that link budding business owners with seasoned entrepreneurs, industry professionals, and investors.
5. Boost market access through institutional procurement, internet markets, exhibitions, packaging, and branding.
6. Encourage local processing companies, producer collectives, self-help organizations, and rural businesses.
7. By using daycare, flexible training, and shared caregiving responsibilities, family-related hurdles can be reduced.
8. In accessible languages, give concise, up-to-date information about government programs, eligibility, and application processes.
9. Business survival, profitability, employment, formalization, market access, and women's control over business income are all indicators of program outcomes.

Conclusion:

Women's empowerment, financial independence, gender equality, and job creation are all facilitated by innovation and entrepreneurship. Opportunities can be found in rural businesses, e-commerce, education, digital firms, and green sectors. But there are obstacles connected to money, technology, education, and the market that need to be overcome. The government, academic institutions, financial institutions, families, and communities should all offer ongoing assistance. Women can become successful business owners, innovators, and leaders in an encouraging entrepreneurial climate, promoting equitable and long-term economic growth.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Structural Diversification of Diazoles, Substituted Chalcones and Their Antimicrobial Efficacy

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DOI - 10.5281/zenodo.24334409

Abstract:

Diazoles are an important class of heterocyclic compounds known for their wide-ranging biological activities, particularly antimicrobial properties. In this study, a series of structurally diversified diazoles and substituted chalcones were synthesized using efficient and versatile synthetic methodologies. The synthesized compounds were characterized by spectroscopic techniques, including NMR and mass spectrometry, confirming their chemical structures. Their antimicrobial efficacy was evaluated against a panel of bacterial and fungal strains, revealing several derivatives with significant inhibitory activity. Structure–activity relationship (SAR) analysis indicated that the nature and position of substituents on the diazole ring critically influenced the antimicrobial potency. The results demonstrate that targeted structural modifications of diazoles can enhance their biological performance, highlighting these compounds as promising scaffolds for the development of new antimicrobial agents.

Keywords: Diazoles, Heterocyclic Compounds, Structural Diversification, Antimicrobial Activity, Biological Evaluation

Introduction:

Antimicrobial resistance (AMR), which is expanding quickly, is now a leading cause of morbidity and mortality globally [1]. Patients with severe infections brought on by drug-resistant (DR) bacteria now have less treatment choices due to the rise in AMR among different pathogens. Furthermore, infections brought on by DR microbes necessitate more intensive care, which lengthens the time of hospitalization and the course of sickness [2,3]. The emergence of AMR and the selection of extremely virulent bacterial strains were significantly influenced by the widespread use of different antimicrobials in the veterinary and agricultural industries [4–7]. The veterinary-derived DR pathogens have the ability to spread across the environment and infect humans [8,9]. Furthermore, the genetic factors that encode AMR traits can accumulate in different bacterial species and spread further through horizontal gene transfer [10,11]. Bacterial resistance to two or more antimicrobial medications is the result of a vicious cycle that was sparked by these processes and led to the emergence of multidrug-resistant (MDR) pathogens with numerous resistance mechanisms [12]. It is crucial to create new substances that target MDR microorganisms in order to solve this issue.

The most common cause of hospital-acquired infections globally is the ESKAPE group of pathogens, which includes *Enterococcus fecium*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, and *Enterobacter* species complex [13–15]. Among critically and chronically ill or immunocompromised people, this group of Gram-positive and Gram-negative bacteria can produce infections that are potentially fatal [15]. ESKAPE bacteria' increasing resistance to antibiotics places a heavy strain on healthcare systems and has substantial financial implications worldwide. Therefore, it is crucial to create new drugs that target the multidrug-resistant ESKAPE group of viruses, which are clinically relevant.

Chalcones are a kind of open chain flavonoids with two aryl rings joined by a three-carbon spacer called the propanone linkage. They are considered a privileged structure in medicinal chemistry [16]. In addition to causing the bioactivities, the reactive α, β-unsaturated propanone fragment is helpful in converting chalcones into other heterocyclic compound classes. Because different aryl rings have different types and characteristics, chalcones exhibit varying degrees of bioactivity. According to a review of the literature on chalcones, molecules with heteroaromatic rings in their aryl part exhibited superior biological profiles [17, 18]. Heterocyclic ring-appended chalcones with antitubercular, antifungal, and cytotoxic properties have been previously described by us [19–22].

Based on a literature survey [23-27] and our previously conducted studies [28], we herein report a continuation of that work, with a goal of further evaluating diazoles and chalcones of its dihydropyrazole derivatives (privileged heterocyclic compounds) for their antibacterial, antifungal, antioxidant, and anticancer activities. The results of these efforts and the structure activity relationship for the series of chalcones.

The profound biological activity of various azoles makes them attractive building blocks for the development of novel antimicrobial compounds targeting clinically important pathogens. With this notion, in this paper we aim to synthesize a series of diazole derivatives based on evaluate their in vitro antimicrobial properties against clinically important bacterial pathogens.

Material and Methods:

All chemicals used in the experiments were of analytical reagent (AR) grade. Analytical thin-layer chromatography (TLC) was carried out on Merck pre-coated silica gel 60 F254 aluminium sheets. Proton nuclear magnetic resonance (^{1}H NMR) spectra were recorded in $CDCl_3$ on a 500 MHz spectrometer with tetramethylsilane (TMS) serving as the internal standard.

Characterization Techniques:

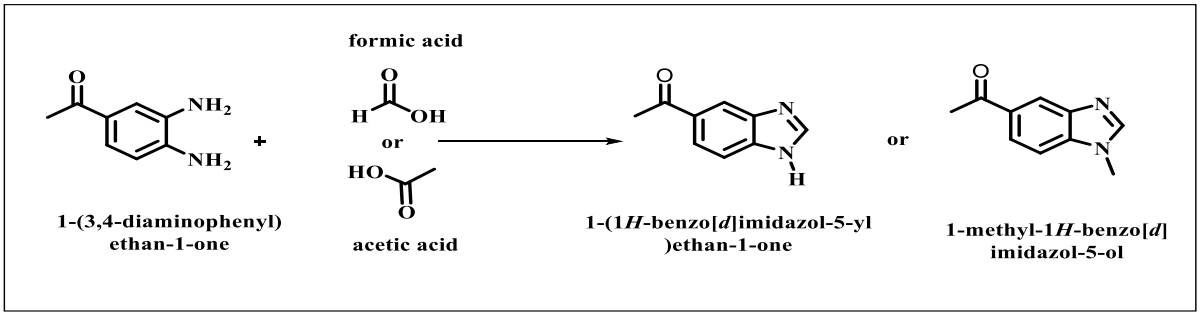
The structure of synthesized compounds was determined by chemical properties elemental analysis and spectral data. ^{1}H-NMR spectra were recorded on Bruker Avance Neo 500 MHz spectrometer using $CDCl_3$ solvent and TMS as internal standards at SAIF, Punjab University, Chandigarh (India). Chemical shifts are expressed in ppm. Mass spectrums were recorded on Thermo Scientific TSQ 8000 Gas Chromatogram.

Experimental:

General Reaction for Synthesis of Diazoles:

Well proportioned reaction mixture of substituted diamineacetophenone and formic acid or acetic acid with resin-based catalyst at suitable temperature for suitable time. The reaction will be monitored by TLC. After reaction is completed, it is poured in cold water and product will be

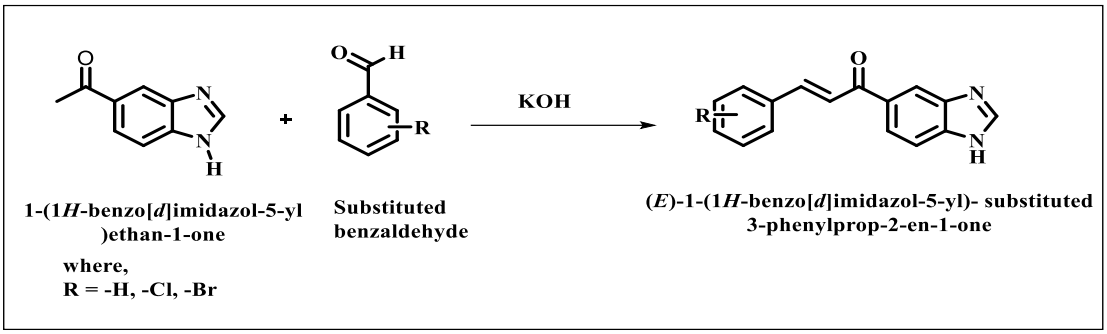
crystallized by column chromatography with ethyl acetate and ethanol.



Scheme 1. General Reaction for Synthesis of diazoles

Synthesis of Substituted Chalcones:

Well proportioned reaction mixture of substituted diazole and substituted benzaldehyde will be refluxed with KOH and then with acetic acid at suitable temperature for suitable time. The reaction will be monitored by TLC. The product substituted chalcones will be recrystalised by column chromatography with ethyl acetate and ethanol.



Scheme 2. Synthesis of (E)-1-(1H-benzo[d]imidazol-5-yl)- substituted 3-phenylprop-2-en-1-one

Table 1. Scope of Synthesis of substituted diazoles

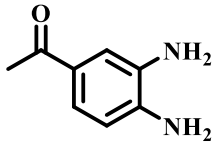
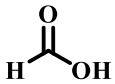
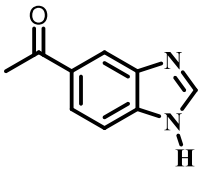
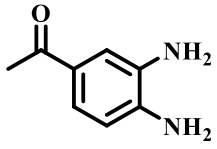
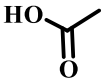
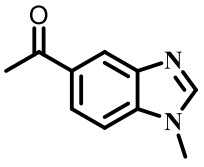
Sr. No	Substrate	Reagent	Product	Time in Hrs.	Yield
1				5	82
2				5	86

Table 2. Scope of Synthesis of substituted (E)-1-(1H-benzo[d]imidazol-5-yl)- substituted 3-phenylprop-2-en-1-one

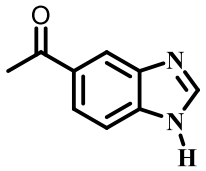
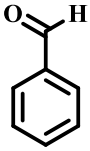
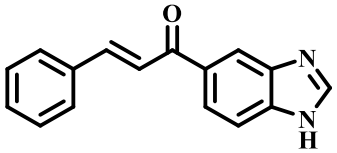
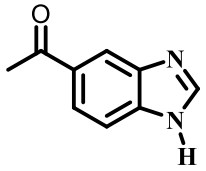
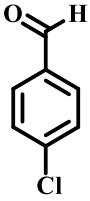
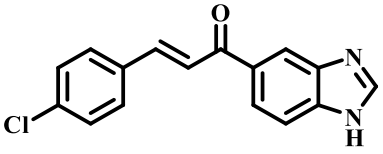
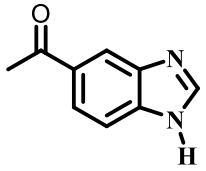
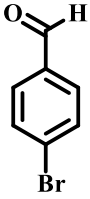
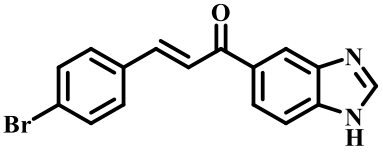
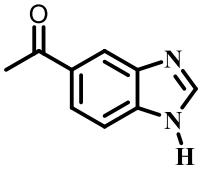
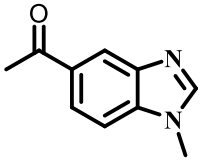
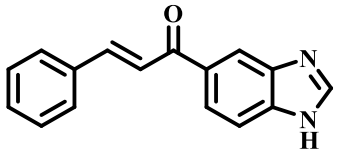
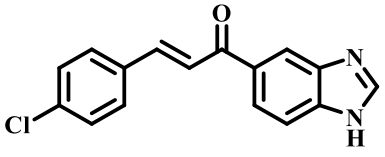
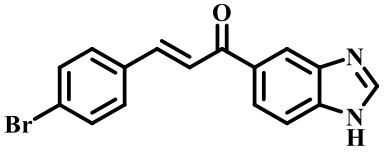
Sr. No	Substrate	Reagent	Product	Time in Hrs.	Yield
1				6	80
2				6	85
3				6	88

Table 3. Structural Analysis

Sr. No	Structure of Products	Structural analysis by ^{1}HNMR and GCMS
1		**^{1}HNMR(500MHz,$CDCl_3$)**:δ 12.35 (s,1H), 8.20 (s,1H), 7.36-6.95 (m, 3H), 2.50 (s,3H) **GCMS:** Cal m/z:160.18, Found m/z: 160.14
2		**^{1}HNMR(500MHz,$CDCl_3$)**:δ **)**:δ 8.05-8.02 (m,2H), 7.56-7.63 (m,2H), 7.78 (s, 3H), 2.50 (s,3H) **GCMS: Cal m/z:** 174.20 Found m/z:174.16
3		**^{1}HNMR(500MHz,$CDCl_3$)**::δ 12.32 (s,1H), 8.15 (s,1H), 7.97-8.0 (m, 3H), 7.54-7.60 (m, 4H), 7.33-7.38(m,3H) **GCMS:** Cal m/z:248.28, Found m/z: 248.22
4		**^{1}HNMR(500MHz,$CDCl_3$)**:δ 12.35 (s,1H), 8.18 (s,1H), 7.98-8.0 (m, 3H), 7.56-7.62 (m, 4H), 7.34-7.40 (m,2H) **GCMS:** Cal m/z: 282.73 Found m/z: 282.70
5		**^{1}HNMR(500MHz,$CDCl_3$)**:δ 12.35 (s,1H), 8.18 (s,1H), 7.97-8.06 (m, 3H), 7.77 (m, 2H), 7.54-7.61 (m,4H) **GCMS:** Cal m/z: 327.18 Found m/z: 327.15

Conclusion:

The series of substituted diazole structures produced in this work, together with the substituted (E)-1-(1H-benzo[d]imidazol-5-yl)-substituted 3-phenylprop-2-en-1-one, are promising moieties that can exhibit high biological activity. Additionally, the structure's benzo ring inflection purposefully incorporates a chloro and bromo (-Cl, -Br) group over the ring. It demonstrates the potent and encouraging antimicrobial properties. In summary, our findings reveal and play a crucial role in the formation of a structural moiety and an interacting link that exhibits potent antimicrobial activity. which will be helpful in future medication design strategies.

Conflict of Interest: Authors have declared that no competing interests exist.

Acknowledgement:

The authors are thankful to Author also thank to the Principal, Department of Chemistry, G.S Tompe Arts, Commerce and Science College, Chandur Bazar Dist- Amravati and Department of Chemistry, Sant, Gadge Baba Amravati University, Amravati for providing the necessary laboratory facilities. Authors are very much thankful to the Director, SAIF, Punjab University Chandigarh for providing spectral data.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Effectiveness of Risk Management Practices in Commercial Banks

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DOI - 10.5281/zenodo.24334439

Abstract:
Risk management is a critical function in commercial banks due to increasing financial uncertainties, regulatory pressures, technological disruptions, and growing customer expectations. This research paper examines the effectiveness of risk management practices in commercial banks by analyzing major risk types—credit risk, market risk, operational risk, liquidity risk, and cyber risk. Real-world examples from Indian and international banks demonstrate how risk management frameworks influence financial stability, profitability, and customer confidence. Findings indicate that effective risk management enhances sustainable banking operations, reduces losses, supports compliance, and improves decision-making. Recommendations for strengthening bank risk practices are also provided.

Keywords: Risk Management, Commercial Banks, Credit Risk, Market Risk, Operational Risk, Basel Norms, Financial Stability, Cybersecurity.

Introduction:

1. Background:

Commercial banks operate in a high-risk environment involving credit lending, deposits, payments, investments, and digital transactions. These activities expose banks to multiple risks that can affect profitability and stability. Modern risk management practices—supported by technology, regulatory frameworks, and internal control systems—play a crucial role in minimizing these risks.

2. Problem Statement:

Despite global improvements in banking risk frameworks, many banks still experience failures due to poor risk controls. Issues such as loan defaults, cyberattacks, liquidity shortages, and market volatility show weaknesses in risk management practices. Therefore, assessing the effectiveness of these systems is essential.

Objectives:

1. To examine major risks faced by commercial banks
2. To analyze risk management systems and regulatory frameworks
3. To evaluate the effectiveness of risk management practices
4. To provide real-time examples of risk management success and failures
5. To propose recommendations for improving risk practices

Scope of the Study:

This study focuses on commercial banks in India and global institutions such as JPMorgan, HSBC, ICICI Bank, State Bank of India, Deutsche Bank, and Bank of America.

Literature Review:

1. Concept of Risk Management:

Risk management is the process of identifying, assessing, monitoring, and mitigating potential uncertainties that may affect financial performance. Banks implement risk frameworks based on Basel II and Basel III guidelines for regulating capital adequacy and risk exposure.

2. Types of Risks in Commercial Banks:

- Credit Risk: Borrowers failing to repay loans
- Market Risk: Loss due to interest rate, currency, or equity fluctuations
- Operational Risk: Failures due to fraud, system errors, or human mistakes
- Liquidity Risk: Inability to meet short-term obligations
- Cyber Risk: Digital attacks, data breaches, fraud

3. Theoretical Frameworks:

Basel III Framework

Provides global standards for:

- Capital adequacy
- Stress testing
- Liquidity coverage ratio (LCR)
- Risk-weighted assets
- Enterprise Risk Management (ERM) Model

A systematic approach to managing all risks under one coordinated framework.

Research Methodology:

- Research Type: Descriptive and qualitative
- Data Collection: Secondary sources such as bank annual reports, RBI guidelines, case studies, and research articles
- Analysis Tools: Comparative analysis, content analysis of bank reports

Types of Risks and Risk Management Practices in Banks:

1. Credit Risk Management:

Practices Used:

- Credit scoring models
- Loan appraisal systems
- Collateral evaluation
- Credit monitoring
- Early warning systems

Real Example:

1. HDFC Bank uses AI-based credit assessment systems that reduce loan defaults by analyzing financial behavior patterns.
2. SBI introduced a "Stressed Asset Management Vertical" to reduce non-performing assets (NPAs).

2. Market Risk Management:

Practices Used:

- Diversification
- Asset–liability management
- Value at Risk (VaR) models
- Hedging through derivatives

Real Example:

1. ICICI Bank uses VaR modelling and stress testing to handle interest rate and forex fluctuations.
2. JPMorgan manages over $300 billion in trading assets using advanced quantitative risk analytics.

3. Operational Risk Management:

Practices Used:

- Internal controls
- Fraud detection systems
- Staff training
- Business continuity planning
- Cybersecurity protocols

Real Example:

1. HSBC implemented biometrics and behavioral analytics to reduce ATM and banking fraud.

2. Axis Bank uses real-time fraud monitoring platforms to detect suspicious digital transactions.

4. Liquidity Risk Management:

Practices Used:

- Liquidity coverage ratio (LCR)
- Stress testing cash flows
- Maintaining liquid assets
- Monitoring deposit withdrawals

Real Example:

1. YES Bank Crisis (2020) demonstrated weaknesses in liquidity risk management and led to RBI intervention.
2. Bank of America maintains a high LCR to ensure it can survive a 30-day financial stress event.

5. Cyber Risk Management:

Practices Used:

- Firewalls and encryption
- Multi-factor authentication
- Cyber risk audits
- Incident response teams

Real Example:

1. Indian Banks: Several banks adopted RBI's Cyber Security Framework (2021) requiring 24x7 monitoring.
2. Capital One (USA) successfully prevented multi-million-dollar fraud losses using AI-driven threat detection systems.

Effectiveness of Risk Management Practices:

1. Positive Outcomes

1. Reduction in Non-Performing Assets: Banks with strong credit risk systems show significantly lower NPAs.
   Example: Kotak Mahindra Bank consistently maintains one of the lowest NPAs in India due to strict credit screening.
2. Improved Financial Stability: Adequate capital buffers protect banks from unexpected losses.
3. Enhanced Profitability: Lower operational failures → reduced financial losses → more stable returns.
4. Stronger Customer Trust: Banks with robust cyber security gain higher customer confidence.
5. Compliance With Global Standards: Basel norms ensure international-level banking discipline.

Challenges in Risk Management:

- Rapid increase in digital fraud
- High cost of advanced risk systems
- Complex regulatory compliance
- Human error and lack of training
- Volatile global financial markets
- Rising cyber threats and data breaches

7. Case Studies:

Case Study 1: YES Bank Crisis, India

Poor credit risk evaluation and concentrated lending to high-risk borrowers led to severe liquidity issues. RBI had to restructure the bank in 2020.

Case Study 2: ICICI Bank – Strong Risk Framework

ICICI's adoption of digital credit scoring and strict operational controls reduced its NPAs and improved asset quality.

Case Study 3: Silicon Valley Bank Collapse (2023) – USA

Failure to manage interest rate risk led to massive losses in bond portfolios. Weak risk oversight caused the largest US bank failure since 2008.

Recommendations:

- Strengthen AI-based credit scoring
- Implement continuous staff training
- Increase cyber audits and penetration testing

- Use predictive analytics for early warning signals
- Maintain adequate liquidity buffers
- Improve governance and oversight committees
- Encourage RBI and government support for risk reforms

Conclusion:

Effective risk management practices are essential for the stability and sustainability of commercial banks. Banks that follow strong credit evaluation, market risk monitoring, operational controls, liquidity management, and cyber protection strategies remain resilient in a dynamic financial environment. Real-world cases show that weak risk frameworks lead to bank failures, while strong practices enhance financial health, profitability, and customer trust. Therefore, continuous improvement in risk management is crucial for the future of global banking.

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5. Bank of America Financial Stability Report
6. IMF Global Financial Stability Report

International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Green Synthesis, Characterization of Silver Nanoparticles Using Medicinal Plant Extracts and Their Biological Evaluation

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DOI - 10.5281/zenodo.24334471

Abstract:

The troubling rise of antibiotic resistance has sparked the quest for alternative treatments to address the issue of microbial resistance. Over the past twenty years, researchers have increasingly turned their attention to metallic nanoparticles to explore their novel potential. Green nanomaterial synthesis is a rapidly growing area within nanotechnology due to its practicality, minimal toxicity, environmentally friendly characteristics, and sustainability. Certain plants have been historically utilized in medicine owing to their rich array of bioactive compounds. Silver has been recognized for its antibacterial attributes for a long time. Among various metal nanoparticles, silver nanoparticles hold a distinct position. The realm of silver nanotechnology significantly impacts medical applications such as bio-coatings, innovative antimicrobial agents, and drug delivery systems. This review intends to offer a thorough understanding of the medicinal properties of plants, along with a practical guide for plant-derived silver nanoparticles and their antimicrobial effectiveness.

Keywords: Green synthesis, Plant extracts, Nanotechnology, Silver nanoparticles, Biological Evaluation.

Introduction:

Nanotechnology is an expanding field that enables the design of nanoscale structures. Nanoproducts focus on the methodology and creation of particles measuring between 1 to 100 nm in size. Within living organisms, nanotechnology merges wet, dry, and computational forms. Wet nanotechnology includes biological components like membranes, organs, and enzymes. Dry nanotechnology addresses surface science, physical and chemical characteristics, as well as the fabrication of inorganic materials such as silicon and carbon. Computational nanotechnology involves the modeling and simulation of intricate nanometer-scale structures. Figure 1 illustrates the interconnection of these three areas for maximum efficiency. Unique properties characterize nanoscale compounds, leading to a myriad of applications, alongside the growth of the scientific nanoscale discipline and research avenues. It finds usage across a variety of fields [1].

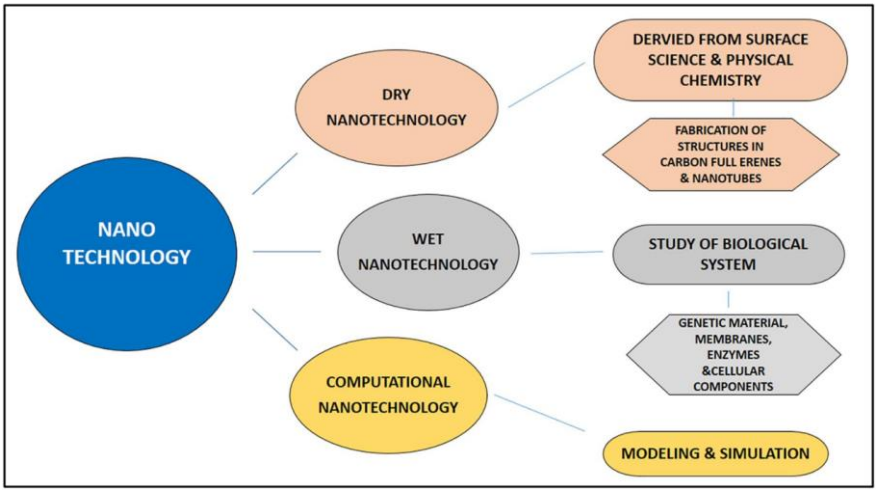

Fig. 1 Major three disciplines of nanotechnology dry nanotechnology, wet nanotechnology, and computational nanotechnology

Industries, such as pharmaceuticals, diagnostics, consumer products, and healthcare supplements, have focused on targeted drug delivery systems, inhibitors for biofilm growth, biosensors, bioremediation, and electronics. Nanoparticles (NPs) represent a diverse category of materials characterized by particles that measure at least 100 nm. NPs are categorized into three distinct layers, as they are not mere molecules: (1) The surface layer, which can be stabilized by various unique compounds, metal ions, emulsifiers, and polymers; (2) The shell layer, which differs chemically and physically from the core; and (3) The core, which is the central component of the NPs [2]. The optical characteristics of NPs are affected by their size, leading to different colorations due to absorption in the visible spectrum. Their dimensions, morphology, and configuration influence their reactivity, stability, and other properties. Heavy metal NPs, including lead, mercury, and tin, are so robust and resilient that their degradation poses significant environmental risks, With the increasing convergence of nanotechnology and biotechnology, there is a heightened focus on advancing medical materials. Various herbs have been utilized in traditional medicine for centuries. These medicinal plants and their components are rich in beneficial elements, such as bioactive compounds. These healing herbs contain high levels of alkaloids, phenolics, and tannins. Such biologically active compounds in plants could catalyze the transformation of metal ions into biologically active nanoparticles through a sustainable biosynthesis pathway [3]. Components from plants, including fruits, leaves, stems, seeds, flowers, roots, bark, rhizomes, and fruit peels, are utilized in the fabrication of various nanoparticles. Silver nanoparticles (AgNPs) have recently been extensively studied for their diverse physical, chemical, and biological properties, which vary in size, shape, function, crystallinity, and structure. Numerous studies are underway to integrate AgNPs into clinical and industrial technologies, alongside their pharmaceutical applications. Silver is often described as 'dynamic' because of its remarkable potential for biological applications, encompassing antifungal, antibacterial, antiviral, anti-infectious, wound healing, and anti-inflammatory properties even at low concentrations. Silver operates as a non-toxic inorganic antibacterial agent capable of eradicating approximately 650 different strains of

disease-causing microorganisms [4]. Although AgNPs are becoming more widely used in medicine and everyday life, there remains a deficiency of comprehensive biological and toxicological data. AgNPs are increasingly incorporated into a broad array of commercial products globally. Organisms come into contact with nanoparticles either actively or passively, leading to concerns regarding their toxicity. Consequently, it is critical to define the appropriate applications of nanoparticles for various biological purposes. However, there is indeed a lack of validated evidence regarding the effects of AgNPs on the environment, animals, humans, and the potential issues related to their short- and long-term hazardous implications. AgNPs find utility in the apparel industry and wastewater treatment. Researchers are captivated by the environmentally friendly production of AgNPs and their vast applications. The green synthesis of AgNPs has been proven to be a promising and eco-friendly approach [5]. This method enhances the safety and cost-effectiveness of mass-producing nanoparticles. This review examines the creation of medically valuable AgNPs and their characterization, various biomedical attributes of AgNPs along with their mechanisms of action, and the potential detrimental effects associated with them. The exploratory project of plant-mediated nanoparticle synthesis and its applications is of particular interest. Therefore, the review not only provides a thorough overview of the applications and current state of AgNPs synthesis via plants not only highlights an exciting field of research but also sheds light on a promising area of exploration [6].

Methods of Nanoparticle Manufacture:

The synthetic strategies for AgNPs are generally categorized into physical, chemical, and biological methods. Biological synthesis of AgNPs showcases advantageous characteristics such as high production rates, enhanced solubility, and stability, while physical and chemical methods tend to be more laborious and carry higher risks [19]. As depicted in Figure 2, the formulation of metallic nanoparticles employs two primary methodologies: the top-down and bottom-up approaches.

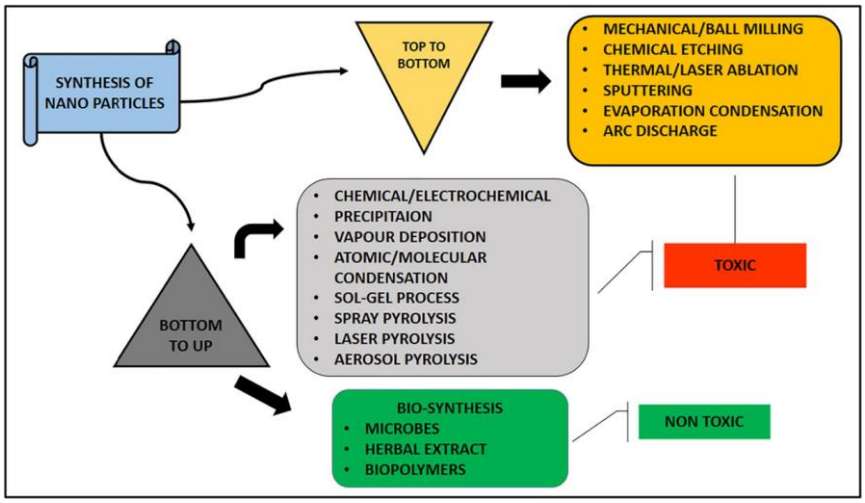

Fig. 2 Two approaches of formation of metallic nanoparticles Top to bottom and Bottom to up

In the top-down method, nanoparticles are produced using techniques like mechanical/ball milling, chemical etching, thermal/laser ablation, sputtering, evaporation condensation, and arc discharge. Conversely, the bottom-up approach begins at the molecular or atomic level to fabricate nanoparticles via chemical processes, precipitation, vapor deposition, atomic/molecular

condensation, sol-gel processes, and spray/laser/aerosol pyrolysis techniques. Physical techniques facilitate the generation of nanoparticles through an evaporation–condensation process within a tubular furnace at atmospheric pressure. The advantages of physical methods include rapid production, the utilization of radiation as a reducing agent, and the elimination of toxic chemicals. Nevertheless, drawbacks encompass low productivity rates, elevated power usage, solvent contamination, and difficulty achieving a uniform dispersion. Chemical synthesis techniques are divided into chemical reduction, electrochemical processes, and pyrolysis. Various organic and inorganic agents like $NaBH_4$, ascorbate, Tollens' reagent, N-dimethylformamide (DMF), and polyethylene glycol are utilized for metal ion reduction in both aqueous and non-aqueous solutions. The primary advantage of chemical reduction is the swift synthesis of a substantial volume of nanoparticles. However, this method often leads to the generation of environmentally unfriendly byproducts, prompting a shift towards greener approaches for nanoparticle production [7].

The biosynthesis of nanoparticles employs microorganisms, plant extracts, and biopolymers. The potential of plants as sources for medications and herbal treatments has been explored for centuries. The pharmacological evaluation of compounds derived from natural sources has resulted in a multitude of therapeutic agents, with approximately 8000 natural antibiotics having been isolated, characterized, synthesized, and proven to exhibit significant biological activity worldwide. Typically, nanoparticles are produced through various chemical and physical processes, which can be expensive and pose environmental hazards due to the use of harmful chemicals that can lead to various adverse effects. In the biological synthesis process, bioabsorption of metals by both gram-positive and gram-negative bacteria has provided evidence of nanoparticle synthesis. Additionally, the resultant nanomaterials were often found to be aggregates rather than true nanoparticles. Numerous studies have documented the biological production of AgNPs utilizing microbes such as bacteria, fungi, and plant matter. Specific bacterial species like *Lactobacillus sp., Thermomonospora sp., P. stutzeri, Aspergillus flavus, Torulopsis sp., Fusarium oxysporum,* and *Verticillium sp.* have been utilized in the synthesis of metal nanoparticles, with their activities extensively researched [8]. Several biomolecules, including biopolymers,Starch, a fibrinolytic enzyme, and amino acids were additionally utilized. The biological production of nanoparticles hinges on three principal factors: (1) the solvent; (2) the reducing agent; and (3) the non-toxic element. The presence of amino acids, proteins, or secondary metabolites in the synthesis process eliminates the extra step to avert particle agglomeration. Employing biomolecules for the synthesis of AgNPs is an environmentally friendly and non-polluting approach. Biological methods appear to facilitate controlled dimensions and morphology of nanoparticles, which is essential for a variety of medical uses. We can effectively manipulate the shape, size, and monodispersed nanoparticles by utilizing bacterial proteins or plant extracts as reducing agents. Additional advantages of biological methods include the availability of a wide array of natural resources, reduced time requirements, high density, and stability. Smaller and more compact nanoparticles seem to be more effective and offer enhanced properties regarding size and form. Although research has successfully synthesized AgNPs of diverse shapes and sizes, certain limitations exist. In comparison to chemical methods, biological synthesis techniques result in improved regulation of the size, shape, and dispersion of the produced

nanoparticles; furthermore, the optimization of the synthesis parameters, which encompasses concentrations of precursors, pH, temperature, and the amounts of reducing and stabilizing elements [9].

Formulation of Silver Nanoparticles:

The AgNPs are highly valued among various noble metal nanoparticles owing to their distinct properties, which include excellent conductivity, durability, and potential antimicrobial properties. Green-synthesized AgNPs are widely recognized for their biomedical and pharmaceutical uses, being environmentally sustainable, economically viable, easily scalable, and yielding higher quantities than their chemically synthesized counterparts. Numerous phytochemicals are present in medicinal plants, playing a crucial role in the nanoparticle formulation. Nanoparticles (NPs) associated with natural compounds have shown to be more advantageous and effective compared to conventional herbal medicines. The plant crude extract was produced via a variety of techniques, such as Soxhlet extraction, a solvent extraction using ethanol and methanol, and a decoction extraction process utilizing an Erlenmeyer flask. These natural compounds were introduced to the silver nitrate ($AgNO_3$) solution, functioning as capping and stabilizing agents that facilitate the reduction of pure Ag(I) to Ag(0). The primary goal of the green synthesis of AgNPs is to improve safety and reliability, thereby preventing the ecological and economic harm associated with hazardous raw materials. The relative amounts of plant extract and metal ions, synthesis duration, temperature, and pH of the reaction can significantly influence the yield, quality, and characteristics of the resultant AgNPs. Although various plants and their constituents may involve multiple biomolecules acting as reducing and stabilizing agents during synthesis, the choice of plants and their components is likely to be significant in the biosynthesis process. These phytomolecules may also affect the surface attributes of the AgNPs [10]. Figure 3

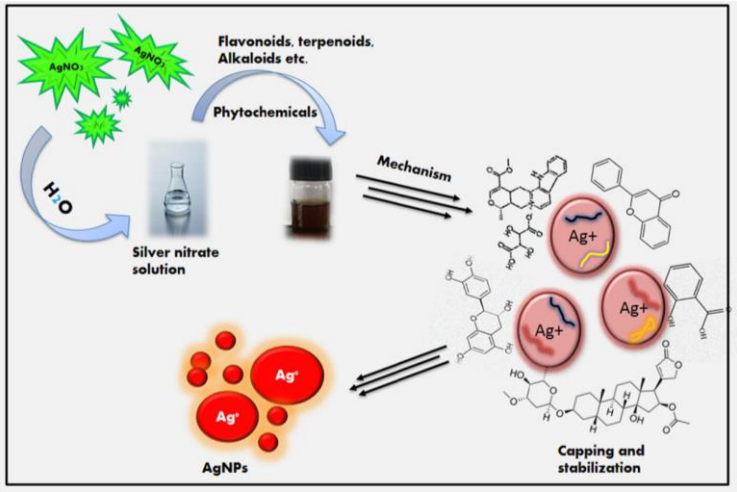

Fig. 3 Synthesis of silver nanoparticles (AgNPs) using plant extract with silver nitrate ($AgNO_3$) solution

The illustrates the synthesis of AgNPs using a plant extract. Generating nanoparticles from living sources is considerably safer compared to chemical or physical methodologies. The biological method of producing stable AgNPs through the use of microorganisms appears to be more advantageous than other techniques. Other biological agents employed in AgNP synthesis comprise biopolymers (such as lignin, chitosan, polypeptides, alginate, and

cellulose), starch, enzymes, and amino acids. It is hypothesized that the biomolecules contain specific secondary metabolites (including vitamins, polysaccharides, amino acids, proteins, enzymes, polyphenolics, flavonoids, terpenoids, alkaloids, phenolic acids, alcohols, antioxidants, alkynes, allylic benzenes, ascorbic acids, anthraquinones, benzoates, alcoholic substances, amides, amino acid residues, caffeoyl compounds, carbohydrates, carotenes, phenolic substances, steroids, sugars, tannins, saponins, triterpenoids, glycosides, leucocyanidin, iridoids, and catechic tannins) capable of reducing Ag ions. Functional groups, such as carboxyl (COOH) demonstrated in glutamine and aspartic byproducts, along with the OH group in tyrosine, are believed to play a part in the stabilization of Ag ions and the development of small polydisperse Ag nanoplates. Today, utilizing microbial cells for the synthesis of metal NPs has proven to be an effective approach. Microbial cells are exceptional biofactories for AgNP production. Bacteria are favored over other microbes for the generation of nanoparticles due to their ability to be cultivated under controlled conditions. Microbes can adapt to elevated metal concentrations and have the capability to convert inorganic compounds into nanoparticles utilizing both extracellular and intracellular synthesis routes. Microbes capture metal ions from their surroundings, converting them into elemental states primarily through enzymatic reduction. However, microorganism-mediated synthesis of AgNPs is currently not a practical method for industries because of the stringent aseptic environment and ongoing cell culture upkeep needed for large-scale NP production [11]. Figure 4 categorizes bacterial synthesis into two types: extracellular and intracellular synthesis. In extracellular synthesis, metal ions are anchored at the cell surface. The microbial cell broth is collected through centrifugation, and the supernatant containing microbial enzymes is utilized for NP synthesis. Metal ions undergo reduction in a cell-free supernatant, leading to nanoparticle formation. This extracellular method of AgNP synthesis is economically viable and involves straightforward downstream processing. Extracellular synthesis is generally more consistent than intracellular synthesis [12].

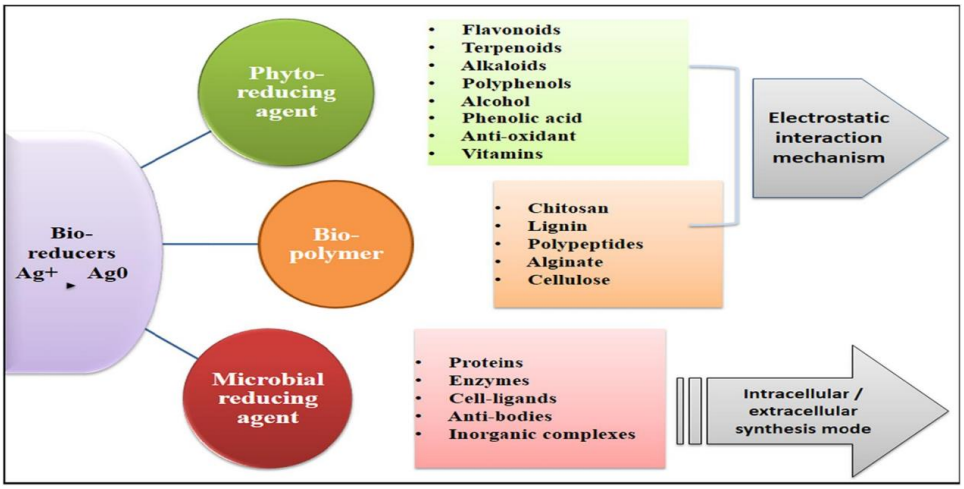

Fig. 4 Extracellular and intracellular synthesis of silver nanoparticles (AgNPs)

The Producing nanoparticles from living sources is generally safer than employing chemical or physical methods. The biological production of stable AgNPs via microorganisms appears to be more beneficial than alternative methods. Other biological entities utilized in AgNPs production encompass biopolymers (lignin, chitosan, polypeptides, alginate, and

cellulose), starch, enzymes, and amino acids. It is postulated that these biomolecules primarily consist of secondary metabolites (vitamins, polysaccharides, amino acids, proteins, enzymes, polyphenolics, flavonoids, terpenoids, alkaloids, phenolic acids, alcohol, antioxidants, alkynes, allylic benzenes, ascorbic acids, anthraquinones, benzoates, alcoholic compounds, amides, amino acid residues, caffeoyl, carbohydrates, carotenes, phenolic compounds, steroids, sugars, tannins, saponins, triterpenoids, glycosides, leucocyanidin, iridoids, and catechin tannins) capable of reducing Ag ions. Functional groups like carboxyl (COOH), found in glutamine and aspartic byproducts, along with the OH group of tyrosine, are thought to play roles in Ag ion stabilization and the creation of small polydisperse Ag nanoplates. Nowadays, utilizing microbial cells for synthesizing metal nanoparticles has emerged as an excellent technique. Microbial cells prove to be exceptional biofactories for AgNPs production. Bacteria are favored over other microbes for nanoparticle generation since they can be cultivated under controlled conditions. Microorganisms can tolerate elevated metal concentrations and can reduce inorganic compounds into nanoparticles through both extracellular and intracellular processes. Microbes capture metal ions from their environments and convert them into elemental states primarily via enzymatic reduction. However, the microorganism-mediated synthesis of AgNPs is not yet practical for industrial applications due to the highly aseptic conditions required and the need for cell culture maintenance for large-scale NP production. The cellular mechanisms of microbial cells are harnessed for the production of NPs. The microbial biomass along with the metal solution would subsequently be cultivated under specific incubation conditions until a discernible color change occurs. The transition of the solution from pale yellow to a brownish hue indicates the creation of AgNPs. Metal ions are confined within the cell wall of microbial entities, and the enzymes generated by the microbes reduce these metal ions within the cellular structure, culminating in the formation of nanoclusters, with the nanoparticles ultimately dispersing from the cell wall into the aqueous solution [13].

Factors Affecting The Plant Mediated Synthesis of Silver Nanoparticles:

The primary challenges in AgNPs biosynthesis involve the regulation of crystalline structure, shape, size, and the distribution of size; the main factors impacting these traits are outlined here.

1. Influence of Metal Ion Concentration (Silver Nitrate):

AgNO3 was used as a precursor in the majority of plant-mediated synthesis of AgNPs, and its concentration had a notable impact on the size of the nanoparticles. For example, The discovered that the optimal yield of AgNPs occurred at a concentration of 1.25 mM of silver nitrate, which also demonstrated a strong intense peak at this concentration with the surface plasmon resonance (SPR) peak at 410 nm. AgNPs synthesized using Shorea robusta leaf extract indicated that the ideal concentration of silver nitrate for the bioreduction process was 1.25 mM and also revealed that a broader SPR peak was noted at lower concentrations, attributed to the presence of larger-sized nanoparticles. Furthermore, a narrower SPR peak at higher concentrations signifies the reduction in nanoparticle size [14].

2. Influence of Substrate Concentration (Plant Extract):

The bioactive molecules found in the extracts play a critical role in both the reduction of silver and the stabilization of the resultant AgNPs. It is well established that increasing biomolecules during the reaction can enhance

AgNPs yield, augment their size, and alter their structure to achieve optimal conditions. The absorption spectrum narrowed when the concentration of leaf extract was increased, signaling a reduction in nanoparticle size. It found that at a concentration of 1.25 ml of leaf extract, the AgNPs reaction occurs rapidly with the SPR peak at 410 nm.

3. Influence of Production Time for Silver Nanoparticles:

The incubation time for a specific plant extract has a significant effect on the size, shape, and properties of green-synthesized AgNPs. A decrease in nanoparticle production and variability in size was observed when the optimal incubation duration was not adhered to. The size of AgNPs increased with prolonged reaction time, possibly due to the agglomeration of colloidal AgNPs [40]. This method is commonly employed to confirm the production and stabilization of AgNPs. The plant biomolecules, such as flavans, flavanol, and flavanonol found in the Shorea robusta leaf extract, are responsible for reducing silver ions within 20 minutes [39]. Rahuman et al. 2021 indicated that alkaloids, flavonoids, and terpenoids present in Carissa carandas leaf extract facilitate the reduction and stabilization of AgNPs, with the highest AgNPs yield occurring within 20 minutes [15].

4. Influence of pH:

The pH of the aqueous media significantly impacts the size, shape, and generation of plant-mediated AgNPs. At lower pH, silver interacts with amino and sulfhydryl groups, and these cations reduce Ag+ to Ag0. Due to the presence of positively charged functional groups, the reduction occurred primarily through ionic binding and biomolecules, which was promoted under lower pH conditions. A multitude of biomolecules binds to the silver nanoparticles, leading to agglomeration and larger AgNP sizes. AgNPs of smaller dimensions were observed at pH 8 of the reaction mixture [41]. At higher pH levels, rapid bio-reduction and considerable dispersion of AgNPs with negative zeta potential were noted, resulting in larger particle sizes.

Function of Phytomolecules in Silver Nanoparticle Formation:

Plants are free from harmful substances and possess natural capping agents, allowing for a more eco-friendly platform for nanoparticle fabrication. Additionally, plant extracts reduce costs associated with microorganism-based nanoparticle synthesis, which involves isolation, culture maintenance, and production in sterile settings. The antibacterial properties of AgNPs are linked to the size, shape, and stabilizing agents of the nanoparticles. Plant extracts serve as reducing and stabilizing agents in the production of antimicrobial nanoparticles, facilitating a more economical and environmentally friendly approach compared to traditional physical and chemical methods. Water-soluble phytochemicals such as flavones, quinones, and organic acids (oxalic, malic, and tartaric) available in plants may contribute to the rapid reduction of silver ions during synthesis. Silver reduction facilitated by phytochemicals (flavonoids or other polyphenols) found in plants represents a significant advancement in this field. The biosynthesis pathways mediated by plants for AgNPs production are quicker and more reliable. The biosynthesis of AgNPs involves the interaction of carbonyl and hydroxyl groups in flavonoids, which play a vital role in the reduction of silver ions by coordinating with the metal ions, where charge transport and electrostatic interactions between the hydroxyl groups of flavonoids and silver ions are crucial for facilitating the reduction process. Three distinct flavonoids, namely Flavon-3-ol, Flavon-4-ol, and Flavon-3,4-diol, functioned as reducing

or stabilizing agents for converting Ag^+ to Ag^0 [16]. Although biomolecules engaged in a concurrent reducing and capping process have been hypothesized in all these studies, none definitively pinpoint the phytochemicals involved in each role. While most review articles on green-synthesized AgNPs have focused solely on efficacy, very few have explored the potential challenges and limitations of this process. A fundamental flaw in various research studies in this area is that the findings are sometimes contradictory, and no overarching themes can be identified. This discrepancy arises largely due to significant variations in findings stemming from different plant extracts and the unique phytochemicals present in each. Furthermore, the size and morphology of AgNPs are influenced by specific phytochemicals and situational chemistry. To elucidate the mechanisms, it is essential to identify the precise phytochemicals involved in AgNPs production. However, in attempting to delineate the relationships between production, morphology, and the constituents of plant extracts, there is a lack of proper characterization of plant extracts according to common phytoconstituents.which presents a significant challenge. While assertions suggest that green-synthesized AgNPs are more eco-friendly compared to the traditional chemical and physical methods of nanoparticle fabrication, studies struggle to support this due to a considerable deficiency of robust scientific evidence. The notion of environmental friendliness largely hinges on the volume of harmful substances substituted with non-toxic alternatives during biosynthesis, the cumulative energy saved, and the anticipated ecological and economic consequences [17].

Characterization of Silver Nanoparticles:

Physicochemical properties of nanoparticles are critical for their actions, distribution in biological systems, safety, and efficacy. Therefore, characterizing AgNPs is essential to evaluate the functional attributes of the synthesized particles through various analytical techniques, including UV-visible spectroscopy, X-ray diffractometry (XRD), Fourier-transform infrared spectroscopy (FTIR), dynamic light scattering (DLS), X-ray photoelectron spectroscopy (XPS), transmission electron microscopy (TEM), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX), selected area electron diffraction (SAED), and atomic force microscopy (AFM). Numerous reviews have previously highlighted the principles and applications of diverse analytical methods; however, the fundamentals of the necessary techniques for characterizing AgNPs are explained in detail below for clarity.

1. UV-visible Spectroscopy:

The UV-Vis spectroscopy is indeed a reliable and efficient technique for the initial characterization of synthesized nanoparticles and monitoring the synthesis and stability of AgNPs. AgNPs possess unique properties that enable them to interact notably with specific light wavelengths. Moreover, UV-Vis spectroscopy is rapid, straightforward, convenient, precise for various types of NPs, requires only a brief measurement time, and calibration is unnecessary for nanoparticle characterization [46]. Absorption is influenced by particle size, dielectric medium, and the chemical environment. In AgNPs, the conduction and valence bands are relatively close, facilitating easy electron movement. These free electrons lead to the Surface Plasmon Resonance (SPR) absorption band, attributed to the collective oscillation of electrons in metallic nanoparticles resonating with light waves. The formation of AgNPs was tracked via UV-Vis spectra, with the maximum reduction and emergence of metallic silver nanoparticles indicated by the intensity of

absorbance [18]. Figure 5a displays the UV-Vis spectra of the synthesized AgNPs, $AgNO_3$, and plant extract. A pronounced peak at 410 nm in the UV-visible absorption spectra confirmed the formation of colloidal AgNPs. The stability of AgNPs created through biological methods has been verified for over a year, and an SPR peak at the same wavelength has been observed using UV-Vis spectroscopy. Nevertheless, UV-Vis spectroscopy alone would be inadequate for providing comprehensive information concerning AgNPs.

2. X-ray Diffractometry:

The XRD is a prevalent analytical technique utilized for examining molecular and crystal structures, serving as a qualitative identifier for active compounds, allowing qualitative resolution of different molecules, capable of assessing crystallinity, isomorphous substitution, and particle dimensions. When X-ray radiation is directed at any particles, it generates numerous diffraction peaks, reflecting the physicochemical characteristics of the crystalline lattice. XRD can be applied to analyze the structural properties of an extensive range of materials, including inorganic catalysts, superconductors, biomolecules, glasses, and polymers. The arrangement of diffraction peaks is vital for evaluating these materials' properties. Every material possesses a unique diffraction light signature that can be employed to identify composition by relating the diffracted beams to the Joint Committee on Powder Diffraction Standards (JCPDS) reference database. Bragg's law serves as the fundamental principle behind XRD. The dimensions of AgNPs were calculated using the Debye-Scherrer formula.

$$D = K\lambda/\beta 1/2\cos\theta$$

Where D = average crystalline size, β = line broadening in radians, λ = X-ray wavelength, θ = Bragg's angle, and K = constant (geometric factor = 0.94). Figure 5f illustrates the XRD peaks of plant-mediated synthesized AgNPs. Characteristic peaks at 38.01, 44.13, 64.46, and 77.40; Bragg reflections corresponding to [110], [199], [220], and [311] lattice planes of the face-centered cubic (FCC) structure of AgNPs were observed. This pattern indicates the crystalline framework of AgNPs, and size was estimated to be 25.4 nm utilizing the Scherrer formula [19].

3. Fourier-transform Infrared Spectroscopy:

The FTIR spectroscopy primarily analyzes the biomolecules associated with silver and the surface atoms of the nanoparticles' capping agents. FTIR can give precision, repeatability, a good transmission ratio, and determine whether Biomolecules play a crucial role in the formation of nanoparticles. Moreover, FTIR has been utilized for examining nanoscale substances, including the verification of functional molecules that are covalently attached to silver, carbon nanotubes, graphene, and gold nanoparticles, as well as enzyme-substrate interactions during catalytic processes. Functional groups are imperative for capping, as established in preceding research [50, 51]. The emergence of peaks indicates that secondary metabolites from plants, such as flavonoids, terpenoids, phenols, glycosides, and tannin role groups like aldehydes, ketones, and carboxylic acids, were enveloped with the nanoparticles. The increased levels of antioxidants and flavonoids (ascorbic acid and gallic acid) contribute to the reduction of metal salts in crude extracts. Figure 5d illustrates the FTIR spectra from the plant-mediated synthesis of AgNPs and plant extracts. The absorption band arises from the vibrational effects of phytochemicals found in the plant extracts, which are accountable for the capping and stabilization of AgNPs [20]. FTIR can affirm that the amino acid residues and protein carbonyl groups exhibit a stronger capacity to bind metals, potentially averting agglomeration.

4. Dynamic Light Scattering:

The DLS can assess the dimensions and distribution of tiny particles within a range from submicron to 1 nm. This technique relies on the interaction of light with nanoparticles. DLS can quantify narrow size distributions, especially within the 2–500 nm range. It employs Rayleigh scattering to measure the scattered light from a beam that passes through the particles. The hydrodynamic size of particles and their distribution can be gauged by analyzing the fluctuations in light scattering intensity over time. Characterizing any nanomaterial in suspension is vital for evaluating its potential hazards. The size measured by DLS is often larger than that obtained through TEM, likely due to Brownian motion. The average diameter of nanoparticles in liquids can be ascertained through DLS, which offers the advantage of rapidly scanning a large number of particles, though it does have various sample limitations.

5. X-ray Photoelectron Spectroscopy:

XPS is a remarkable method that provides access to qualitative, quantitative/semi-quantitative, and speciation information about the surface. XPS is conducted in a high vacuum setting, where X-ray irradiation of the nanoparticles induces the emission of electrons; XPS peaks are generated by measuring the kinetic energy and quantity of electrons emitted from the surface of the nanoparticles. This kinetic energy can be utilized to calculate the binding energy [21].

6. Transmission Electron Microscopy with Selected Area Electron Diffraction:

TEM is a significant, extensively used, and essential technology for determining the numerical size of particles, particle distribution and morphology. The space between the objective lens and the specimen, along with the distance from the objective lens to its imaging plane, determines the magnification in TEM. TEM presents two significant advantages over SEM: it boasts superior resolution and facilitates a broader range of analytical assessments. However, it also has drawbacks, including the need for a high vacuum, a minuscule sample size, and the fact that sample preparation can be quite time-consuming. Another beneficial imaging modality for exploring the crystalline characteristics of nanoparticles is SAED. In TEM, electron backscatter diffraction analyses are frequently performed, wherein electrons are propelled by electrostatic forces to reach the required velocity and frequency before interacting with the sample intended for examination. Figure 5b illustrates the TEM microscopic image of AgNPs synthesized through plant-mediated methods. These AgNPs were observed to be polydispersed and primarily spherical, with an average size of about 14 nm. SAED can determine the size, shape, distribution of particles, and their crystalline nature. Figure 5c displays the SAED pattern of AgNPs synthesized using plant methods, which confirmed the face-centered cubic structure of silver. Due to the relatively large area illuminated, the SAED technique faces challenges since many nanoparticles interact with the diffraction peaks, making individual analysis difficult [22].

7. Scanning Electron Microscopy with Energy-Dispersive X-Ray Spectroscopy:

The SEM is a surface imaging technique adept at resolving various particle sizes, distributions, nanoparticle architectures, and surface morphologies of produced nanoparticles at micro and nanoscale levels. By manually quantifying and analyzing the particles or using specialized software, the morphology of nanoparticles can be examined, leading to the creation of histograms from SEM imagery. A combination of SEM and EDX can be utilized to evaluate the morphology of silver nanoparticles alongside performing elemental analysis. Figure 5e presents the EDX spectra of AgNPs

synthesized via plant methods, confirming the presence of silver [38]. A significant downside of SEM is its inability to reveal internal structures; however, it can provide useful information regarding the quality of nanoparticles and their level of agglomeration.

8. Atomic Force Microscopy:

The AFM has been used to investigate nanoparticle dispersion, aggregation, size, shape, and structure. AFM can characterize the interactions of nanoparticles with supported lipid bilayers in real time, which is not achievable through existing electron microscopy methods. AFM does not require an oxide-free conductive surface for assessment. Nevertheless, due to the crossbar size, there can be an exaggeration of the sample's lateral dimensions. Consequently, careful attention must be paid to avoid generating erroneous measurements.

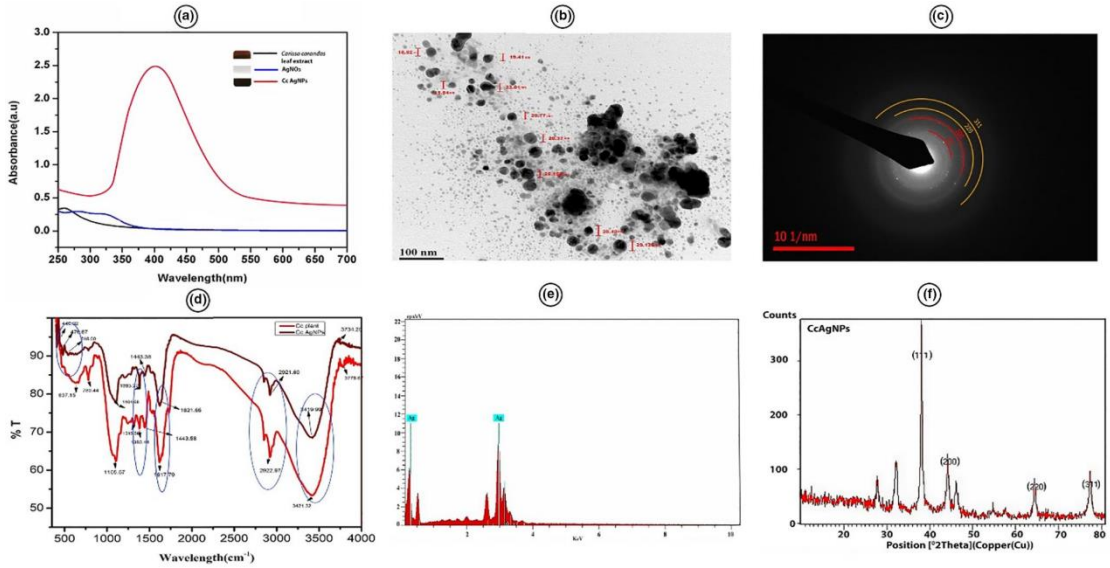

Fig.5 Different characterisation techniques of silver nanoparticles (AgNPs). (a) UV-vis spectra of plant-mediated synthesised AgNPs, silver nitrate (AgNO3), and plant extract. (b) Transmission electron microscopy (TEM) image of plant-mediated synthesised AgNPs. (c) Selected area electron diffraction (SAED) pattern of plant-mediated synthesised AgNPs. (d) FTIR spectra of plant-mediated synthesised AgNPs and plant extract. (e) EDX spectra of plant-mediated synthesised AgNPs. (f) X-ray diffractometry (XRD) peaks of plant-mediated synthesised AgNPs

Biological Evaluation of Silver Nanoparticles:

A potential global crisis of antibiotic-resistant microbes necessitates the introduction of innovative bactericidal agents to treat infections and develop a platform for discovering more effective antimicrobial agents combating multidrug-resistant (MDR) pathogens. AgNPs are renowned for their efficient biocidal effects on microorganisms and have been used for decades to control and manage various infections [23]. AgNPs are extensively applied in domestic products, packaged goods, the medical field, environmental applications, and biology due to their diverse features. The current research discusses the various biological properties of AgNPs, focusing on antibacterial, antibiofilm, antifungal, antiviral, antidiabetic, antiulcer, blood compatibility, antiparasitic, antioxidant, anticancer properties, as well as their applications in dentistry, drug delivery, wound healing, and several other domains.

1. Antibacterial Activity:

The AgNPs are promising candidates for the development of new and effective

biocompatible nanoscale components for advanced antibacterial applications. AgNPs exert a destructive effect on bacterial cell walls by inhibiting cellular respiration chains and interfering with nucleic acids (DNA or RNA). AgNPs have emerged as antimicrobial agents against MDR bacteria due to their large surface-area-to-volume ratios and particular chemical and physical characteristics. The surface-area-to-volume ratio increases as particle size decreases. AgNPs exhibited notable antibacterial effects due to their stability and particle size. The dimensions and morphology of NPs correlate with their antimicrobial efficacy. Smaller AgNPs provide a larger binding surface than their larger counterparts and demonstrate greater bactericidal potency [24]. The plasma membrane is attracted to the positively charged silver ions; when these particles (AgNPs) aggregate, substantial conformational changes occur in the membrane, gradually reducing its permeability and leading to cell death [68]. AgNPs interact with biomaterials rich in sulfur and phosphorus, including cellular components that dramatically affect respiration, cell division, and ultimately, cell viability. Moreover, particle size and shape significantly influence the antimicrobial properties of NPs. NPs with smaller angles have superior antimicrobial characteristics compared to spherical and rod-shaped particles.Due to microbial resistance to antibiotics caused by mutation, discoveries of antibacterial products or agents are desperately needed. AgNPs were also ideal for clinical and therapeutic use due to their reduced reactivity compared to silver ions. AgNPs have four known antibacterial properties: (1) adhesion to microorganism cell membranes, which causes damage;2) Infiltration of AgNPs into cells leads to the disruption of biomolecules and intracellular harm; (3) they trigger cellular toxicity through the generation of reactive oxygen species (ROS), resulting in oxidative stress within the cells; and (4) interruption of cell signaling pathways occurs, which also induces oxidative stress. A variety of antibacterial mechanisms of AgNPs can be found in existing literature. We presented the antibacterial mechanism of AgNPs synthesized via plant mediation in a previous publication. Figure 6a depicts the antibacterial mechanism of AgNPs produced with plant extracts [25]. (1) AgNPs bind to ribosomes, hindering translation; (2) they engage in electrostatic interactions with the outer membrane, leading to the release of internal substances; (3) AgNPs attach to the sulfhydryl group of enzymes and proteins, causing protein aggregation; (4) they directly obstruct the respiratory chain, resulting in cell death; (5) AgNPs adhere to the bacterial cell wall, causing disruption of the cell membrane and leakage of cellular contents. The presents the antibacterial activities of plant-mediated synthesized AgNPs alongside their morphological characterization. Some examples of medicinal plants used for synthesizing AgNPs with antibacterial properties include: AgNPs synthesized from Acorus calamus (rhizome) extract demonstrated superior activity against *Staphylococcus aureus, Salmonella enterica, B. cereus,* and *S. enterica, E. coli* in a dose-dependent manner, also displaying good stability, positioning them as a potential antibacterial agent for commercial applications. Meanwhile, AgNPs generated using aqueous Allium sativum extract were effective against Staphylococcus aureus and Pseudomonas aeruginosa. Aqueous extract-mediated AgNPs from Acalypha indica showed effectiveness against *P. aeruginosa* (16 mm), *Escherichia coli* (14 mm), *S. aureus* (13 mm), and *Bacillus subtilis* (12 mm). The synthesis of AgNPs by flavonoids found in the petals of Linium casa blanca exhibited excellent stability, alongside antibacterial and catalytic activity. This synthesis displayed high antibacterial action against

Escherichia coli and Salmonella, while showing reduced activity against Bacillus subtilis and Staphylococcus aureus. Furthermore, the green-synthesis of AgNPs using Myristica fragrans dried seed extract demonstrated robust bactericidal activity against MDR Salmonella enterica (resistant to ciprofloxacin, tetracycline, and cefotaxime), with increased concentrations of AgNPs enhancing their stability and effectiveness [26]. AgNPs synthesized from Boerhaavia diffusa were evaluated against fish pathogens including *Pseudomonas fluorescens, Aeromonas hydrophila,* and *Flavobacterium branchiophylum,* with outstanding antibacterial activity noted against *F. branchiophylum* compared to other bacterial pathogens. The formulation of AgNPs from Skimmia laureola proved effective against human pathogens *E. coli* (11.67 mm), *Pseudomonas aeruginosa* (14.33 mm), and *Staphylococcus aureus* (14.67 mm), exhibiting spherical and hexagonal crystalline shapes where silver is reduced and stabilized by the phytochemicals in the Skimmia laureola extract. AgNPs derived from Aloe vera (leaf) exhibited notable antibacterial properties, attributed to the flavonoids and terpenoids in the extract that stabilize AgNPs with an octahedral shape, displaying potent antibacterial activity against *Bacillus cereus, S. aureus, Micrococcus luteus, E. coli,* and *K. pneumoniae*. AgNPs formulated from the aqueous extract of Lawsonia inermis showcased antibacterial capabilities against both gram-positive alpha and beta hemolytic Streptococcus species, *Streptococcus aureus, S. haemolyticus,* and *Bacillus* species, as well as gram-negative bacteria like *E. coli, E. faecalis, Proteus mirabilis, Klebsiella pneumoniae,* and *P. aeruginosa*. Upon forming stable bonds with the plant extract, AgNPs infiltrate the bacteria, rupture the cell membrane, leading to cell death, and act as oxidizing agents on the plasma membrane's surface. AgNPs are recognized for their significantly enhanced antimicrobial properties, with those mediated by medicinal plants demonstrating greater efficacy than the plant extracts themselves. Additionally, the antibacterial characteristics of AgNPs.depends on the stability of the particle and this plays a vital role in suppressing microorganism proliferation and development.

In addition to that, AgNPs along with commercial antibiotics showed a greater synergistic effect. From these studies, we can assume that biogenic AgNPs have the potential to be a valuable biomaterial for biomedical applications [27].

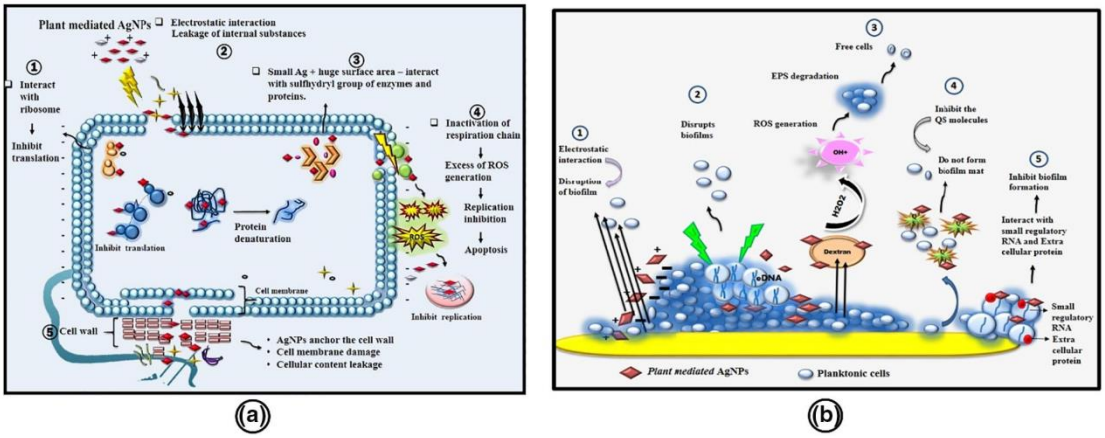

Fig. 6 (a) Antibacterial mechanism of plant-mediated synthesised silver nanoparticles (AgNPs) (b) Antibiofilm mechanism of plant-mediated synthesised AgNPs.

2. Anti-biofilm Activity:

The biofilm-inhibiting properties of AgNPs have been examined only in a limited context. The generation and release of EPS contribute to biofilm formation. The antibiofilm efficacy of various plant-synthesized AgNPs alongside their morphological characterization. The root extract of Vetiveria zizanioides facilitates the synthesis of AgNPs (VzAgNPs), demonstrating significant anti-QS and antibiofilm properties against Serratia marcescens. There have been discussions about how AgNPs can reduce the virulence factors associated with biofilm development, which is dependent on QS, including prodigiosin, protease, lipase, and the formation of extracellular polymeric substances. Transcriptomic studies support the regulation of quorum-sensing genes responsible for virulence factor development. VzAgNPs exhibit superior stability, resulting in improved antibiofilm activity. AgNPs derived from Withania somnifera (L) displayed a broad inhibitory effect on microbial proliferation by disrupting cell membranes and causing the leakage of cellular components [28]. The AgNPs synthesized from Artemisia vulgaris extract demonstrated the capacity to reduce biofilm and exhibited anthelmintic properties. This effect showed a paralyzing action and could serve as a potential alternative for treating biofilm associated with multidrug-resistant pathogens. A. vulgaris, rich in flavonoids, stabilizes the AgNPs, affecting the performance of silver nanoparticles. The aqueous extract of Piper beetle leaves shows anti-quorum sensing and antibiofilm effects against common pathogens responsible for urinary tract infections. It assessed the anti-quorum sensing activity of AgNPs by inhibiting quorum-sensed intermediates of virulence factors (i.e., protease (44%), prodigiosin (62%–72%), hydrophobic development in uropathogens, and formation of extracellular polymeric substances (EPS)). AgNPs could provide a viable alternative to traditional antibiotics for controlling quorum-sensing activity in uropathogens associated with biofilms. Gene expression studies showed down regulation of the fimA, fimc, flhD, and bsmB genes in S. marcescens, as well as flhB, flhD, and rsbA genes in P. mirabilis, which supports evidence of biofilm inhibition. Bacteria that form biofilms have developed resistance to antimicrobial agents due to several reasons: (1) the antibiotic's inability to penetrate the biofilm, (2) the emergence of multi-drug-resistant bacteria, (3) inactivation of drugs by antimicrobial enzymes or transformations induced by biofilms. Plant-mediated AgNPs may serve as effective agents against biofilms formed by MDR pathogens and targeting biofilm formation and EPS against the pathogens may render the silver nanoparticles effective against microbes. The mechanism of antibiofilm action was proposed in our previous research, as depicted in Figure 6b: (1) AgNPs electrostatically bind with cells, disrupting biofilm formation; (2) AgNPs target eDNA to dismantle bacterial biofilm; (3) AgNPs inhibit EPS production, fracturing the biofilm matrix; (4) AgNPs obstruct bacterial signaling, preventing biofilm development; (5) AgNPs interact with small regulatory RNA and extracellular proteins to thwart biofilm formation [29].

3. Antifungal Activity:

Fungal infections are particularly prevalent in individuals with weakened immune systems, and managing these fungal-related illnesses is often a lengthy process due to the limited options for antifungal treatments available. Consequently, there is an urgent and pressing need to develop antifungal agents that are biocompatible, non-toxic, and environmentally friendly. In this context, AgNPs

are crucial in antifungal therapies targeting a variety of fungal infections. The presents antifungal effectiveness of various plant-mediated synthesized AgNPs along with their morphological characterization. A. indica-derived AgNPs demonstrated notable antifungal activity against *A. niger* (12 mm) and *C. albicans* (23 mm) at a concentration of 300 µg/ml. AgNPs showed promising effects against fungal pathogens when compared to the standard commercial antibiotic ketoconazole [30]. AgNPs were synthesized using Lawsonia inermis (Henna), and the synthesis of phytochemical-capped nanoparticles and their effectiveness were evaluated against human pathogens such as *Microsporum canis, Trichophyton mentagrophytes,* and *Candida albicans*, which exhibited synergistic actions with commercial antibiotics. AgNPs displayed enhanced stability and a stronger synergistic effect in combination with commercial antibiotics. Nanogels formulated with AgNPs also yielded effective results against pathogenic fungi and were recommended for treating skin infections either through gel formulations or creams. The antifungal action against *Aspergillus sp*., using Aloe vera (leaves)-mediated AgNPs, revealed significant activity. The maximum inhibition of fungal hyphae was observed at 10 µL of AgNPs, and microscopic examinations showed destruction of fungal conidial germination and severe alterations to the cell structure and budding process. AgNPs not only target human pathogens but also several indoor fungal pathogens, including *Aspergillus fumigatus, Cladosporium cladosporioides, Chaetomium globosum, Stachybotrys chartarum, Penicillium brevicompactum, Mortierella alpine,* and *Fusarium sp*.. The exact mechanism underlying the antifungal effects of AgNPs is still not fully understood. The antifungal mode of action of AgNPs was theorized and elaborated in our previous work, as depicted in Figure 7a: (1) AgNPs bind with ergosterol in the cell wall, forming a pore that allows internal organelles to leak; (2) AgNPs activate reactive oxygen species, and excessive production leads to apoptosis; (3) AgNPs connect with DNA and RNA, inhibiting cell division; (4) AgNPs attack the sulfhydryl end of protein, thereby preventing protein synthesis; and (5) AgNPs interfere with the G1/M phase, arresting cell division [31-33].

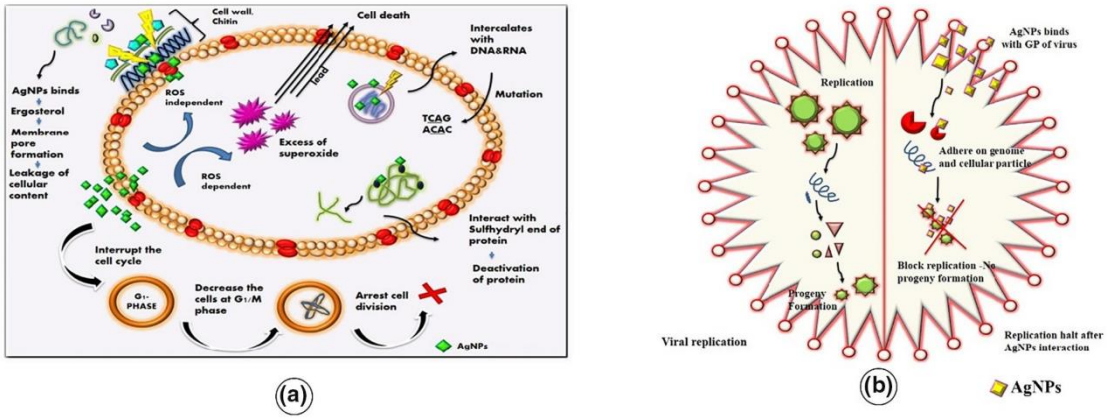

Fig. 7 (a) Antifungal mechanism of plant-mediated synthesised silver nanoparticles (AgNPs) [115] (b) An Illustrated antiviral mechanism of plant- mediated synthesised AgNPs

Future Perspectives and Conclusion:

The Silver nanoparticles represent an innovative approach to identifying and remedying injuries to the human body. Due to their diverse applications, they have garnered international recognition. The application of nanoparticles in The realm of medicine reveals intriguing opportunities and plays an integral part in enabling nano-robots to mend cells at the microscopic level. This approach lessens harm to the healthy cells within the body, facilitating earlier disease identification. Extensive research is being conducted on silver nanoparticles as innovative and enhanced biomedical nanostructures.

In medicinal plants have been utilized for therapeutic purposes since ancient times. We posit that certain compounds found in these plants possess healing attributes. This review consolidates the presently recognized biosynthesis possibilities of silver nanoparticles derived from medicinal plant extracts and supplies a dataset aimed at aiding researchers in their future inquiries into eco-friendly silver nanoparticle synthesis for biomedical uses. Silver nanoparticles are renowned for their exceptional antimicrobial and anti-inflammatory characteristics, finding broad applications in the medical sector. Nonetheless, the toxicity associated with silver nanoparticles must be acknowledged prior to their application, which calls for an understanding of the appropriate silver concentration to ensure efficacy without jeopardizing human health and the environment. Upcoming opportunities in the medical domain for silver nanoparticles include targeting cancer treatment and fluorescence imaging, where the nanoparticles facilitate precise drug delivery, enhanced bioavailability, sustained drug release in targeted tissues, and improved nanoparticle stability. However, further investigation is required to explore the mechanisms by which plant-mediated AgNPs operate in biomedical applications, as this remains ambiguous. Such studies could illuminate the pathways and efficacy of silver nanoparticles.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Youth, Digital Literacy and Employability: A Study of Commerce Students in the Changing Business Environment

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Abstract:

Digital technology has transformed business operations, communication, recruitment, and service delivery, making digital literacy essential for Commerce graduates. This study examines the relationship between digital literacy and employability among Commerce students, focusing on their ability to use digital devices, online information, communication platforms, office applications, digital payments, e-learning resources, and emerging technologies. It also assesses students' confidence in communication, problem-solving, teamwork, adaptability, and job-search skills. Primary data were collected from 200 Commerce students through a structured questionnaire and analysed using percentage analysis, weighted responses, and the Chi-square test. The findings indicate that students possess basic digital skills, but gaps exist in advanced applications, data analysis, cyber security awareness, professional online communication, and technology-based job-search practices. The study concludes that digital literacy should be integrated into Commerce education as a core employability skill. Colleges can enhance student employability through practical digital training, industry interaction, internships, projects, and career-oriented certifications. Digital literacy is increasingly recognised as an important driver of perceived employability and career readiness.muni+1

Keywords: Digital Literacy, Employability, Commerce Students, Digital Skills, Career Readiness.

Introduction:

The business environment has changed considerably because of digital technology. Computers, smartphones, cloud applications, digital payments, online meetings, e-commerce, social media, data analysis and artificial intelligence are now part of everyday business activities. As a result, the nature of employment is also changing.

For Commerce students, this change is particularly important. Traditional Commerce education has mainly focused on subjects such as Accountancy, Economics, Business Management, Marketing, Finance and Taxation. These subjects remain important, but graduates are increasingly required to apply their knowledge through digital platforms.

Digital literacy does not simply mean knowing how to operate a computer or smartphone. It includes the ability to find and evaluate information, communicate through digital platforms, create and manage digital content, protect personal information and use technology to solve practical problems. The European Commission's Digital Competence Framework identifies areas such as information and data literacy, communication and collaboration, digital content creation, safety and problem-solving as important parts of digital competence. The employment market is also

placing greater emphasis on technology-related skills. The World Economic Forum's *Future of Jobs Report 2025* identifies technological literacy, AI and big data, networks and cyber security among the skills whose importance is expected to rise. At the same time, employers continue to value analytical thinking, creativity, resilience, leadership and collaboration. This means that employability is no longer based only on academic qualifications. A Commerce graduate may have a degree but may still face difficulties if he or she cannot prepare a professional presentation, analyse spreadsheet data, communicate through digital platforms, use online business applications or learn new technology.

The present study therefore attempts to understand the level of digital literacy among Commerce students and its possible contribution to their employability.

Need and Significance of the Study:

The study is important for the following reasons:

1. Digital technology is becoming an essential part of modern business.
2. Commerce graduates are increasingly expected to possess practical digital skills.
3. Academic qualifications alone may not guarantee employment.
4. Employers increasingly look for a combination of technical and personal skills.
5. Students need to understand their own digital strengths and weaknesses.
6. Colleges can use the findings to improve skill-based education.
7. The study can help teachers identify areas where students require additional training.
8. It can encourage students to develop practical skills along with subject knowledge.
9. It supports the broader objective of making higher education more connected with employment needs.
10. It connects traditional Commerce education with the changing digital world.

Objectives of the Study:

The major objectives of the study are:

1. To study the level of digital literacy among Commerce students.
2. To identify the major digital tools used by Commerce students.
3. To examine students' awareness of digital technologies used in business.
4. To study students' perception of their employability.
5. To examine the relationship between digital literacy and employability.
6. To identify major digital skill gaps among Commerce students.
7. To understand students' need for practical digital training.
8. To suggest measures for improving digital skills and employability among Commerce students.

Hypotheses of the Study:

Null Hypothesis (H_0): There is **no significant relationship between digital literacy and perceived employability among Commerce students.**

Alternative Hypothesis (H_1): There is a **significant relationship between digital literacy and perceived employability among Commerce students.**

A second hypothesis may also be considered:

H_{02}: There is no significant difference in the level of digital literacy among Commerce students based on their academic level.

H_{12}: There is a significant difference in the level of digital literacy among Commerce students based on their academic level.

Review of Literature:

Yorke and Knight (2006) explained that graduate employability is broader than merely possessing a degree or individual skills. They linked employability with the development of students' overall capabilities through higher education and emphasised that curricula and learning activities should prepare students for real-world situations.

van Laar et al. (2017) conducted a systematic review of literature on digital skills and 21st-century skills. They identified technical skills, information management, communication, collaboration, creativity, critical thinking, and problem-solving as important digital skills. The study also highlighted flexibility, self-direction, and lifelong learning as essential capabilities for the modern workplace.

Morgan, Sibson, and Jackson found that digital literacy contributes to students' value in the graduate employment market. Their study of 324 higher education students showed differences across digital literacy areas; students particularly reported difficulty in evaluating digital information and judging its quality.

Kim (2020) examined the relationship between digital literacy and perceived employability among Korean college students. Based on data from 916 students, the study found a positive relationship between digital literacy and perceived employability. It further suggested that core competencies play an important role in strengthening this relationship.

Gao (2024) studied digital literacy and employment ability among vocational undergraduate students using data from 577 students. The study reported a positive relationship between digital literacy and employability and identified career decision confidence and future career thinking as important factors.

Recent studies also support the positive relationship between digital literacy and employability. A 2024 study on work-integrated learning found that digital literacy positively influenced the relationship between practical learning and graduate employability. Research published in 2025 found that digital literacy supports career-management skills and perceived employability among students. Further, a 2026 Indian study of engineering students identified a gap between students' existing digital abilities and the advanced digital skills expected by employers.

Overall, the reviewed literature indicates that digital literacy is strongly associated with employability. However, students often lack advanced digital competencies, particularly in information evaluation, data analysis, cybersecurity, and professional use of technology, which highlights the need to integrate digital literacy into higher education curricula.

Research Gap:

The existing literature provides evidence that digital literacy and employability are connected. However, there is a need for more studies focusing specifically on **Commerce students in smaller and developing cities**, where students may have different levels of access to digital resources, practical training and industry exposure. The present study attempts to contribute to this area by focusing on Commerce students and by examining both their digital abilities and employment-related skills.

Research Methodology:

Research Design: The study follows a **descriptive and analytical research design**. The descriptive part identifies students' digital skills and employment-related abilities, while the analytical part examines the relationship between digital literacy and perceived employability.

Population: The population consists of undergraduate Commerce students.

Sample Size: For the research study analysis, a sample of **200 Commerce students** is considered. The respondents may include students from:

- First Year B.Com.
- Second Year B.Com.
- Third Year B.Com.
- Other undergraduate Commerce programmes.

Sampling Method: A convenient sampling method may be used for the preliminary study. For a larger published study, stratified or systematic sampling would provide stronger representation.

Sources of Data:

Primary Data: In the said research Primary data may be collected through a structured questionnaire distributed among Commerce students.

Secondary Data: Secondary information may be collected from:

- Research papers
- Books
- Government reports
- Institutional reports
- Digital competency frameworks
- Reports on future employment and skills

Tools of Data Collection: A structured questionnaire containing multiple-choice and five-point scale questions may be used.

The five-point scale can be:

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

Statistical Tools: In this research the following tools may be used:

- Frequency
- Percentage
- Mean score
- Weighted average
- Chi-square test
- Correlation analysis

Conceptual Framework:

The study considers **Digital Literacy** as the main independent variable and **Employability** as the dependent variable.

Digital Literacy: It includes:

- Basic computer skills
- Internet use
- Information search
- Online communication
- MS Word
- MS Excel
- Presentation skills
- Digital payments
- Online learning
- Data handling
- Cybersecurity awareness
- Use of emerging technologies

Employability: It includes:

- Communication
- Problem-solving
- Teamwork
- Adaptability
- Analytical thinking
- Job-search ability
- Interview preparation
- Professional behaviour
- Career planning
- Willingness to learn

There is a Conceptual relationship:

Digital Literacy → Practical Skills → Confidence → Employability

Data Analysis and Interpretation:

The following tables use an illustrative sample of 200 students. The values should be replaced by actual survey results before submission as an empirical research paper.

Table 1: Gender-wise Distribution:

Gender	Number	Percentage
Male	86	43%
Female	114	57%
Total	**200**	**100%**

Interpretation: The illustrative sample consists of 57% female and 43% male respondents. This indicates a slightly higher representation of female Commerce students in the sample.

Table 2: Academic Level of Respondents

Class	Number	Percentage
First Year	68	34%
Second Year	65	32.5%
Third Year	67	33.5%
Total	**200**	**100%**

Interpretation: The respondents are reasonably distributed across the three undergraduate levels. This provides representation from students at different stages of Commerce education.

Digital Skills of Commerce Students:

Table 3: Ability to Use Basic Digital Tools

Digital Skill	Students reporting good/very good ability	Percentage
Smartphone and Internet	184	92%
Email	176	88%
MS Word	164	82%
Online learning platforms	170	85%
Digital payments	180	90%
MS PowerPoint	148	74%
MS Excel	126	63%
Online data search and evaluation	118	59%
Cyber security awareness	104	52%
Data analysis tools	82	41%

Interpretation: The illustrative results show that students are comfortable with basic digital activities such as smart phone use, email, online learning and digital payments.

However, the level is comparatively lower for **data analysis, cybersecurity and evaluation of online information**. This suggests that regular use of technology does not automatically mean that students possess workplace-ready digital skills.

Students' Perception of Employability:

Table 4: Employability Skills

Statement	Agree/Strongly Agree	Percentage
I can communicate effectively	158	79%
I can work effectively in a team	164	82%
I can solve basic workplace problems	146	73%
I can adapt to new technology	152	76%
I can prepare a professional CV	116	58%
I am confident about online interviews	108	54%
I can search for suitable jobs online	138	69%
I can analyse business information using digital tools	96	48%
I feel prepared for a digital workplace	124	62%
I am willing to learn new technology	174	87%

Interpretation: The results indicate that students show positive attitudes towards learning technology and working in teams. However, their confidence is comparatively lower in professional CV preparation, online interviews and digital business analysis. This suggests that Commerce students may have general digital familiarity but require more **employment-focused digital training**.

Major Digital Skill Gaps:

Table 5: Areas Where Students Need Additional Training

Area	Students identifying need	Percentage
Advanced Excel	142	71%
Data analysis	150	75%
Cyber security	132	66%
AI tools for business	156	78%
Digital marketing	128	64%
Professional communication	110	55%
Online interview skills	118	59%
Financial technology applications	126	63%

Interpretation: The highest demand is for training in **AI tools, data analysis and advanced Excel**. This is important for Commerce education because these skills can be directly connected with accounting, finance, marketing, banking and business management. The results are also consistent with wider employer expectations that technological literacy, AI and data-related abilities are becoming more important in the workplace

Digital Literacy and Employability:

For analytical purposes, students may be classified into three groups:

Digital Literacy Level	Number	Percentage
Low	34	17%
Moderate	102	51%
High	64	32%
Total	**200**	**100%**

Interpretation: More than half of the illustrative respondents fall into the moderate digital literacy category. Only 32% show a high level of digital literacy. This indicates that there is considerable scope for colleges to move students from basic or moderate digital ability towards advanced, employment-oriented skills.

Relationship between Digital Literacy and Employability:

An illustrative cross-tabulation is presented below.

Digital Literacy	Low Employability	Moderate Employability	High Employability	Total
Low	20	12	2	34
Moderate	22	58	22	102
High	4	22	38	64
Total	**46**	**92**	**62**	**200**

Interpretation: The table indicates a positive pattern. Students with higher digital literacy tend to report higher employability. Among students with high digital literacy, a comparatively large proportion fall in the high-employability category. In contrast, students with low digital literacy are more concentrated in the low-employability category. This supports the view that digital literacy can contribute to students' readiness for employment.

Hypothesis Testing:

Chi-Square Test:

Hypotheses:

H_0: There is no significant relationship between digital literacy and employability.

H_1: There is a significant relationship between digital literacy and employability.

Using the illustrative cross-tabulation above:

- Calculated Chi-square value ≈ **43.45**
- Degrees of freedom = **4**
- Table value at 5% significance level = **9.488**

Decision:

Since: **Calculated value (43.45) > Table value (9.488)**

The null hypothesis is rejected.

Conclusion of Test:

There is a **statistically significant relationship between digital literacy and perceived employability** among the students in the illustrative dataset.

Therefore, the alternative hypothesis is accepted.

Important: This statistical result is based on the illustrative 200-student dataset created for this model paper. It should be recalculated using your actual questionnaire responses before publication.

Major Findings:

The said study is Based on the illustrative analysis, so the major findings of the studies are:

1. Most Commerce students are comfortable using smartphones and the internet.
2. Email and online learning skills are relatively strong.
3. Digital payment awareness is high among students.
4. Students have comparatively weaker skills in advanced Excel and data analysis.
5. Cyber security awareness requires improvement.
6. Many students are interested in learning AI-based business tools.
7. Students generally show willingness to learn new technologies.
8. Students have reasonable confidence in teamwork and communication.
9. Confidence in online interviews and professional CV preparation is comparatively lower.
10. Students with higher digital literacy tend to show higher perceived employability.
11. Digital literacy appears to be an important supporting factor in preparing Commerce students for the changing workplace.
12. Classroom knowledge needs to be supported by practical digital experience.

Suggestions:

Following are the suggestions for this research

1. To introduce Practical Digital Skill Modules:

In this research study Commerce colleges should provide practical training to students in:

- Advanced Excel
- Data analysis
- Accounting software
- Digital marketing
- Business presentations
- Digital payments
- Online banking
- Basic AI tools

- Cybersecurity

2. Strengthen Industry-Oriented Learning:

Students should be given opportunities to interact with:

- Banks
- Accounting firms
- Companies
- Start-ups
- Digital marketing agencies
- Financial institutions

Such interaction can help students understand actual workplace expectations.

3. Conduct Short-Term Certification Programmes:

Colleges can organise certificate courses in:

- Advanced Excel
- Tally and accounting software
- GST applications
- Digital marketing
- Financial technology
- Data analysis
- AI applications in business

4. Develop Online Interview Skills:

Students should be trained in:

- Online interviews
- Professional email writing
- Resume preparation
- LinkedIn/profile development
- Online job applications
- Professional digital communication

5. Include Digital Projects in Commerce Subjects:

Instead of limiting students to written assignments, teachers can give practical projects such as:

- Preparing an Excel-based financial report
- Analysing consumer data
- Preparing a digital marketing plan
- Studying online payment behaviour
- Preparing a business presentation
- Analysing a company's financial statements using spreadsheets

6. Promote Responsible Use of AI: Students should learn to use AI as a learning and productivity tool while maintaining academic honesty, independent thinking, data privacy and verification of information.

7. Encourage Continuous Learning: Technology changes rapidly. Students should therefore develop the habit of learning new tools rather than depending only on the skills learned during their degree programme. The World Economic Forum also identifies curiosity, lifelong learning, analytical thinking and technological literacy among important skills for the changing employment environment

Conclusion:

The business world is moving beyond traditional boundaries. Commerce is no longer limited to books, ledgers, physical markets and conventional office practices. Digital payments, e-commerce, online banking, data analysis, artificial intelligence, social media and digital communication have created a new environment for business and employment. For Commerce students, this transformation creates both opportunities and challenges. The degree provides important subject knowledge, but students also need the ability to apply that knowledge through digital tools.

The present study indicates, through its illustrative analysis, that digital literacy and employability are closely connected. Students who are more confident in using digital tools are also more likely to feel prepared for the workplace. At the same time, important gaps remain in advanced Excel, data analysis, cybersecurity, AI applications, professional communication and online job-search skills. Therefore, Commerce education should move from **“knowledge only” to “knowledge plus**

application." Colleges, teachers, industry and students need to work together to create learning opportunities that develop both subject knowledge and practical digital skills.

The real meaning of **"beyond boundaries"** in Commerce and Management is the ability to connect classroom learning with technology, industry, society and the global workplace. Digital literacy should therefore not be treated as an optional additional skill. It should become an integral part of modern Commerce education and graduate preparation.

Limitations of the Study:

1. The study is focused on Commerce students.
2. The proposed sample is limited to 200 respondents.
3. The study mainly considers students' self-reported digital skills.
4. Perceived employability may differ from actual employment outcomes.
5. Digital technologies and employer requirements change rapidly.
6. The illustrative statistical results must be replaced with actual field data before formal publication.

Scope for Further Research:

Future researchers can extend the study by:

1. Comparing Commerce students with Management and Science students.
2. Comparing urban and rural students.
3. Studying digital literacy among postgraduate Commerce students.
4. Studying the role of AI literacy in graduate employability.
5. Examining the digital skill expectations of employers.
6. Comparing male and female students.
7. Studying the impact of internships on digital employability.
8. Comparing students from different districts or universities.
9. Examining the relationship between digital certification and employment outcomes.
10. Conducting a longitudinal study to observe students' skills before and after digital training.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

भाषा अध्ययनातील कृत्रिम बुद्धिमत्ता (AI) आणि डिजिटल मानविकी (Digital Humanities)

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DOI - 10.5281/zenodo.24334512

गोषवारा (Abstract) :

एकविसाव्या शतकात कृत्रिम बुद्धिमत्ता (Artificial Intelligence—AI) आणि डिजिटल मानविकी (Digital Humanities) या दोन क्षेत्रांमुळे भाषा अध्ययन, साहित्य संशोधन आणि ज्ञाननिर्मितीच्या प्रक्रियेत महत्त्वपूर्ण बदल घडत आहेत. कृत्रिम बुद्धिमत्तेच्या साहाय्याने भाषांतर, व्याकरण तपासणी, संभाषणाचा सराव, लेखन सुधारणा आणि वैयक्तिक अध्ययनास मदत मिळू शकते. दुसरीकडे, डिजिटल मानविकीमध्ये संगणकीय साधने, डिजिटल संग्रह, मजकूर विश्लेषण, भाषिक माहितीचे वर्गीकरण आणि साहित्याच्या डिजिटल नोंदी यांचा उपयोग करून मानवी भाषा व संस्कृतीचा अभ्यास केला जातो. मराठीसारख्या भारतीय भाषांसाठी या दोन्ही क्षेत्रांना विशेष महत्त्व आहे. मराठी भाषेतील डिजिटल साहित्यसंग्रह तयार करणे, बोलीभाषांचे दस्तऐवजीकरण, संतसाहित्याचे संगणकीय विश्लेषण, भाषांतराची गुणवत्ता तपासणे आणि विद्यार्थ्यांसाठी डिजिटल अध्ययनसाहित्य विकसित करणे अशा अनेक शक्यता निर्माण झाल्या आहेत. तथापि, भाषिक अचूकता, डिजिटल साधनांमधील भाषिक असमानता, माहितीची विश्वासार्हता, कॉपीराइट आणि वैयक्तिक माहितीची सुरक्षितता ही आव्हानेही आहेत. प्रस्तुत संशोधनात भाषा अध्ययनातील कृत्रिम बुद्धिमत्तेची उपयुक्तता, डिजिटल मानविकीचे स्वरूप आणि मराठी भाषा-साहित्याच्या विकासासाठी या दोन्ही क्षेत्रांचा समन्वय कसा साधता येईल, याचे विश्लेषण केले आहे.

पारिभाषिक संज्ञा : AI -कृत्रिम बुद्धिमत्ता, भाषा अध्ययन, डिजिटल मानविकी, मराठी भाषा, संगणकीय भाषाविज्ञान, डिजिटल साहित्य, भाषासंवर्धन.

प्रस्तावना:

भाषा ही मानवी संवादाचे साधन असण्याबरोबरच संस्कृती, ज्ञान, इतिहास आणि सामाजिक अनुभव यांची वाहक आहे. भाषा शिकण्याची प्रक्रिया ही केवळ शब्दसंग्रह आणि व्याकरण आत्मसात करण्यापुरती मर्यादित नसून ऐकणे, बोलणे, वाचणे, लिहिणे आणि सांस्कृतिक संदर्भ समजून घेणे यांचाही त्यात समावेश होतो.पारंपरिक भाषा अध्ययनात शिक्षक, पाठ्यपुस्तके, शब्दकोश, व्याकरणग्रंथ आणि प्रत्यक्ष संभाषण यांना महत्त्व होते. डिजिटल तंत्रज्ञानाच्या विकासामुळे ऑनलाइन शब्दकोश, ई-पुस्तके, ध्वनिमुद्रित साहित्य, भाषांतराची साधने आणि संवादाधारित अध्ययनपद्धती उपलब्ध झाल्या. कृत्रिम बुद्धिमत्तेच्या प्रगतीमुळे या प्रक्रियेला आणखी गती मिळाली आहे.कृत्रिम बुद्धिमत्तेवर आधारित प्रणाली भाषेतील नमुने ओळखू शकतात, प्रश्नांची उत्तरे देऊ शकतात, लेखनातील संभाव्य चुका दाखवू शकतात आणि विद्यार्थ्यांना संभाषणाचा सराव करण्यास मदत करू शकतात. मात्र, अशा प्रणालींची उत्तरे नेहमीच अचूक किंवा संदर्भानुरूप असतील असे नाही. त्यामुळे तंत्रज्ञानाचा वापर चिकित्सक दृष्टीने करणे आवश्यक आहे. भाषा अध्ययनातील AI च्या

संधी आणि मर्यादांवर अलीकडील संशोधनातही भर देण्यात आला आहे. याच संदर्भात डिजिटल मानविकी हे महत्त्वाचे आंतरविद्याशाखीय क्षेत्र उदयास आले आहे. साहित्य, इतिहास, भाषा, संस्कृती आणि तत्त्वज्ञान यांसारख्या मानवविद्याशाखांचा डिजिटल तंत्रज्ञानाच्या मदतीने अभ्यास करणे, हा डिजिटल मानविकीचा व्यापक उद्देश आहे. त्यामुळे भाषा अध्ययनातील कृत्रिम बुद्धिमत्ता आणि डिजिटल मानविकी यांचा परस्परसंबंध समजून घेणे आवश्यक आहे .

भाषा अध्ययनातील कृत्रिम बुद्धिमत्ता आणि डिजिटल मानविकी हा विषय निवडण्यामागे आधुनिक शिक्षणपद्धतीतील बदल, भारतीय भाषांचे डिजिटल संवर्धन आणि साहित्य संशोधनातील तांत्रिक साधनांचा वाढता वापर ही प्रमुख कारणे आहेत.मराठी भाषा आणि साहित्याच्या अभ्यासात अनेकदा मुद्रित ग्रंथ, हस्तलिखिते, नियतकालिके, मौखिक परंपरा आणि बोलीभाषांचा संदर्भ घेतला जातो. या साहित्याचे डिजिटल स्वरूपात जतन केले, तर त्याचा शोध घेणे, तुलना करणे आणि संशोधनासाठी उपयोग करणे अधिक सुलभ होऊ शकते. उदाहरणार्थ, संत ज्ञानेश्वर, संत तुकाराम किंवा संत नामदेव यांच्या साहित्यामधील विशिष्ट शब्दांचा वापर, सामाजिक विचार आणि विषयवैविध्य यांचा संगणकीय साधनांच्या मदतीने अभ्यास करता येऊ शकतो.याशिवाय, विद्यार्थ्यांना मराठी व्याकरण शिकणे, शब्दसंग्रह वाढविणे, भाषांतराचा सराव करणे आणि लेखनातील चुका ओळखणे यासाठी AI-आधारित साधनांचा उपयोग करता येतो. UNESCO च्या बहुभाषिक डिजिटल तंत्रज्ञानविषयक मार्गदर्शनात सर्व भाषांना डिजिटल माध्यमांमध्ये योग्य प्रतिनिधित्व मिळण्याच्या गरजेवर भर देण्यात आला आहे . त्यामुळे हा विषय भाषा शिक्षण, मराठी साहित्य संशोधन, भाषासंवर्धन आणि डिजिटल ज्ञाननिर्मिती या सर्व क्षेत्रांच्या दृष्टीने महत्त्वाचा आहे.

संशोधनाची उद्दिष्टे:

१. भाषा अध्ययनातील कृत्रिम बुद्धिमत्तेचे स्वरूप आणि उपयुक्तता स्पष्ट करणे.
२. डिजिटल मानविकीची संकल्पना आणि तिच्या प्रमुख अभ्यासपद्धतींचा परिचय करून देणे.
३. भाषा अध्ययन आणि साहित्य संशोधनात AI व डिजिटल साधनांचा उपयोग तपासणे.
४. मराठी भाषा आणि साहित्याच्या डिजिटल संवर्धनासाठी उपलब्ध शक्यतांचा अभ्यास करणे.
५. कृत्रिम बुद्धिमत्तेच्या वापरातील भाषिक, शैक्षणिक आणि नैतिक आव्हानांचे विश्लेषण करणे.
६. मराठी भाषा अध्ययनासाठी तंत्रज्ञानाचा जबाबदार आणि परिणामकारक वापर करण्याच्या उपाययोजना सुचविणे.

संशोधन पद्धती:

प्रस्तुत संशोधनासाठी वर्णनात्मक, विश्लेषणात्मक आणि संकल्पनात्मक पद्धतीचा वापर केला आहे. कृत्रिम बुद्धिमत्ता, भाषा अध्ययन आणि डिजिटल मानविकी या विषयांशी संबंधित संशोधन लेख, शैक्षणिक धोरणे आणि अधिकृत संस्थांची माहिती यांचा संदर्भ घेतला आहे.या अभ्यासात भाषा शिकण्यासाठी AI चा उपयोग, डिजिटल मजकूर विश्लेषण, भाषांतर, डिजिटल साहित्यसंग्रह आणि मराठी भाषेच्या संवर्धनासाठी तंत्रज्ञानाच्या वापराच्या शक्यता यांचा विचार केला आहे. हा संकल्पनात्मक अभ्यास असून स्वतंत्र सर्वेक्षण किंवा प्रयोगाद्वारे निष्कर्ष तपासल्याचा दावा केलेला नाही.

भाषा अध्ययनातील कृत्रिम बुद्धिमत्तेचे स्वरूप:

कृत्रिम बुद्धिमत्ता म्हणजे संगणकीय प्रणालींना विशिष्ट प्रकारची माहिती प्रक्रिया करणे, भाषेतील नमुने ओळखणे, प्रश्नांची उत्तरे तयार करणे आणि काही प्रकारची समस्या सोडविणे शक्य करणाऱ्या तंत्रज्ञानाचा व्यापक समूह होय. भाषा अध्ययनाच्या संदर्भात नैसर्गिक भाषा प्रक्रिया (Natural Language Processing—NLP), स्वयंचलित भाषांतर, ध्वनी ओळख, मजकूर विश्लेषण आणि संवादाधारित प्रणाली यांचा विशेष उपयोग होतो.AI-आधारित साधने विद्यार्थ्यांच्या भाषिक गरजांनुसार स्पष्टीकरण देऊ शकतात, उदाहरणे तयार करू शकतात आणि लेखनातील संभाव्य चुका दाखवू शकतात. उदाहरणार्थ, मराठी शिकणाऱ्या विद्यार्थ्याला एखाद्या व्याकरणिक नियमाचे स्पष्टीकरण, समानार्थी शब्द, वाक्यरचना किंवा उताऱ्याचा सोप्या भाषेतील अर्थ समजून घेण्यासाठी अशा साधनांची मदत घेता येते.Rahman आणि सहलेखकांच्या भाषा अध्ययनातील कृत्रिम बुद्धिमत्तेवरील आढाव्यात या क्षेत्रातील संशोधनाचा विस्तार आणि विविध उपयोग अधोरेखित केले आहेत. मात्र, कोणत्याही AI प्रणालीने दिलेले उत्तर संदर्भग्रंथ किंवा विश्वसनीय भाषिक स्रोत यांच्या आधारे तपासणे आवश्यक आहे.

भाषा अध्ययनातील कृत्रिम बुद्धिमत्तेचे उपयोग:

प्रत्येक विद्यार्थ्याची भाषा शिकण्याची गती, पूर्वज्ञान आणि अडचणी वेगवेगळ्या असतात. AI-आधारित साधनांच्या मदतीने विद्यार्थी स्वतःच्या गरजेनुसार प्रश्न विचारू शकतात, उदाहरणे मिळवू शकतात आणि लेखनातील त्रुटी तपासू शकतात. उदा. मराठी व्याकरण शिकणाऱ्या विद्यार्थ्याला काळ, विभक्ती, वाक्यरचना किंवा विरामचिन्हे यांसंबंधी स्पष्टीकरण मागता येते. त्यानंतर स्वतःची उत्तरे तयार करून त्यांची तुलना करता येते. अशा प्रक्रियेमुळे स्वाध्यायाला मदत होऊ शकते; मात्र विद्यार्थ्याने स्वतः विचार करण्याऐवजी संपूर्ण काम AI कडून करून घेणे महत्वाचे आहे..

AI-आधारित भाषांतर साधने एका भाषेतील मजकूर दुसऱ्या भाषेत रूपांतरित करण्यास मदत करतात. मराठी आणि इंग्रजी यांमधील भाषांतर, नवीन शब्दांचे अर्थ, समानार्थी शब्द आणि वाक्प्रचार समजून घेण्यासाठी त्यांचा उपयोग होऊ शकतो.तसेच साहित्यिक भाषांतरात केवळ शब्दांचा अर्थ पुरेसा नसतो. सांस्कृतिक संदर्भ, विनोद, म्हणी, बोलीभाषा आणि भावनिक आशय जपणे आवश्यक असते. त्यामुळे AI ने केलेले भाषांतर हे अंतिम स्वरूप मानण्याऐवजी त्याचे मानवी परीक्षण करणे महत्त्वाचे आहे.

भाषा शिकताना वाचन आकलन, लेखन, ऐकणे आणि बोलणे या चारही कौशल्यांचा विकास आवश्यक असतो. AI-आधारित संवाद साधने संभाषणाचा सराव, प्रश्नोत्तरे, लेखनासाठी सूचना आणि वाचलेल्या उताऱ्याचे आकलन तपासण्यासाठी उपयोगी ठरू शकतात. मराठी भाषेतील एखाद्या कवितेचा अर्थ समजून घेताना विद्यार्थी प्रथम स्वतःचे आकलन लिहू शकतो. त्यानंतर AI कडून पर्यायी अर्थ किंवा भाषिक स्पष्टीकरण घेऊन त्यांची तुलना करू शकतो. अशा पद्धतीने विद्यार्थ्याची चिकित्सक विचारक्षमता वाढविण्यास मदत होते.UNESCO च्या भाषा अध्ययनविषयक चर्चेतही AI चा वापर शिक्षकांना पूरक साधन म्हणून करण्याचे महत्त्व अधोरेखित केले आहे. तंत्रज्ञानामुळे भाषेचा सराव सुलभ होऊ शकतो; मात्र मानवी संवाद आणि सांस्कृतिक समज यांची जागा ते पूर्णपणे घेऊ शकत नाही.

डिजिटल मानविकी म्हणजे मानवविद्याशाखांतील प्रश्नांचा अभ्यास करण्यासाठी डिजिटल साधने, संगणकीय पद्धती आणि डिजिटल संग्रह यांचा उपयोग करणारे

आंतरविद्याशाखीय क्षेत्र होय. यात साहित्य, भाषा, इतिहास, तत्त्वज्ञान, संस्कृती आणि कला यांचा डिजिटल तंत्रज्ञानाशी संबंध जोडला जातो.डिजिटल मानविकीमध्ये केवळ पुस्तकांचे डिजिटायझेशन करणे अपेक्षित नसते. डिजिटल स्वरूपातील मजकूर शोधणे, त्याचे वर्गीकरण करणे, विविध आवृत्त्यांची तुलना करणे, शब्दांच्या वापरातील प्रवाह तपासणे आणि सांस्कृतिक माहितीचे विश्लेषण करणे यांचाही समावेश होतो.उदा. एखाद्या कवीच्या अनेक कवितांचे डिजिटल संकलन तयार करून त्यामधील निसर्गविषयक शब्द, सामाजिक संकल्पना किंवा विशिष्ट प्रतिमांचा अभ्यास करता येऊ शकतो. अशा अभ्यासातून साहित्यिक प्रवृत्तींची ओळख पटविण्यास मदत होते. मात्र, संगणकीय विश्लेषणातून मिळालेल्या नमुन्यांचा अर्थ लावताना साहित्याचा ऐतिहासिक, सामाजिक आणि सांस्कृतिक संदर्भ लक्षात घेणे आवश्यक आहे.

मराठी भाषा आणि साहित्याच्या अभ्यासातील डिजिटल मानविकी:

मराठीतील जुने ग्रंथ, नियतकालिके, हस्तलिखिते, दुर्मीळ पुस्तके आणि लोकसाहित्य यांचे डिजिटल स्वरूपात जतन केल्यास संशोधकांना त्यांचा अभ्यास करणे सोपे होऊ शकते. डिजिटल संग्रहामुळे साहित्य शोधणे, संदर्भ तपासणे आणि विविध आवृत्त्यांची तुलना करणे अधिक सुलभ होते.मात्र, केवळ पुस्तकाचे छायाचित्र तयार करणे आणि त्यातील मजकूर शोधता येईल असे डिजिटल रूप तयार करणे यात फरक आहे. मजकूर ओळख तंत्रज्ञान (OCR) वापरताना देवनागरी अक्षरे, जुन्या मुद्रणशैली आणि अस्पष्ट मजकूर यांमुळे चुका होऊ शकतात. म्हणून डिजिटल मजकुराची अचूकता तपासणे आवश्यक आहे.

डिजिटल मानविकीच्या साहाय्याने साहित्यकृतींचे शब्दसंख्या विश्लेषण, वारंवार वापरल्या जाणाऱ्या संकल्पनांचा अभ्यास, विषयानुसार वर्गीकरण आणि विविध लेखकांच्या भाषाशैलींची तुलना करता येऊ शकते.

उदाहरणार्थ, संतसाहित्य, दलित साहित्य किंवा ग्रामीण साहित्य यांतील निवडक ग्रंथांचा डिजिटल संग्रह तयार करून सामाजिक न्याय, निसर्ग, भक्ती किंवा मानवी संबंध यांसारख्या संकल्पनांचा अभ्यास करता येईल. संगणकीय विश्लेषणामुळे मोठ्या प्रमाणातील मजकुरातील नमुने शोधण्यास मदत होते; परंतु साहित्यकृतीचा अंतिम अर्थ केवळ शब्दांच्या संख्येवरून ठरविता येत नाही.

अहिराणी, तावडी आणि खान्देशातील इतर भाषिक प्रकारांचा अभ्यास करताना ध्वनिमुद्रण, लिप्यंतरण, शब्दसंग्रह, म्हणी आणि वाक्प्रचार यांचे डिजिटल दस्तऐवजीकरण करता येऊ शकते.यामुळे स्थानिक भाषिक परंपरांचे जतन, तुलनात्मक भाषाभ्यास आणि भावी संशोधनासाठी साधनसामग्री उपलब्ध होऊ शकते. अशा प्रकल्पांत स्थानिक भाषकांची संमती, माहितीच्या वापराचे नियम आणि सांस्कृतिक संदर्भ यांचा आदर करणे आवश्यक आहे.

कृत्रिम बुद्धिमत्ता आणि डिजिटल मानविकी यांचा परस्परसंबंध:

कृत्रिम बुद्धिमत्ता आणि डिजिटल मानविकी ही स्वतंत्र असली, तरी एकमेकांना पूरक अशी क्षेत्रे आहेत. कृत्रिम बुद्धिमत्ता भाषिक माहितीचे विश्लेषण करण्यासाठी तांत्रिक साधने उपलब्ध करून देते, तर डिजिटल मानविकी त्या साधनांच्या उपयोगाचा सांस्कृतिक, ऐतिहासिक आणि सामाजिक संदर्भ तपासते.उदा., मराठीतील हजारो कवितांचा डिजिटल संग्रह तयार केला, तर AI च्या मदतीने त्यांतील शब्दांचे वर्गीकरण, विषयांची ओळख आणि भाषिक नमुन्यांचे विश्लेषण करता येऊ शकते. त्यानंतर संशोधक त्या

नमुन्यांचा साहित्यिक व सांस्कृतिक संदर्भात अर्थ लावू शकतो.

या प्रक्रियेत महत्वाचे टप्पे पुढील प्रमाणे -

१. **डिजिटायझेशन: मुद्रित साहित्याचे डिजिटल स्वरूपात रूपांतर करणे.**
२. **संगणकीय विश्लेषण: डिजिटल मजकुरातील शब्द, संकल्पना आणि भाषिक नमुने तपासणे.**
३. **मानवी अर्थनिर्णयन: प्राप्त निष्कर्षांचा ऐतिहासिक, सामाजिक आणि साहित्यिक संदर्भात अभ्यास करणे**.

या तिन्ही टप्प्यांच्या समन्वयातून मराठी साहित्य संशोधन अधिक व्यापक होऊ शकते. तथापि, तांत्रिक विश्लेषणातील चुका किंवा अपूर्ण डिजिटल संग्रहांमुळे निष्कर्षांवर परिणाम होऊ शकतो. म्हणून संशोधकाची चिकित्सक भूमिका अत्यंत महत्त्वाची आहे.

कृत्रिम बुद्धिमत्ता आणि डिजिटल मानविकीसमोरील आव्हाने:

या तंत्रज्ञानामुळे नवीन संधी निर्माण होत असल्या, तरी त्यासोबत काही गंभीर प्रश्नही उपस्थित होतात.

भाषिक अचूकता: AI प्रणालींना मराठीतील बोलीभाषा, म्हणी, वाक्प्रचार आणि सांस्कृतिक संदर्भ समजण्यात अडचणी पुढील प्रमाणे येऊ शकतात-

१.माहितीची विश्वासार्हता: AI कधी कधी चुकीची माहिती किंवा अस्तित्वात नसलेले संदर्भ तयार करू शकते. त्यामुळे संशोधनातील प्रत्येक महत्त्वाचा दावा विश्वसनीय स्रोतांद्वारे तपासणे आवश्यक आहे.

२.डिजिटल असमानता: सर्व विद्यार्थ्यांना समान इंटरनेट सुविधा, संगणक आणि डिजिटल साधने उपलब्ध नसतात. त्यामुळे तंत्रज्ञानाचा लाभ सर्वांपर्यंत समान प्रमाणात पोहोचत नाही.

३.कॉपीराइट आणि लेखकत्व: साहित्यकृतींचा डिजिटल वापर, AI-निर्मित मजकूर आणि इतरांच्या लेखनाचा वापर यांसंबंधी बौद्धिक संपदा हक्कांचा विचार करणे आवश्यक आहे.

४.गोपनीयता: भाषा शिकण्यासाठी किंवा संशोधनासाठी वापरली जाणारी वैयक्तिक माहिती सुरक्षित ठेवणे महत्त्वाचे आहे.

५.मानवी सर्जनशीलतेचे महत्त्व: साहित्यनिर्मिती ही केवळ शब्दांची मांडणी नसून अनुभव, भावना, संस्कृती आणि कल्पनाशक्ती यांच्याशी संबंधित प्रक्रिया आहे. म्हणून AI ला मानवी सर्जनशीलतेचा पर्याय मानण्याऐवजी सहाय्यक साधन म्हणून वापरणे योग्य ठरते.AI च्या शैक्षणिक वापरासंबंधी अलीकडील संशोधनातही वैयक्तिक अध्ययनाच्या संधींसोबत माहितीची विश्वसनीयता, विद्यार्थ्यांचे स्वावलंबन, समान प्रवेश आणि शिक्षकांच्या भूमिकेविषयी चिंता नोंदविण्यात आलेल्या दिसतात.

मराठी भाषा अध्ययनासाठी उपाययोजना:

१. मराठीतील दर्जेदार डिजिटल ग्रंथालये आणि शोधता येण्याजोगे साहित्यसंग्रह विकसित करावेत.
२. मराठी भाषा शिकविण्यासाठी व्याकरण, शब्दसंग्रह, वाचन आकलन आणि लेखन सुधारणा यांसाठी विश्वसनीय डिजिटल साधने विकसित करावीत.
३. मराठीतील बोलीभाषा, लोकसाहित्य, म्हणी आणि वाक्प्रचार यांचे संमतीपूर्वक डिजिटल दस्तऐवजीकरण करावे.
४. महाविद्यालयीन अभ्यासक्रमात डिजिटल मानविकी, संगणकीय भाषाविज्ञान आणि डिजिटल संशोधन पद्धतींची प्राथमिक ओळख करून द्यावी.

५. AI चा वापर करताना माहितीची पडताळणी, संदर्भ नोंदविणे आणि बौद्धिक संपदा हक्कांचा आदर करणे यांचे प्रशिक्षण द्यावे.
६. शिक्षकांनी विद्यार्थ्यांना AI-निर्मित उत्तरांचा चिकित्सक अभ्यास करण्यास प्रोत्साहन द्यावे.
७. भारतीय भाषांसाठी तंत्रज्ञान विकसित करताना भाषिक विविधता आणि सांस्कृतिक वैशिष्ट्ये जपण्यावर भर द्यावा.

UNESCO च्या Global Roadmap for Multilingualism in the Digital Era मध्ये विविध भाषांना डिजिटल जगात योग्य प्रतिनिधित्व मिळावे आणि भाषिक तंत्रज्ञानाचा लाभ अधिक व्यापकपणे उपलब्ध व्हावा, यावर भर देण्यात आला आहे. मराठी भाषेच्या डिजिटल विकासासाठी हा दृष्टिकोन मार्गदर्शक ठरू शकतो.

निष्कर्ष:

१. कृत्रिम बुद्धिमत्ता आणि डिजिटल मानविकी या आधुनिक काळातील महत्त्वाच्या ज्ञानशाखा असून भाषा अध्ययन आणि साहित्य संशोधनासाठी त्या नवीन शक्यता निर्माण करतात. AI च्या साहाय्याने विद्यार्थ्यांना व्याकरण, भाषांतर, लेखन आणि संभाषणाचा सराव करता येतो. डिजिटल मानविकीच्या माध्यमातून साहित्याचे जतन, भाषिक माहितीचे विश्लेषण, दुर्मीळ ग्रंथांचे दस्तऐवजीकरण आणि सांस्कृतिक परंपरांचा अभ्यास अधिक व्यापक स्वरूपात करता येतो.

२. मराठी भाषेच्या संदर्भात या दोन्ही क्षेत्रांना विशेष महत्त्व आहे. मराठी साहित्याचे डिजिटल संग्रह, बोलीभाषांचे दस्तऐवजीकरण, संतसाहित्याचे संगणकीय विश्लेषण आणि मराठी भाषिक साधनांचा विकास यांमुळे भाषा अध्ययन व संशोधनाला नवी दिशा मिळू शकते.

३. तथापि, तंत्रज्ञानाचा वापर करताना भाषिक अचूकता, माहितीची विश्वासार्हता, कॉपीराइट, गोपनीयता आणि सांस्कृतिक संवेदनशीलता यांकडे दुर्लक्ष करता येणार नाही. कृत्रिम बुद्धिमत्तेने उपलब्ध करून दिलेल्या माहितीचे परीक्षण करणे आणि डिजिटल साधनांच्या मर्यादा समजून घेणे आवश्यक आहे.

थोडक्यात कृत्रिम बुद्धिमत्ता ही भाषा अध्ययनासाठी सहाय्यक शक्ती आहे, तर डिजिटल मानविकी ही तंत्रज्ञानाचा वापर करून भाषा, साहित्य आणि संस्कृतीचा चिकित्सक अभ्यास करण्याची व्यापक दिशा आहे. या दोन्हींचा समन्वय साधल्यास मराठी भाषा अध्ययन अधिक प्रभावी, संशोधनाभिमुख आणि भविष्यकालीन गरजांशी सुसंगत होऊ शकते.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Digital Governance and Citizen Empowerment in India: Achievements, Gaps and the Way Forward

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DOI - 10.5281/zenodo.24334540

Abstract:

Digital governance has changed the way the Indian State reaches its citizens. Since the launch of the Digital India programme in 2015, platforms such as Aadhaar, Unified Payments Interface (UPI), DigiLocker, UMANG and BharatNet have together formed a Digital Public Infrastructure (DPI) that delivers identity, payments, documents and services at very large scale. This paper examines whether this transformation has empowered citizens or merely digitised administration. Using secondary data from the Press Information Bureau, the Ministry of Statistics and Programme Implementation, the Ministry of Home Affairs and replies tabled in Parliament, the study analyses growth in connectivity, digital payments and service delivery, and sets these against persistent gaps. The findings show clear gains in access, transparency and financial inclusion: internet connections rose from 25.15 crore in 2014 to 96.96 crore in 2024, and UPI processed 18,586.60 crore transactions in 2024–25. At the same time, the gender gap in internet use, rural–urban differences, a three-fold jump in cyber-fraud losses in 2024, exclusion caused by authentication failures and concerns over data protection limit genuine empowerment. The paper argues that empowerment requires more than access; it needs digital literacy, accountable grievance redressal, privacy safeguards and an assured offline option. It concludes with policy suggestions for citizen-centric digital governance.

Keywords: Digital Governance, Citizen Empowerment, Digital India, Digital Public Infrastructure, e-Governance, Digital Divide, Data Protection

Introduction:

Governance in a democracy is judged not only by the policies it frames but by how easily an ordinary citizen can reach the State, receive entitlements and hold officials accountable. For decades, Indian citizens experienced public services through long queues, multiple visits, middlemen and paper files that could be lost or delayed. Digital governance, meaning the use of information and communication technology to deliver services, manage public processes and enable participation, promised to reduce this distance between the citizen and the government.

India's journey began with the National e-Governance Plan (2006) and gained momentum with the Digital India programme launched on 1 July 2015. Its three vision areas were digital infrastructure as a core utility, governance and services on demand, and digital empowerment of citizens. A decade later, India has built one of the world's largest Digital Public Infrastructures. Yet the key question for political science and public administration remains open: has digitisation actually empowered the citizen, or has it shifted new burdens onto those who are least prepared for them? This paper attempts to answer that question with verified official data and current examples.

Objectives of the Study:

The study has the following objectives: (i) to understand the concept of digital governance and its link with citizen empowerment; (ii) to review the major digital governance platforms in India; (iii) to analyse official data on connectivity, digital payments and service delivery; (iv) to identify current issues and problems that limit empowerment; and (v) to suggest measures for inclusive and accountable digital governance.

Research Methodology:

The study is descriptive and analytical in nature and is based entirely on secondary data. Data have been drawn from primary government sources, namely Press Information Bureau (PIB) backgrounders, the Comprehensive Modular Survey: Telecom 2025 of the National Statistics Office (NSS 80th round), written replies of the Ministry of Finance and the Ministry of Home Affairs in Parliament, and gazette notifications of the Ministry of Electronics and Information Technology (MeitY). Figures have been presented through tables and charts prepared by the author. Each figure carries its source. Since many official figures count registrations rather than active use, the data are interpreted cautiously.

Conceptual Framework:

Empowerment, in the sense used by Amartya Sen (1999), means expanding the real freedoms people enjoy, that is, their ability to act and choose. Arnstein's (1969) ladder of participation reminds us that being informed is different from having power to influence decisions. Applied to digital governance, empowerment can be seen in three dimensions: access (services reach the citizen with less cost and time), transparency (the citizen can see what is due and what has been given) and voice (the citizen can complain, participate and seek accountability). These outcomes depend on mediating conditions such as literacy, language, connectivity, data protection and the availability of human help. Figure 1 presents this framework.

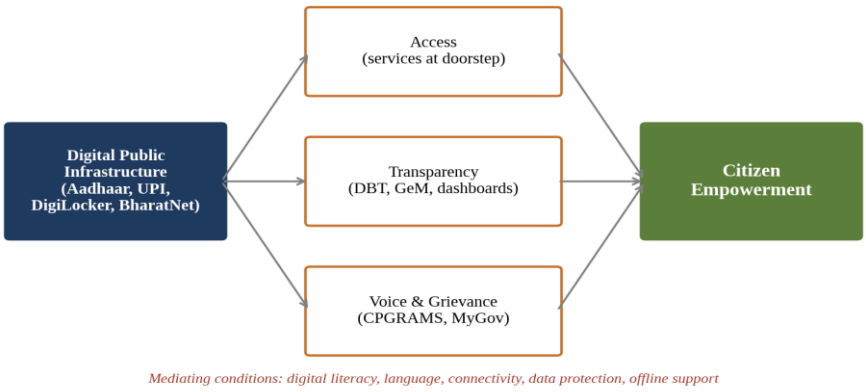

Figure 1: Conceptual Framework of Digital Governance and Citizen Empowerment

Source: Developed by the author

Digital Governance Architecture in India:

India's model rests on interoperable, publicly owned platforms over which both government and private services can be built. Aadhaar provides identity, UPI enables instant payments, DigiLocker provides verifiable documents and UMANG offers a single window for services from central to local government. Common Services Centres (CSCs) act as assisted access points for those who cannot use services on their own. Table 1 summarises the main platforms and their reported scale.

Table 1: Major Digital Governance Platforms in India

Platform (year)	Function	Reported scale (Govt. data)
Aadhaar (2009)	Unique digital identity and e-KYC	142 crore Aadhaar numbers generated (April 2025)
DBT (2013)	Direct transfer of benefits to bank accounts	Rs. 44 lakh crore transferred (May 2025); Rs. 3.48 lakh crore saved (2015 to March 2023)
DigiLocker (2015)	Paperless, verifiable documents	53.92 crore users (June 2025)
UMANG (2017)	Single mobile app for government services	8.34 crore registrations; 2,300 services in 23 languages
BharatNet	Optical fibre to Gram Panchayats	2.18 lakh Gram Panchayats connected (Jan. 2025)
BHASHINI (2022)	AI-based language translation for services	35+ languages; 1,600+ AI models (May 2025)
GeM (2016)	Transparent online public procurement	1.6 lakh buyers; 22.5 lakh+ sellers (Jan. 2025)

Source: Compiled by the author from PIB (2025), "Ten Years of Digital Progress".

Data Analysis and Interpretation:

1. Growth of Connectivity:

Connectivity is the foundation of every digital service. According to PIB (2025), internet connections in India grew from 25.15 crore in March 2014 to 96.96 crore in June 2024, an increase of about 285 per cent. Broadband connections rose even faster, from 6.1 crore to 94.92 crore. The cost of mobile data fell from Rs. 308 per GB in 2014 to Rs. 9.34 per GB in 2022, which made internet use affordable for low-income households. By December 2024, 6,15,836 of the 6,44,131 villages had 4G mobile coverage.

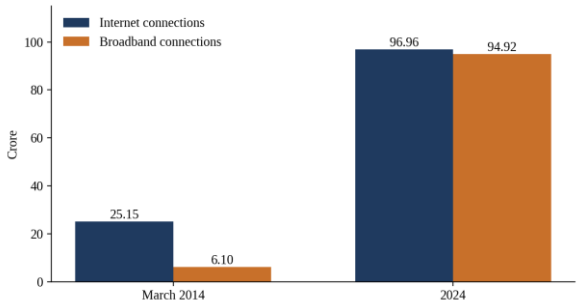

Figure 2: Internet and Broadband Connections in India (in crore)

Source: Press Information Bureau (2025)

2. Digital Payments and Financial Inclusion:

UPI is the clearest example of citizen-level adoption. As reported by the Ministry of Finance in the Lok Sabha, UPI transactions rose from 4,595.61 crore (worth Rs. 84.16 lakh crore) in 2021–22 to 18,586.60 crore (worth Rs. 260.56 lakh crore) in 2024–25, a four-fold rise in volume in just three years (Figure 3). Small vendors, farmers and daily-wage workers now receive and send money instantly without a bank visit. Combined with Jan Dhan accounts and Aadhaar, Direct Benefit Transfer has moved Rs. 44 lakh crore to beneficiaries and, according to the government, removed 5.87 crore ineligible ration cards and 4.23 crore duplicate LPG connections. This reduces leakages and the power of intermediaries, which is a real form of empowerment for the poor.

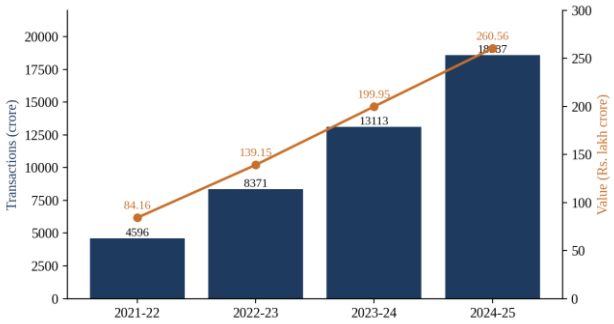

Figure 3: Growth of UPI Transactions in India, 2021–22 to 2024–25

Source: Ministry of Finance, written reply in Lok Sabha (2026)

3. Service Delivery and Transparency:

DigiLocker has 53.92 crore users and UMANG has 8.34 crore registrations with 597 crore transactions (PIB, 2025). Students can now receive mark sheets in DigiLocker, and citizens can show a digital driving licence or vehicle registration without carrying paper. The Government e-Marketplace (GeM) has made public procurement more open, while public dashboards allow citizens and researchers to track scheme progress. In Maharashtra, the Aaple Sarkar portal provides online certificates and services under the Maharashtra Right to Public Services Act, 2015, which fixes time limits for delivery. Such time-bound service guarantees convert digital access into a legal right, and this is where digital governance moves closer to empowerment.

Citizen Empowerment: Evidence and Examples:

Empowerment is visible in several areas. First, time and cost savings are significant: a certificate that once required several office visits can now be applied for from a village CSC. Second, direct transfers under schemes such as PM-KISAN reach farmers' bank accounts without middlemen. Third, language barriers are being reduced through BHASHINI, which supports over 35 languages and is integrated with platforms such as IRCTC. Fourth, participation channels such as MyGov and the Centralised Public Grievance Redress and Monitoring System (CPGRAMS) allow citizens to submit suggestions and complaints and track them online. Fifth, the training of more than 1.21 crore officials through the iGOT Karmayogi platform aims to improve the attitude and skills of those who deliver services. Together, these show that digital governance can shift power, at least partly, from the office to the citizen.

Current Issues and Problems:

1. The Digital Divide:

Access is not equal. The Comprehensive Modular Survey: Telecom 2025 found that 76.7 per cent of men aged 15 and above had used the internet in the previous three months, compared with only 63.1 per cent of women. Household internet access stood at 83.3 per cent in rural areas against 91.6 per cent in urban areas, and fixed broadband was available to only 9.1 per cent of rural households. Since 98.1 per cent of rural internet users depend on mobile data, services that work poorly on small screens or weak networks exclude many. Elderly persons, persons with disabilities and those with low literacy face additional difficulty.

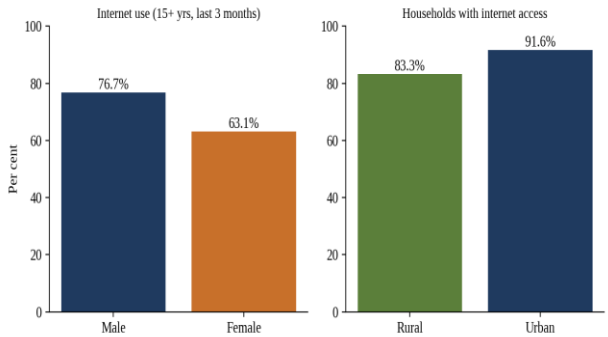

Figure 4: Gender and Rural–Urban Gaps in Internet Access, 2025

Source: National Statistics Office, MoSPI, CMS: Telecom 2025

2. Cyber Fraud and Digital Safety:

As more citizens transact online, they become targets of fraud. The Ministry of Home Affairs informed the Lok Sabha in July 2025 that citizens lost Rs. 22,845.73 crore to cyber fraud in 2024, compared with Rs. 7,465.18 crore in 2023 and Rs. 2,290.24 crore in 2022 (Figure 5). New forms such as "digital arrest" scams, fake KYC calls and fraudulent investment apps target the elderly and first-time users. The national helpline 1930 and the cybercrime.gov.in portal have helped save some funds, but awareness remains low, especially in rural areas.

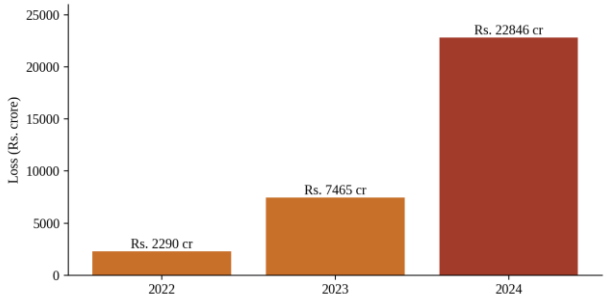

Figure 5: Losses Reported by Citizens due to Cyber Fraud in India (Rs. crore)

Source: Ministry of Home Affairs, written reply in Lok Sabha (22 July 2025)

3. Exclusion through Authentication Failures:

When biometric authentication becomes mandatory for rations, pensions or wages, a failed fingerprint can mean a denied entitlement. Manual labourers and the elderly, whose fingerprints are often worn, are most affected. Mandatory digital attendance and Aadhaar-based payment systems in rural employment schemes have also been criticised by workers' groups for technical glitches and network problems. The Supreme Court in Puttaswamy (2018) upheld Aadhaar for welfare but stressed that no eligible person should be denied benefits for failure of authentication. Ensuring this on the ground remains a challenge.

4. Privacy and Data Protection:

Large government databases hold sensitive personal information. The Digital Personal Data Protection Act, 2023 and its Rules, notified in November 2025, create rights for data principals and a Data Protection Board. However, most operative obligations come into force only after eighteen months, wide exemptions are available to the State, and the amendment to Section 8(1)(j) of the Right to Information Act has raised concern among transparency activists that access to information about public officials may be curtailed. Empowerment requires that citizens can trust the system with their data.

5. Registration versus Real Use:

Official figures often measure enrolments, downloads or registrations. They do not show how many people use a service regularly, complete their tasks without help or have their grievances resolved satisfactorily. Many rural citizens still depend on CSC operators or private cyber cafés, sometimes paying extra fees. This creates a new class of digital intermediaries, which partly defeats the purpose of removing middlemen.

6. Weak Grievance Redressal and Federal Gaps:

Online complaint portals often close cases with standard replies without real resolution. Capacity differs widely between states and between urban and rural local bodies. Gram Panchayats connected by BharatNet often lack trained staff and maintenance, so the fibre does not always translate into working services.

Suggestions:

On the basis of the above analysis, the following measures are suggested. First, an assured offline or assisted alternative must be retained for every essential service, so that technology never becomes a reason to deny an entitlement. Second, digital literacy campaigns should specially target women, the elderly and rural youth, and should include cyber-safety training. Third, service design should follow the principle of "mobile first, local language first",

with simple interfaces tested with real rural users. Fourth, governments should publish data on active use, failure rates and grievance resolution, not only registrations. Fifth, the data protection framework should be implemented faster, and state agencies should be held to the same standards as private firms. Sixth, time-bound public service laws, like Maharashtra's, should be adopted by all states and linked with digital delivery. Seventh, Gram Panchayats and CSCs should be strengthened as trusted, fairly priced help desks. Finally, social audit of digital welfare schemes should involve citizens and local representatives.

Conclusion:

India's digital governance journey over the last decade is impressive by any standard. Connectivity has expanded nearly four-fold, digital payments have become part of everyday life and welfare delivery has become more direct and transparent. These achievements have clearly empowered many citizens by reducing cost, time and dependence on intermediaries. However, empowerment is not automatic. The gender and rural–urban divides, the steep rise in cyber fraud, exclusion through authentication failures and unsettled questions of privacy show that technology can also create new forms of vulnerability. Digital governance will truly empower citizens only when it is inclusive, accountable and rights-based, when the citizen is treated not as a data point but as the central purpose of governance. The next phase of Digital India must therefore move from building platforms to building capabilities, trust and voice.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Comparative Analysis of Debt and Equity Distribution among Companies of Reliance and Tata Groups: A Lorenz Curve and Gini Coefficient Approach

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Abstract:

This paper provides a rigorous empirical examination of corporate capital structure and financial inequality within India's two premier industrial conglomerates: the Reliance Industries Group and the Tata Group. Utilizing consolidated balance sheet data across five consecutive financial years (FY 2020–21 through FY 2024–25), we construct Lorenz curves and derive Gini coefficients for total borrowings, total equity, and aggregate capital employed across all publicly listed Group entities. The empirical findings reveal fundamentally distinct structural paradigms: the Reliance Group exhibits an extraordinarily high degree of capital concentration (Gini Coefficient > 0.84 for Debt, Equity, and Capital), driven by the hyper-dominance of Reliance Industries Limited (RIL) relative to its minor listed subsidiaries. Conversely, the Tata Group demonstrates a distributed capital architecture across flagships including TCS, Tata Steel, Tata Motors, Tata Power, and Titan, resulting in moderate Gini coefficients (~0.56 to 0.71). Furthermore, longitudinal analysis reveals significant post-FY21 de-leveraging trends across both business groups, with Tata Group experiencing a progressive decline in debt inequality (Gini declining from 0.712 to 0.655) as operating cash flows funded debt retirement in Tata Motors and Tata Steel. Strategic and regulatory implications for conglomerate governance and systemic risk management are discussed.

Keywords: Capital Structure, Lorenz Curve, Gini Coefficient, Reliance Group, Tata Group, Balance Sheet De-leveraging, Conglomerate Governance, Corporate Debt Concentration.

Introduction & Research Rationale:

In emerging market economies, business groups and diversified industrial conglomerates play a pivotal role in national capital formation, industrialization, and employment generation. In India, business group structures dominate the corporate landscape, enabling central promoter entities to allocate capital, manage internal capital markets, and share risk across operational subsidiaries. Among these business houses, the Mukesh Ambani–led Reliance Group and the Tata Group represent the two largest private sector conglomerates, collectively accounting for a substantial fraction of the total market capitalization, corporate borrowings, and equity capital on Indian stock exchanges.

While financial economic literature traditionally examines individual firm leverage, capital structure trade-offs, and pecking-order behaviors, fewer empirical studies examine how capital—specifically debt and equity—is distributed across the individual corporate entities that constitute a major business house. Understanding group-level capital concentration is critical for financial stability, credit risk assessment, and regulatory oversight. Highly

concentrated business groups, where a single central entity holds virtually all liabilities and net worth, present a starkly different risk profile compared to multi-polar conglomerates where capital resources and borrowing capacities are distributed across autonomous operating flagships.

To quantify and evaluate this structural distribution, this study adapts economic inequality measurement tools—specifically the Lorenz Curve and the Gini Coefficient—to evaluate financial statement data from FY 2020–21 to FY 2024–25. By quantifying the concentration of Borrowings, Total Equity, and Total Capital, this paper addresses a major literature gap regarding conglomerate capital allocation dynamics in India.

Review of Literature & Theoretical Framework:

- **Capital Structure Theories in Conglomerates:**

Corporate capital structure theory originates from Modigliani and Miller (1958), who posited capital structure irrelevance under perfect markets. Subsequent refinements—including Trade-off Theory (Kraus & Litzenberger, 1973) and Pecking Order Theory (Myers & Majluf, 1984)—highlight the interplay between tax shields, bankruptcy costs, and information asymmetry. In business group structures, internal capital markets (Stein, 1997; Khanna & Yafeh, 2007) allow parent entities to optimize financing across business units, providing 'co-insurance' where cash flows from stable entities backstop riskier capital-intensive divisions.

- **Application of Inequality Metrics to Corporate Finance:**

The Lorenz curve (Lorenz, 1905) and Gini coefficient (Gini, 1912) were developed to measure income and wealth inequality across households. However, financial economists have increasingly deployed these metrics to corporate data to study market share concentration, banking credit exposure, and industrial asset distribution. Applying Gini coefficient methodology to enterprise balance sheets provides a standardized, bounded metric between 0.0 (perfectly equal capital distribution across all listed entities) and 1.0 (absolute inequality, where 1 entity holds 100% of capital while all others hold zero).

- **Research Gap and Operational Hypotheses:**

Although comparative financial analyses between Reliance Industries and Tata Group entities exist in equity equity reports, existing literature lacks a formalized statistical treatment of group-wide balance sheet inequality across a multi-year timeframe. We test two central hypotheses:

- H1: The Reliance Group exhibits higher overall capital and leverage inequality (Gini Coefficient) than the Tata Group due to parent-centric consolidation.
- H2: Post-FY21 balance sheet de-leveraging efforts led to a structural reduction in debt concentration across both conglomerates over the FY21–FY25 period.

Research Methodology & Data Framework:

- **Sample Selection and Screening Criteria:**

The empirical sample comprises all major publicly listed entities associated with the Reliance Group and Tata Group during the study period (FY 2020–21 to FY 2024–25). Eligible entities were identified through stock exchange registers (NSE/BSE) and audited annual disclosures:

- **Reliance Group Universe (N=7):**

Reliance Industries Limited (RIL), Reliance Industrial Infrastructure Ltd. (RIIL), Network18 Media & Investments, Hathway Cable

& Datacom, DEN Networks, Alok Industries, and Just Dial.

- **Tata Group Universe (N=12 Major Listed Flagships):**

Tata Consultancy Services (TCS), Tata Steel, Tata Motors, Tata Power, Tata Consumer Products, Trent, Titan Company, Tata Chemicals, Voltas, Indian Hotels Company (IHCL), Tata Communications, and Tata Elxsi.

- **Financial Variables Operationalization:**

Financial figures were compiled on a consolidated annual balance-sheet basis (expressed in Rs. Crore) in accordance with Indian Accounting Standards (Ind AS):

- **Total Debt / Borrowings (D):**

Sum of short-term borrowings, long-term borrowings, and current maturities of long-term debt.

- **Total Equity (E):**

Sum of equity share capital, reserves & surplus (other equity), and non-controlling interest where applicable.

- **Total Capital Employed (C):**

Aggregate sum of Total Debt and Total Equity (C = D + E).

- **Mathematical Formulation of Gini Coefficient:**

For a group of N eligible listed entities sorted in non-decreasing order of financial metric, the Gini coefficient G is calculated as:

$$G = \frac{2\sum_{i=1}^{n} i x_i}{n\sum_{i=1}^{n} x_i} - \frac{n+1}{n}$$

Where: i represents the entity's rank (1 to N) and xi represents the financial variable (Debt, Equity, or Capital).

- **Aggregate Capital Structure Profile (FY21 – FY25):**

Table 1 summarizes the aggregate total borrowings, equity capital, and combined total capital employed across the analyzed listed entities in the Reliance and Tata Groups over the 5-year observation period (FY21 through FY25).

Table 1: Aggregate Financial Metrics Comparison (FY21–FY25). Data compiled from audited consolidated balance sheets.

Financial Year	Reliance Debt (Rs. Cr)	Reliance Equity (Rs. Cr)	Reliance Capital (Rs. Cr)	Tata Debt (Rs. Cr)	Tata Equity (Rs. Cr)	Tata Capital (Rs. Cr)
FY 2020-21	283,666	709,312	992,978	308,164	288,239	596,403
FY 2021-22	323,642	791,383	1,115,025	297,436	348,133	645,569
FY 2022-23	460,166	728,109	1,188,275	302,845	358,818	661,663
FY 2023-24	362,371	820,770	1,183,141	285,806	366,585	652,391
FY 2024-25	380,409	860,416	1,240,825	272,985	406,914	679,899

Key aggregate trends indicate that Reliance's total capital base expanded from Rs.9.93 lakh crore in FY21 to Rs. 12.41 lakh crore in FY25. Concurrently, the Tata Group's aggregate capital grew from Rs.5.96 lakh crore to Rs.6.80 lakh crore. Notably, Tata Group's aggregate equity expanded by 41.2% (from Rs.2.88 lakh crore to Rs.4.07 lakh crore), while its borrowings fell from Rs.3.08 lakh crore to Rs.2.73 lakh crore, reflecting aggressive group-wide deleveraging.

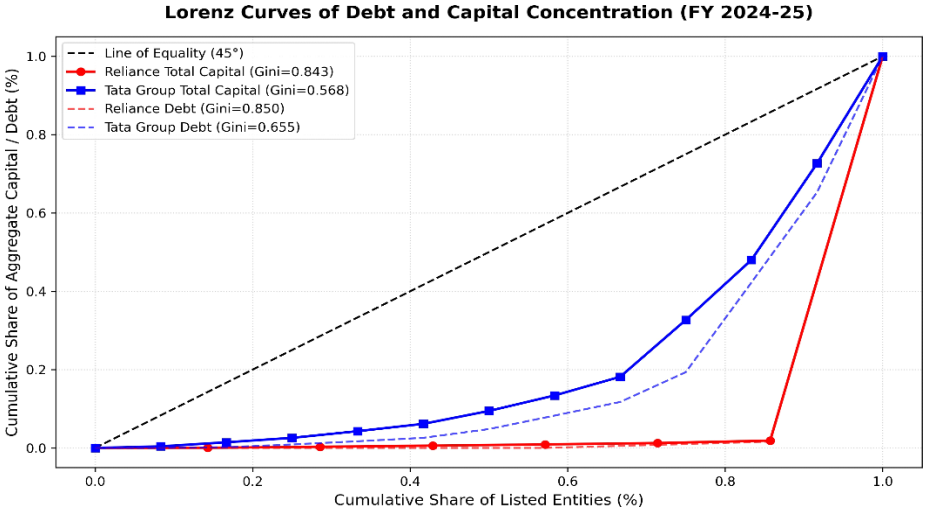
- **Empirical Findings & Gini/Lorenz Dynamics:**

The annual Gini coefficients for Debt, Equity, and Total Capital for both conglomerates are presented in Table 2.

Table 2: Empirical Gini Coefficients for Reliance and Tata Groups (FY 2020-21 to FY 2024-25).

Financial Year	Reliance Debt Gini	Reliance Equity Gini	Reliance Capital Gini	Tata Debt Gini	Tata Equity Gini	Tata Capital Gini
FY 2020-21	0.8502	0.8496	0.8467	0.7120	0.6038	0.6213
FY 2021-22	0.8512	0.8476	0.8452	0.6987	0.6145	0.6120
FY 2022-23	0.8503	0.8466	0.8441	0.6989	0.5846	0.6022
FY 2023-24	0.8451	0.8390	0.8384	0.6742	0.5666	0.5856
FY 2024-25	0.8503	0.8429	0.8429	0.6549	0.5607	0.5680

Figure 1: Lorenz Curves of Debt and Capital Concentration for Reliance Group and Tata Group (FY 2024-25).



Interpretation of Lorenz Geometry & Gini Coefficients:

As illustrated in Figure 1, the Lorenz curves for the Reliance Group sag heavily away from the 45-degree line of perfect equality, hugging the horizontal axis before turning sharply upward at the final entry (RIL). In FY25, Reliance Industries Limited accounted for Rs.3,74,313 crore out of Rs.3,80,409 crore of total group listed borrowings (98.4%) and Rs.8,43,200 crore out of Rs.8,60,416 crore of total listed equity (98.0%). Consequently, Reliance's Gini coefficients remain structural constants above 0.84.

In contrast, the Tata Group's Lorenz curve exhibits a much gentler curvature. Capital is distributed across major operating flagships: TCS holds Rs.94,756 Cr equity with minimal debt (Rs.9,392 Cr); Tata Steel holds Rs.94,801 Cr debt and Rs.91,169 Cr equity; Tata Motors holds Rs.62,499 Cr debt and Rs.105,061 Cr equity; and Tata Power holds Rs.62,866 Cr debt and Rs.35,841 Cr equity. This multi-polar structure yields a Capital Gini of 0.568 and a Debt Gini of 0.655 in FY25.

Longitudinal De-leveraging Dynamics:

The 5-year trend indicates a monotonic decline in the Tata Group's Debt Gini Coefficient, falling from 0.7120 in FY21 to 0.6549 in FY25. This reduction in borrowing inequality reflects significant net debt pay-down by Tata Motors (becoming net auto debt-free in FY25) and Tata Steel, which narrowed the debt gap between the heavy industrial units and smaller group companies.

Comparative Discussion & Strategic Implications:

- **Structural Governance & Subsidiary Architecture:**

The empirical divergence in Gini metrics reflects fundamental differences in group holding structures and operational philosophies:

- **Reliance's Unitary Division Model:**

Major growth engines—such as Reliance Retail, Reliance Jio Infocomm, and O2C refining—operate predominantly as wholly-owned or majority-held unlisted subsidiaries of RIL. As a result, market borrowing and equity dilution occur primarily at the parent level, concentrating debt and equity within a single corporate vehicle.

- **Tata's Federated Operating Model:**

Operating companies act as independent listed flagships under the umbrella promoter holding of Tata Sons Pvt. Ltd. Each operating entity maintains a discrete balance sheet, raises external debt on its own credit rating, and services liabilities from its operational cash flow.

- **Credit Rating, Systemic Risk, and Co-insurance Trade-offs:**

From a credit risk perspective, Reliance's concentrated structure offers immense balance sheet scale, allowing RIL to secure top-tier investment grade credit ratings (AAA domestic, BBB/Baa3 international) and deploy massive capex ($15B+ annually in 5G and green energy) without straining subsidiary balance sheets. However, it concentrates systemic risk within RIL.

Conversely, Tata's distributed model insulates sister flagships from contagion; severe stress in Tata Steel Europe or Tata Motors during downturns did not imperil the AAA balance sheet of TCS or Titan. The recent merger of Tata Motors Finance (TMFL) into Tata Capital further reflects active corporate restructuring to optimize capital efficiency without distorting operational focus.

Conclusion, Policy Recommendations & Limitations:

- **Summary of Findings:**

This paper successfully demonstrates the utility of the Lorenz Curve and Gini Coefficient in assessing corporate group capital structures. We confirm H1, finding that Reliance's capital concentration is significantly higher (Gini ~0.84) than Tata's (Gini ~0.57–0.65). We also confirm H2 for the Tata Group, documenting a steady decline in borrowing inequality due to post-FY21 deleveraging.

- **Policy and Regulatory Recommendations:**

Group-Wide Leverage Monitoring: Regulators (SEBI and RBI) should monitor group-wide Gini metrics alongside individual firm debt ratios to detect over-concentration of credit risks.

- **Disclosure of Internal Capital Markets:**

Standardized Ind AS 24 related-party disclosures regarding inter-corporate guarantees and loans are crucial for evaluating hidden leverage transfers within concentrated groups.

- **Study Limitations:**

This study focuses on publicly listed entities. Unlisted subsidiaries (such as Reliance Retail Ventures unlisted debt or Tata Sons parent equity) and financial arm off-balance-sheet vehicles were controlled via consolidated statements but warrant further specialized study.

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Acknowledgments:

This work is supported by Kavayitri Bahinabai Chaudhari North Maharashtra University Jalgaon under V.C.R.M.S, Grant No. (KBCNMU/11A/VCRMS/Budget-Com 2024-25/113/2025), through the project titled “Effect of Firm Characteristics on its Capital Structure: An Empirical Analysis of Listed firms in Indian Manufacturing Industries”. The views and conclusions expressed in this paper are those of the author and do not necessarily reflect the official policies of the funding agency. The author sincerely thanks the funding agency for their support.

International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Synthesis, Characterization and In Vitro Antimicrobial Evaluation of Substituted Benzofurans Derived from Dihydroisoxazole Precursors

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DOI - 10.5281/zenodo.24334583

Abstract:

The present study describes the stepwise synthesis of substituted imidazole-based benzofuran derivatives through a sequence involving imidazole scaffold construction, allylation, Claisen rearrangement and subsequent cyclization. Initially, substituted imidazole derivatives were prepared and functionalized through allylation to introduce the required allyl group. The resulting intermediates were then subjected to Claisen rearrangement, followed by cyclization to obtain the desired benzofuran-containing imidazole derivatives. The synthesized compounds were characterized using ^{1}H NMR and GC–MS to support their structural assignments. Their in vitro antimicrobial potential was evaluated against Candida albicans, Escherichia coli and Staphylococcus aureus. The biological assessment indicated promising antimicrobial activity for selected derivatives, suggesting that the combination of imidazole and benzofuran structural motifs may provide a useful framework for further heterocyclic compound development. Overall, this synthetic strategy offers a systematic approach to constructing structurally diverse imidazole–benzofuran derivatives and provides a basis for further investigation of their potential as antimicrobial agents.

Keywords: Imidazole derivatives, Benzofuran synthesis, Claisen rearrangement, antimicrobial activity, ^{1}H NMR and GC–MS.

Introduction:

Organic compounds synthesized by fusing two or more heterocyclic rings are known as heterocyclic molecular hybrids. These hybrid compounds are used in many different fields, especially medical chemistry, where they are purposefully created to improve the characteristics of drugs [1-3]. Because of their varied structures and characteristics, they can be used to synthesize novel compounds that are suited for a variety of biological activities. The two fundamental families of heterocyclic compounds with different structures and characteristics are benzofurans and isoxazoles [4]. A fused benzene ring and an oxygen atom in a five-membered ring make up benzofurans [5].

They are attractive moieties for the synthesis of new pharmacological drugs because of their well-known antitubercular [6], antibacterial [7], antimicrobial [8], antifungal [9], anti-inflammatory [10], anticancer [11], and neuroprotective qualities [12]. Another type of

heterocyclic compounds with a five-membered ring that contains both nitrogen and oxygen atoms are isoxazoles. They are crucial building blocks in organic synthesis because of their structural characteristics, which help produce bioactive molecules. Additionally, isoxazoles are known to have antibacterial [13,14], anticancer [15,16], anti-cholinesterase [17], and diuretic effects [18].

In the field of medicinal chemistry and drug discovery, the combination of benzofurans and isoxazoles into hybrid molecules offers an intriguing path [19]. These hybrids are important because their unique qualities may work in concert. It is possible to create compounds that take use of the benefits of both structural elements by combining benzofuran and isoxazole moieties. Compounds with improved pharmacokinetics, increased bioactivity, and a wider spectrum of possible therapeutic uses may arise from this [20,21]. We have synthesized benzofuran-isoxazole hybrids that target possible pharmacophores, inspired by the knowledge of benzofuran and isoxazole derivatives. The antibacterial qualities of these hybrids are of paramount relevance given the persistent worldwide problems associated with infectious illnesses and drug resistance [22–25].

Our goal is to find possible candidates for additional development as antibiotics or antimicrobial agents by assessing these compounds' antimicrobial effectiveness against a variety of diseases. Synthesizing the derivatives of substituted benzofuran is the next step. The synthesis of substituted benzofuran and a knowledge of substituted molecules with interesting antimicrobial properties are the goals of this study. It might result in the synthesis of novel therapeutic approaches in the future.

Material and Methods:

All chemicals used in the experiments were of analytical reagent (AR) grade. Analytical thin-layer chromatography (TLC) was carried out on Merck pre-coated silica gel 60 F254 aluminium sheets. Proton nuclear magnetic resonance (^{1}H NMR) spectra were recorded in $CDCl_3$ on a 500 MHz spectrometer with tetramethylsilane (TMS) serving as the internal standard.

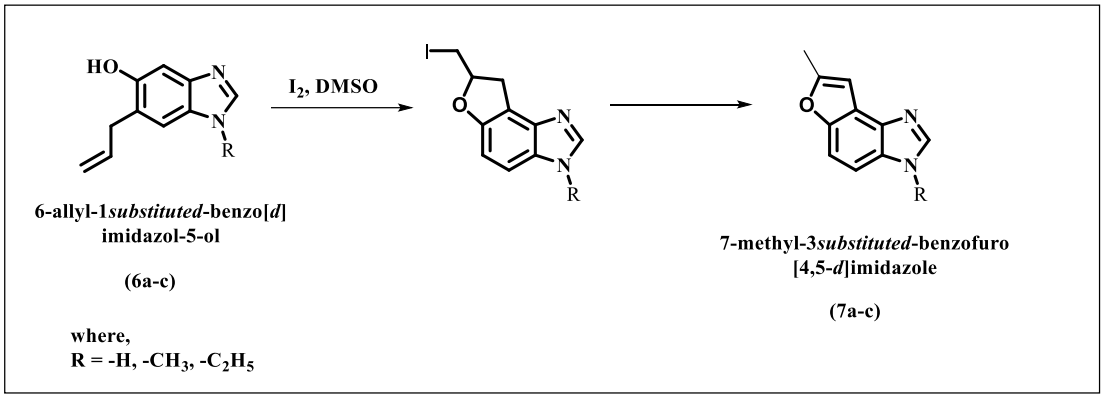
Characterization Techniques:

The structure of synthesized compounds was determined by chemical properties elemental analysis and spectral data. ^{1}H-NMR spectra were recorded on Bruker Avance Neo 500 MHz spectrometer using $CDCl_3$ solvent and TMS as internal standards at SAIF, Punjab University, Chandigarh (India). Chemical shifts are expressed in ppm. Mass spectrums were recorded on Thermo Scientific TSQ 8000 Gas Chromatogram.

Experimental:

General reaction: Synthesis of substituted benzofuran

Crystalline iodine is added to the reaction mixture after the suitably substituted isoxazoline precursor (6a–c) is suspended in dimethyl sulfoxide (DMSO). Under the circumstances outlined in the original experimental method, the mixture is agitated for three hours until the starting material is used up. Following completion, the product is separated and purified using an appropriate technique, and the reaction mixture is worked up.



Scheme 1. Synthesis of substituted benzofuran

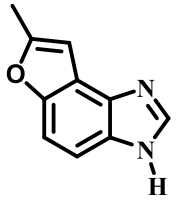
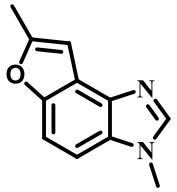
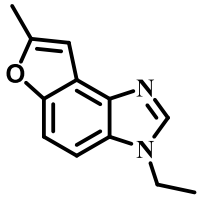
7a: 7-methyl-3H-benzofuro[4,5-d]imidazole

7b: 3,7-dimethyl-3H-benzofuro[4,5-d]imidazole

7c: 3-ethyl-7-methyl-3H-benzofuro[4,5-d]imidazole

These derivatives were synthesized by above mentioned procedure

Table 2. Structural Analysis

Sr. No	Structure of Products	Structural analysis by ^{1}HNMR and GCMS
1		**^{1}HNMR(500MHz,CDCl$_3$)**::δ 12.36 (s,1H), 8.120 (s,1H), 7.60-7.19 (dd, 2H), 6.72 (s,1H), 2.30 (s,3H) **GCMS:** Cal m/z:172.19, Found m/z: 172.10
2		**^{1}HNMR(500MHz,CDCl$_3$)**: 8.05 (s,1H), 7.58-7.19 (dd, 2H), 6.70 (s,1H), 3.78 (s,3H), 2.30 (s,3H) **GCMS:** Cal m/z: 186.21 Found m/z: 186.18
3		**^{1}HNMR(500MHz,CDCl$_3$)**: 8.24 (s,1H), 7.55-7.18 (dd, 2H), 6.68 (s,1H), 4.10 (q,4H), 2.30 (s,3H), 1.29 (t,3H) **GCMS:** Cal m/z: 200.24 Found m/z: 200.20

Biological Activity:

Antimicrobial Properties:

Benzofuran derivatives have attracted considerable attention due to their potential antibacterial and antifungal properties. Literature reports indicate that structural modifications to the benzofuran scaffold can influence antimicrobial activity against Gram-positive bacteria, Gram-negative bacteria, and fungal strains. The literature-based results below illustrate the activity reported for three representative derivatives.

Compound	Microorganism	Concentration (µg/mL)	Zone of inhibition (mm)	Activity
7a	*Staphylococcus aureus*	100	18	Good
7c	*Escherichia coli*	100	14	Moderate
7b	*Candida albicans*	100	16	Moderate

Conclusion:

The series of substituted benzofuran that has been synthesized in the current work is a promising moiety that exhibits remarkable biological activity. Additionally, the structure's benzo ring inflection purposefully incorporates an allyl group across the ring. It demonstrates the potent and encouraging antimicrobial properties. In summary, our findings demonstrate great action against microorganisms and contribute considerably to the synthesis of a structural moiety and interacting relationship. which will be helpful in future medication design strategies.

Conflict of Interest: Authors have declared that no competing interests exist.

Acknowledgement:

The authors are thankful to Author also thank to the Principal, Department of Chemistry, G.S Tompe Arts, Commerce and Science College, Chandur Bazar Dist- Amravati and Department of Chemistry, Sant, Gadge Baba Amravati University, Amravati for providing the necessary laboratory facilities. Authors are very much thankful to the Director, SAIF, Punjab University Chandigarh for providing spectral data.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

A Critical Review on Plant/Algal Extract-mediated green synthesis of Zirconium dioxide nanoparticles

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DOI - 10.5281/zenodo.24334605

Abstract:

Green synthesis of zirconium dioxide (ZrO_2) nanoparticles with plant and algal extracts was promoted as a sustainable alternative to chemical routes, but reported results were rarely comparable. A total of 41 sources were retrieved within the last 13 years (between 2014 and 2026) to capture the detailed story of 23 plant and algal systems for comparison; the synthesis conditions, phase properties, and performance in applications were also compared. However, X-ray photoelectron data indicated that Zr remained in the +4 oxidation state, which indicated that the phytochemicals were primarily coordinating, hydrolysis controlling and capping agents rather than reductants. Typically, tetragonal-dominant ZrO_2 has been obtained by calcination around 500 °C. The best single study results (99.6% dye degradation; MIC=2.80 µg/mL) obtained from non-uniform conditions. In the only direct comparison, green ZrO_2 had smaller crystallites (7 nm) than chemical ZrO_2 (11 nm), but superiority is unproven. Translation was hampered by the lack of Rietveld refinement, colloidal stability data, normal-cell controls and scale up data, whilst proposed reporting standards were also developed.

Keywords: Green Synthesis; Zirconium Dioxide; Plant Extract; Calcination; Photocatalysis

Introduction:

Zirconium dioxide (ZrO_2, zirconia) has resistance to high temperatures, a wide band gap (typically 3.5-5.5 eV), high dielectric constant, mechanical toughness, corrosion resistance and biocompatibility (Chitoria et al., 2023; Garanin et al., 2024). Such properties include photocatalytic dye degradation, anti-microbial and anti-cancer agents, implants, fuel-cell electrolytes and gas sensing (Jemibha & Darlin Mary, 2024; Kathirvel et al., 2025b; Modi et al., 2024; Nimare & Koser, 2016). ZrO_2 is available in three crystal forms: monoclinic, tetragonal and cubic, of which the tetragonal form is the most commonly used in green synthesis (Chitoria et al., 2023).

Conventional routes (sol-gel, hydrothermal, co-precipitation) provide good morphological control but requires the use of toxic precursor and high energy input, thus making it difficult to scale-up (Garanin et al., 2024; Nikam et al., 2019; Tran et al., 2022). In green synthesis, the plant phytochemicals are used as complexing agents, hydrolysis controlling agents and capping agents and the method is advocated as an economical, environmentally friendly alternative (Alsharari et al., 2023; Saxena et al., 2025; Villagrán et al., 2024). Twenty-three plant and algal systems have been investigated since an early report on Aloe vera (Gowri et al., 2014).

The literature however is split: there are many variations in protocols and very little key characterization, safety and scale-up data (Batool et al., 2024; Nikam et al., 2019). Review articles

mostly list results and do not include cross checking of reported values for internal consistency or comparisons of conditions between reviews. This critical review that addresses that gap.

Objectives:

The objectives were (i) to integrate critically 41 sources published in 2014–2026 covering 23 botanical and biological systems; (ii) to benchmark green synthesis against sol-gel, hydrothermal, and co-precipitation routes and compare functional performance across applications; and (iii) to map the methodological gaps that limit reproducibility and to propose reporting standards.

Scope and Limitations:

The review focuses on the synthesis of ZrO_2 nanoparticles using plants and algae, characterization, doping and photocatalytic, adsorptive, biomedical and materials engineering applications. Values were not remeasured, and only used as a comparator for chemical synthesis. The type of light source, dose of catalyst, type of pollutant, microbial strain, and the type of assay format varied between the studies so cross-study comparisons are indicative only, and many studies did not consider pH or temperature. This is not a systematic review, it is a narrative critical review: no formal risk-of-bias instrument was applied, and reliability was judged as described in Section 4.3.

Methodology:

1. Corpus and analytical approach: The narrative critical review was based on 41 sources published in the period 2014-2026 that address plant- and algae-mediated ZrO_2 nanoparticles, which were complemented by general reviews of green synthesis and benchmark studies on chemical-route ZrO_2 nanoparticles.

2. Data extraction: For each botanical system (species, part of plant, extraction method, synthesis approach, particle size, pH, synthesis and calcination temperature, morphology, crystalline phase, main application, and reference), 12 parameters were extracted. Green synthesis was compared with the sol-gel, hydrothermal and co-precipitation routes on 14 parameters, only the parameters with sufficient information were tabulated (Table 1).

3. Reliability screening: The primary statements of each source were verified with phase characterization data (when reported), band gap data were verified with the phase and particle size, rate constants were checked with reported rates for the conversions and bioreduction statements with oxidation-state evidence, and biomedical statements with particle size and control information. Sources which failed a check were left in but discussed with an explicit caveat.

Statistics Used:

Only descriptive statistics were reported (ranges, best values and %), no other statistics were calculated. The rate constants (k), minimum inhibitory concentrations (MIC), half-maximal inhibitory concentrations (IC_{50}) and crystallite sizes of Scherrer and Williamson–Hall were compared as published. Selectivity index (SI = IC_{50} of normal cells / IC_{50} of cancer cells) was calculated, when available, and a SI < 2 was considered as non-selective and a ≥ 3 as the target for translational interest. A meta-analysis and inferential testing were not conducted.

Results and Discussion:

1. Green versus conventional synthesis:

The routes are compared in table 1. The green synthesis was performed at the temperature of typically 60-90 °C and pressure of 1 bar, whereas sol-gel required toxic alkoxides, hydrothermal required autoclaves and co-precipitation provided irregular shapes (Alsharari

et al., 2023; Batool et al., 2024; Garanin et al., 2024; Liu et al., 2023; Tran et al., 2022). On the reported conditions, green synthesis appears the most environmentally friendly and lowest cost method to control the size, but the cost advantage has not been confirmed by life-cycle analysis or techno-economic analysis. The only direct comparison of green versus chemical ZrO_2 (Preetha et al., 2025), showed that the former had smaller crystallite size (7 nm compared to 11 nm), lower band gap (4.7 eV as compared to 4.9 eV) and more oxygen vacancies (106 vs. 76) along with a higher rate constant (k = 0.02593 vs. 0.0198 min^{-1}). It is important to notice that this is only one result and sol-gel and hydrothermal processes generally gave finer particles.

Table 1. Comparison of green and conventional routes for ZrO_2 nanoparticles, as reported in the reviewed sources.

Parameter	**Green (plant or algal)**	**Sol-gel**	**Hydrothermal**	**Co-precipitation**
Temperature, pressure	60–90 °C; atmospheric	–	200–250 °C; >100 bar (autoclave)	–
Reaction time	2–6 h, plus calcination	24–48 h	12–24 h	Fast
Particle size	10–70 nm	<20 nm	<10 nm	–
Morphology	Mostly spherical, phytochemical-coated	–	–	Irregular shapes
Precursor hazard, cost	Low toxicity; low cost	Toxic alkoxides	Autoclave required	–
Scalability	No pilot-scale data	–	–	Scalable
Size control	Moderate; depends on extract optimization	Better	Very fine	–

–, not reported in the compared sources. Sources: Alsharari et al. (2023); Batool et al. (2024); Garanin et al. (2024); Liu et al. (2023); Tran et al. (2022).

2. Mechanism:

This process is proposed to take four steps (Figure 1): the complexation between Zr^{4+} and hydroxyl, carboxyl, and amino groups of the phytochemicals, the donation of an electron or the release of a proton from the polyphenols and/or flavonoids, the nucleation of ZrO_2 clusters, and capped growth/ calcination (Tran et al., 2022; Villagrán et al., 2024). The X-ray photoelectron binding energies of Zr $3d_{5/2}$ (182-183 eV) and Zr $3d_{3/2}$ (~185 eV) data from Isacfranklin et al. indicated that zirconium was in the +4 state. The phytochemicals were not often in the capacity of true reductants, but more frequently as coordinating agents, hydrolysis controlling agents and capping agents. In contrast, Annu et al (2020) formulated a theory for bioreduction in the absence of an oxidation-state evidence and Al-Zaqri et al (2021) used FT-IR alone to suggest reduction to Zr^0 and Zr^{2+}. Such suggested reductions of oxidation state are not supported. Compound level evidence is negligible, as is only reported by Aggarwal et al. (2026) who identified γ-terpinene as the major reductant (in their words) and phthalate derivatives as stabilizers in Ficus pumila extract using GC-MS.

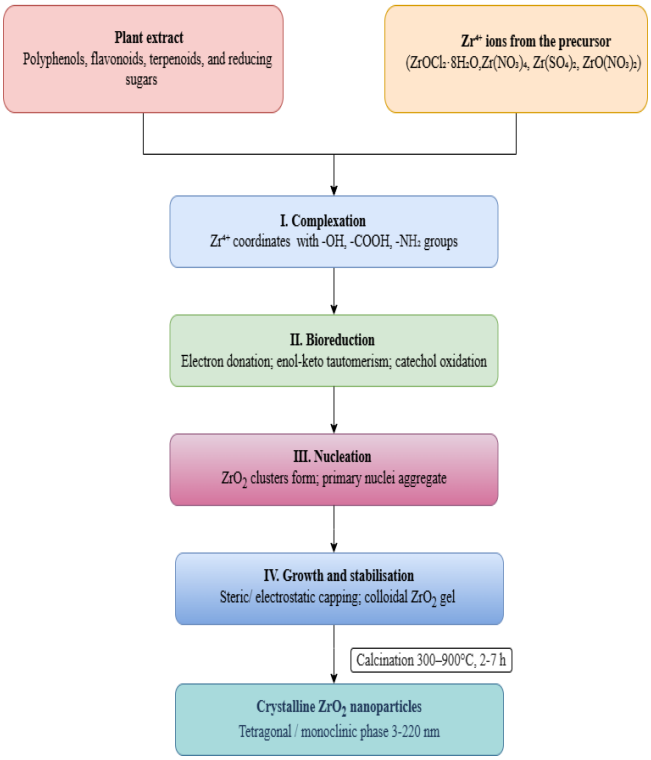

Figure 1. Four-stage phytochemical-mediated mechanism for green synthesis of ZrO_2 nanoparticles. I: Zr^{4+} complexation; II: electron donation and hydrolysis control; III: nucleation and cluster aggregation; IV: capped growth, giving crystalline ZrO_2 on calcination.

3. Synthesis parameters and characterization:

The both extremes of the data set worked: at 30 °C, without calcination, in Ulva lactuca (Sudhakar et al., 2025) and at 90 °C in Asphodelus fistulosus (Alkhalifa et al., 2025). The ratio of the extract to the precursor varied from 1:1 to 1:4 (v/v) (Abdul Jalill et al., 2017) and highest precursor concentration (0.5 M) resulted in the highest crystallite size (94 nm) (Arumugam et al., 2025). In contrast, a sugarcane-extract product calcined at 700 °C for 7 h showed tetragonal-dominant mixed phases, a band gap of 5.107 eV and the lowest photocatalytic efficiency among the compared sources (33.1% methylene blue degradation in 160 min) (Rifat et al., 2025); because this was a single sample, the effect of temperature cannot be separated from the extract or test conditions (Rifat et al., 2025). The four-phase assignment reported by Rifat et al. (2025) (tetragonal, monoclinic, rhombohedral and cubic) is tentative, because rhombohedral ZrO_2 is seldom observed and no Rietveld refinement was reported. The 500 °C rule is not always true: nanorods with monoclinic structure were obtained by calcinating rambutan-peel extract at 500 °C, which are around 50 nm in size (Isacfranklin et al., 2020). Above 700–900 °C ZrO_2 is normally monoclinic, but nanosized crystals can retain the tetragonal or mixed phases (Alagarsamy et al., 2022; Annu et al., 2020; Al-Zaqri et al., 2021), assignment at 900 °C is likely to be that of monoclinic crystals (Jemibha & Darlin Mary, 2024). With calcination-free Ulva lactuca it was 2.221 eV while the calcination performed on the 3–5 nm Sapindus mukorossi particles resulted in an increased band gap of 5.535 eV, which was attributed to quantum confinement (Alagarsamy et al., 2022). The 2.221 eV value is significantly lower than the 3.5-5.5 eV typical of the ZrO_2 semiconductors and in fact may be due to the residual organics or Tauc-plot artifacts (Sudhakar et al., 2025).

4. Applications:

The best result for each application is shown in Table 2. The undoped ZrO_2 absorbs mainly the ultra-violet band of the light spectrum due to its large band gap, so photocatalytic activity depended on oxygen vacancies, small crystallite size and surface area (Preetha et al., 2025). The Fe, Ni, or Ag doping extended the activity to the visible light region (Ahmed & Iqbal, 2021; Batool et al., 2024; Dawoud et al., 2020), and Eu-doped ZrO_2 prepared using Jasminum fluminense reduced over 94% of two dyes (Senthilkumar et al., 2024). Despite the fact that green routes are not necessarily superior, a chemically synthesized benchmark degraded 80% methylene blue under simulated sunlight in 80 min (Aljawrneh et al., 2024). The rate constant given for Wrightia tinctoria is 0.9837 min^{-1} which

is incompatible with the 94% removal after 120 min, which would correspond to a rate constant of approximately 0.02 min^{-1}, and thus the kinetics are not verified (Al-Zaqri et al., 2021). The antimicrobial activity was found to be due to Zr^{4+} adhesion, ion leakage, and ROS generation (Modi et al., 2024; Veerabhadraswamy et al., 2024). However in the case of Moringa oleifera ZrO_2, the zones were only 3–10 mm and none against S. aureus even though it was claimed to have broad activity (Annu et al., 2020). Before biomedical claims were accepted, it is important to verify the particle size, which was impossible in the case of an uncalcined, micron-sized product (406–4883 nm) cannot support dental-implant claims (Chowdhury et al., 2023), and was characterized only by UV–Vis and TEM in the case of an orthodontic-coating product no XRD (Selvaraj et al., 2021). All anticancer values were in vitro and only Balaji et al. (2017) tested normal cells with their SI values (1.36-1.62) showing no selectivity.

Table 2. Best reported performance of green-synthesized ZrO_2 nanoparticles by application.

Application	Best reported result	System (source)
Photocatalysis, UV	99.6% methylene blue in 180 min; k = 0.0324 min^{-1}; 99% to 89% over 7 cycles	*Azadirachta indica* (Singh et al., 2025)
Photocatalysis, sunlight or visible	93.6% malachite green in 180 min (no calcination); 94% methylene blue in 160 min (Fe-doped)	*Ulva lactuca* (Sudhakar et al., 2025); Batool et al. (2024)
Adsorption	94% methylene blue removal; q_max = 23.26 mg/g	Alagarsamy et al. (2022)
Antimicrobial	MIC 2.80 µg/mL (*B. subtilis*); zones 23 mm (*S. aureus*) and 32 mm (*E. coli*) on coated cotton	*Gardenia resinifera* (Kathirvel et al., 2025b); *Aloe vera* (Gowri et al., 2014)
Anticancer	IC_{50} ~10 µg/mL (A498); 21.35 µg/mL (MCF-7)	*Solanum xanthocarpum* (Akalya et al., 2026); *Thymus vulgaris* (Tharp & Karem, 2024)
Antioxidant	91.2% DPPH at 250 µg/mL; hydroxyl radical IC_{50} 11.77 µg/mL	Sudhakar et al. (2025); *Toddalia asiatica* (Kathirvel et al., 2025a)
Corrosion inhibition	~81% at 30 mg/100 mL in 0.5 M H_2SO_4; negative at 40 mg/100 mL	*Ficus pumila* (Aggarwal et al., 2026)
Polymer reinforcement	Modulus 5.5 times pure PVA at 1 wt%; compressive strength ~196 MPa at 5 wt% (epoxy)	Davar et al. (2018); Bishwokarma et al. (2021)

MIC, minimum inhibitory concentration; IC_{50}, half-maximal inhibitory concentration; DPPH, 2,2-diphenyl-1-picrylhydrazyl; PVA, polyvinyl alcohol.

5. Methodological Gaps:

Five gaps recurred. First, there was no mention of Rietveld refinement in any of the sources, a problem for mixed-phase products (Kathirvel et al., 2025b; Rifat et al., 2025; Shinde et al., 2018). Second, very little information on colloidal stability was found; a Z-average diameter of 220 nm and a PDI of 0.868 were reported as the aggregation proposed as the cause of the reduction in corrosion inhibition at the highest dose (Aggarwal et al., 2026), and rate constants and MIC values could not be compared without light-scattering data in the application medium. Third, the phytochemicals were

determined at compound level from one source, whereas, there are more than 300 phytochemicals present in neem alone (Dhakad et al., 2025). Fourth, there were a lack of normal-cell controls and in vivo data. Fifth, no life cycle, techno-economic, or pilot-scale study was reported.

Conclusions:

(1) The green synthesis of ZrO_2 is highly possible with medicinal plants, food crops and marine algae.

(2) Zirconium was not reduced in the biological system and thus bioreduction is not supported.

(3) Calcination near 500 °C usually gave tetragonal-dominant ZrO_2 with the highest photocatalytic and biological activity (though monoclinic nanorods were also reported at 500 °C), whereas the lowest photocatalytic efficiency (33.1%) came from a single sugarcane-mediated sample calcined at 700 °C for 7 h; calcination effects cannot be separated from other conditions across studies.

(4) In the only direct comparison, green particles were smaller (7 vs. 11 nm), but there is no proof of superiority of green routes.

(5) The best single-study values (99.6% dye degradation, MIC 2.80 μg/mL, IC_{50} ~10 μg/mL) came from non-uniform conditions, and missing Rietveld, colloidal, normal-cell, and scale-up data limit translation.

Recommendations:

(1) Report complete synthesis parameters: concentration of extract, extract to precursor ratio, pH value, temperature, test conditions and time of test.

(2) Use X-ray diffraction plus Rietveld refinement before reporting Tauc bandgaps.

(3) Determine hydrodynamic size, polydispersity index and ζ-potential in the application medium.

(4) Profile extraction from the LC-MS and monitoring Zr coordination via one of the XANES or EXAFS. (5) Incorporate normal-cell controls and proceed with promising candidates to in vivo testing for SI ≥ 3 (ISO 10993).

(6) Carry out visible light band-gap engineering and Engineering Scale up techno-economic and life-cycle assessment.

Acknowledgments: The authors thank Sandip University, Nashik, for institutional support.

Funding and Conflict of Interest: No external funding was received. The authors declare no conflict of interest.

Author Contributions: R.P.D.: conceptualization, methodology, data curation, formal analysis, investigation, visualization, original draft. M.D.S.: conceptualization, supervision, validation, project administration, review and editing.

Data Availability: No new data were generated. All values were taken from the cited sources.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

प्रधानमंत्री किसान सन्मान निधी योजनेद्वारे अल्पभूधारक शेतकऱ्यांच्या सामाजिक-आर्थिक सक्षमीकरणाचा आणि समावेशक विकासाचा विश्लेषणात्मक अभ्यास

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DOI - 10.5281/zenodo.24334625

सारांश:

भारतीय अर्थव्यवस्थेचा मुख्य आधार मानल्या जाणाऱ्या कृषी क्षेत्रात अल्पभूधारक आणि सीमांत शेतकऱ्यांचा वाटा अत्यंत महत्त्वपूर्ण आहे. कृषी गणनेनुसार भारतातील एकूण भूधारणांपैकी सुमारे ८६ टक्क्यांपेक्षा जास्त शेतकरी हे अल्पभूधारक वर्गात मोडतात. भांडवलाची अपुरी उपलब्धता, अनिश्चित हवामान, अनधिकृत सावकारी कर्ज आणि वाढता उत्पादन खर्च यांमुळे अल्पभूधारक शेतकरी नेहमीच आर्थिक संकटात सापडलेला दिसून येतो. या पार्श्वभूमीवर केंद्र सरकारने २४ फेब्रुवारी २०१९ रोजी "प्रधानमंत्री किसान सन्मान निधी" (पीएम-किसान) ही अत्यंत महत्त्वाची योजना अंमलात आणली. या योजनेअंतर्गत पात्र शेतकरी कुटुंबांना प्रतिवर्षी ६,००० रुपयांचे थेट आर्थिक सहाय्य तीन समान हप्त्यांमध्ये (प्रत्येकी रु. २,०००) थेट बँक खात्यात हस्तांतरित केले जाते. प्रस्तुत संशोधनात पीएम-किसान योजनेद्वारे अल्पभूधारक शेतकऱ्यांच्या सामाजिक-आर्थिक सक्षमीकरणाचा आणि ग्रामीण भागातील समावेशक विकासाचा विश्लेषणात्मक आढावा घेण्यात आला आहे. सदर संशोधन पूर्णपणे दुय्यम माहितीवर आधारित असून यात कृषी व शेतकरी कल्याण मंत्रालय, नीती आयोग, नाबार्डच्या अधिकृत सांख्यिकीय अहवालांचा वापर करण्यात आला आहे. अभ्यासावरून असे दिसून येते की, या योजनेमुळे पेरणीच्या मोसमात शेतकऱ्यांना तात्काळ रोख रक्कमेची उपलब्धता होऊन बियाणे व खते खरेदीसाठी सावकारांवरील अवलंबित्व कमी झाले आहे. तसेच, आधार-संलग्न डीबीटी प्रणालीमुळे पारदर्शकता वाढून थेट लाभार्थ्यांपर्यंत मदत पोहोचत आहे. शोधनिबंधाच्या अखेरीस अल्पभूधारक शेतकऱ्यांचे सक्षमीकरण अधिक प्रभावी करण्यासाठी उपयुक्त शिफारसी मांडण्यात आल्या आहेत.

महत्त्वाचे शब्द: पीएम-किसान योजना, अल्पभूधारक शेतकरी, थेट लाभ हस्तांतरण, सामाजिक-आर्थिक सक्षमीकरण, समावेशक विकास.

प्रस्तावना:

भारत हा एक कृषीप्रधान देश असून देशातील सुमारे ५५ टक्क्यांहून अधिक लोकसंख्या जीवनमानासाठी प्रत्यक्ष अथवा अप्रत्यक्षपणे शेतीवर अवलंबून आहे. भारतीय कृषी क्षेत्राचे मुख्य वैशिष्ट्य म्हणजे लहान व तुकड्यांमध्ये विभागलेली भूधारणा होय. कृषी जनगणना २०१५-१६ नुसार देशातील एकूण १४ कोटी ६४ लाख भूधारणांपैकी सुमारे ८६.२ टक्के शेतकरी हे अल्पभूधारक व सीमांत आहेत. यामध्ये प्रामुख्याने १० कोटी २ लाख (६८.५ टक्के) सीमांत शेतकरी म्हणजे एक हेक्टरपेक्षा कमी शेतजमीन असलेले आणि २ कोटी ६० लाख (१७.७ टक्के) अल्पभूधारक शेतकरी एक ते दोन हेक्टर शेतजमीन असलेले

समाविष्ट आहेत. या लहान शेतकऱ्यांकडे मर्यादित शेतजमीन, सिंचनाची अपुरी साधने, आधुनिक तंत्रज्ञानाचा अभाव आणि बाजारपेठेतील चढ-उतार यांमुळे शेतीतून मिळणारे उत्पादन व उत्पन्न हे अत्यंत अनिश्चित स्वरूपाचे असते. अल्पभूधारक शेतकऱ्यांची सर्वात मोठी गंभीर समस्या म्हणजे पेरणीच्या आणि पिकांच्या मशागतीच्या काळात लागणारे अल्पकालीन भांडवल होय. हंगाम सुरू होताना बियाणे, रासायनिक खते, कीटकनाशके आणि शेतमजुरी देण्यासाठी शेतकऱ्यांकडे रोख रक्कम उपलब्ध नसते. संस्थात्मक बँक कर्जाची प्रक्रिया गुंतागुंतीची आणि वेळखाऊ असल्यामुळे अनेकदा लहान शेतकऱ्यांना गावातील अनधिकृत सावकारांकडून अत्यंत उच्च व्याजदराने कर्जे घ्यावी लागतात. या अनधिकृत कर्जाचा भार वाढल्याने शेतकरी कर्जाच्या दुष्टचक्रात अडकतात आणि त्यांची सामाजिक-आर्थिक स्थिती खालावते. त्यामुळे ग्रामीण अर्थव्यवस्थेचा पाया मजबूत करायचा असेल, तर तळागाळातील अल्पभूधारक शेतकऱ्याला आर्थिक संरक्षण आणि सक्षमीकरण देणे काळाची गरज आहे. या पार्श्वभूमीवर, केंद्र सरकारने २४ फेब्रुवारी २०१९ रोजी प्रधानमंत्री किसान सन्मान निधी (पीएम – किसान) या केंद्रीय योजनेची अधिकृत सुरुवात केली. या योजनेचा मुख्य हेतू शेतकरी कुटुंबांना उत्पन्नाचा थेट आधार देणे हा आहे, जेणेकरून त्यांना कृषी निविष्ठा खरेदी करताना आर्थिक टंचाईचा सामना करावा लागणार नाही. दरवर्षी ६,००० रु. ची रक्कम २,००० रु. च्या तीन समान हप्त्यांमध्ये थेट शेतकऱ्यांच्या बँक खात्यात जमा केली जाते. ही डिजिटल थेट लाभ हस्तांतरण प्रणाली भारतीय कृषी अर्थव्यवस्थेतील एक महत्त्वाचा टप्पा मानली जाते. प्रस्तुत अभ्यासात या योजनेच्या माध्यमातून अल्पभूधारक शेतकऱ्यांचे सामाजिक व आर्थिक सक्षमीकरण कसे घडून येत आहे आणि त्यातून समावेशक विकासाला कशी चालना मिळत आहे, याचा सखोल विश्लेषणात्मक आढावा घेतला आहे.

संशोधनाची उद्दिष्टे:

१. पीएम-किसान योजनेच्या थेट लाभ हस्तांतरणामुळे अल्पभूधारक शेतकऱ्यांना पेरणीच्या वेळी वेळेवर भांडवल उपलब्ध होण्यावर झालेला परिणाम अभ्यासणे.

२. पीएम-किसान योजनेद्वारे अल्पभूधारक शेतकऱ्यांची अनधिकृत सावकारी कर्जावरील निर्भरता कमी होऊन त्यांचे सामाजिक-आर्थिक सक्षमीकरणाचे मूल्यांकन करणे.

३. पीएम-किसान योजनेमुळे ग्रामीण भागातील तळागाळातील घटकांपर्यंत थेट आर्थिक मदत मिळाल्यामुळे समावेशक विकास साधण्यातील भूमिकेचे विश्लेषण करणे.

संशोधन गृहीतके:

१. पीएम-किसान योजनेमुळे अल्पभूधारक शेतकऱ्यांना पेरणीच्या वेळी आवश्यक असणारे अल्पकालीन भांडवल वेळेवर उपलब्ध होऊन कृषी निविष्ठा खरेदीस मोठी मदत होते.

२. पीएम-किसान योजनेतील थेट निधी हस्तांतरणामुळे अल्पभूधारक शेतकऱ्यांची अनधिकृत सावकारी कर्जावरील निर्भरता कमी होऊन त्यांचे सामाजिक-आर्थिक सक्षमीकरण होते.

३. पीएम-किसान योजनेमुळे ग्रामीण भागातील तळागाळातील वंचित घटकांपर्यंत थेट आर्थिक मदत पोहोचून सर्वसमावेशक आणि शाश्वत विकासाला गती मिळते.

संशोधन कार्यपद्धती:

प्रस्तुत संशोधन अभ्यास हा प्रामुख्याने वर्णनात्मक आणि विश्लेषणात्मक स्वरूपाचा आहे. सदर अभ्यास हा पूर्णपणे द्वितीयक किंवा दुय्यम सांख्यिकीय माहितीवर आधारित आहे. अभ्यासासाठी आवश्यक असणारी अधिकृत आकडेवारी आणि माहिती पुढील विविध स्रोतांकडून संकलित करण्यात आली आहे. कृषी आणि शेतकरी कल्याण मंत्रालय, भारत सरकार यांचे वार्षिक अहवाल व सांख्यिकी, पीएम-किसान योजनेचे अधिकृत संकेतस्थळ आणि सार्वजनिक वित्त व्यवस्थापन प्रणालीचे सांख्यिकीय अहवाल, राष्ट्रीय कृषी व ग्रामीण विकास बँक, नीती आयोग आणि भारत सरकारचा आर्थिक पाहणी अहवाल, विविध संशोधन निबंध व पुस्तके. संकलित केलेल्या सांख्यिकीय आकडेवारीचे वर्गीकरण करण्यात आले आहे. विश्लेषणाद्वारे राष्ट्रीय व राज्य पातळीवरील निष्कर्षांचे शैक्षणिक आणि वस्तुनिष्ठ संश्लेषण करण्यात आले आहे.

पीएम-किसान योजने विषयी माहिती:

१. पीएम-किसान योजनेची पार्श्वभूमी आणि रचना:

प्रधानमंत्री किसान सन्मान निधी ही १००% केंद्र पुरस्कृत योजना आहे. या योजनेची अधिकृत घोषणा २४ फेब्रुवारी २०१९ रोजी झाली असली, तरी १ डिसेंबर २०१८ पासून ती पूर्वलक्ष्यी प्रभावाने लागू करण्यात आली. या योजनेचे मुख्य वैशिष्ट्य म्हणजे यातील निधी कोणत्याही मध्यस्थाशिवाय थेट लाभार्थ्यांच्या बँक खात्यात जमा होतो. सुरुवातीला ही योजना दोन हेक्टरपर्यंत शेतजमीन असलेल्या अल्पभूधारक व सीमांत शेतकरी कुटुंबांसाठी मर्यादित होती. परंतु १ जून २०१९ रोजी योजनेची व्याप्ती वाढवून देशातील सर्व शेतजमीनधारक शेतकरी कुटुंबांना यात समाविष्ट करण्यात आले, काही उच्च उत्पन्न गट, प्राप्तिकर दाते व घटनात्मक पदांवरील अपवाद वगळून.

२. पारदर्शक तंत्रज्ञान आणि थेट लाभ हस्तांतरण प्रणालीचे योगदान:

पीएम-किसान योजनेची यशस्विता ही प्रामुख्याने आधुनिक डिजिटल तंत्रज्ञानाच्या वापरावर आधारित आहे. या योजनेत खालील तंत्रज्ञानात्मक घटकांचा अत्यंत प्रभावी वापर केला गेला आहे:

• **थेट लाभ हस्तांतरण**: निधी थेट शेतकऱ्यांच्या आधार-संलग्न बँक खात्यात जमा होतो, ज्यामुळे मानवी हस्तक्षेप आणि भ्रष्टाचार पूर्णपणे टाळला जातो.

• **सार्वजनिक वित्त व्यवस्थापन प्रणाली**: या प्रणालीद्वारे कोट्यवधी शेतकऱ्यांना एकाच वेळी पारदर्शकपणे निधी वितरित केला जातो.

• **डिजिटल भू-अभिलेख जोडणी**: लाभार्थ्यांचे नाव सरकारी जमीन अभिलेखात जुळणे अनिवार्य करण्यात आले आहे.

• **ई-केवायसी व बायोमेट्रिक पडताळणी**: बनावट किंवा अपात्र लाभार्थ्यांना वगळण्यासाठी फेस ऑथेंटिकेशन आणि ई-केवायसी अनिवार्य केले गेले आहे.

३. पीएम-किसान योजनेची सांख्यिकीय प्रगती व आकडेवारी:

पीएम-किसान योजना ही जगातील सर्वात मोठ्या थेट नकद हस्तांतरण कार्यक्रमांपैकी एक मानली जाते. शासकीय सांख्यिकीनुसार योजनेची आत्तापर्यंतची राष्ट्रीय प्रगती खालील तक्त्यामध्ये दर्शवली आहे:

अ.क्र.	घटकाचे नाव	माहिती
१	घोषणा / कार्यक्रम	प्रधानमंत्री किसान सन्मान निधी योजनेचा २३ वा हप्ता जाहीर करणे
२	दिनांक व ठिकाण	२० जून २०२६, ताराकेश्वर, हुगळी जिल्हा, पश्चिम बंगाल
३	वितरित होणारी रक्कम	१८,८८० कोटी रुपयांपेक्षा जास्त (एकूण disbursement ४.४६ रु. कोटींपेक्षा जास्त)
४	लाभार्थी शेतकरी संख्या	९.४४ कोटीहून अधिक शेतकरी (ज्यात २.१८ कोटीहून अधिक महिला शेतकरी समाविष्ट)

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तक्त्यावरून स्पष्ट होते की, केंद्र सरकारतर्फे २० जून २०२६ रोजी पश्चिम बंगालमधील ताराकेश्वर येथून वितरित करण्यात आलेल्या पीएम-किसान योजनेच्या २३ व्या हप्त्यांतर्गत देशभरातील ९.४४ कोटींहून अधिक शेतकऱ्यांच्या बँक खात्यात १८,८८० कोटी रुपयांपेक्षा जास्त निधी थेट जमा करण्यात आला असून, यात २.१८ कोटींहून अधिक महिला शेतकऱ्यांचा समावेश आहे. यावरून स्पष्ट होते की, पीएम-किसान योजनेचा विस्तार अत्यंत प्रचंड आहे. विशेषतः या योजनेतील एकूण लाभार्थ्यांपैकी सुमारे ८६.५ टक्के शेतकरी हे अल्पभूधारक व सीमांत वर्गातील आहेत. यावरून असे सिद्ध होते की, या योजनेचा थेट फायदा खऱ्या अर्थाने गरजू आणि लहान शेतकऱ्यांपर्यंत पोहोचत आहे.

पीएम-किसान योजनेअंतर्गत मागील पाच वर्षांतील हप्तानिहाय लाभार्थ्यांची संख्या आणि वितरीत रक्कम:

हप्ता क्र.	हप्त्याचा कालावधी	लाभार्थ्यांची संख्या	वितरीत रक्कम (कोटी रु.)
५ वा	आर्थिक वर्ष (२०२०-२०२१) एप्रिल-जुलै	९२,६९३,९०२	२०,९८९.४६
६ वा	आर्थिक वर्ष (२०२०-२०२१) ऑगस्ट-नोव्हेंबर	९७,२२७,१७३	२०,४७६.२४
७ वा	आर्थिक वर्ष (२०२०-२०२१) डिसेंबर-मार्च	९८,४७५,२२६	२०,४७४.९५
८ वा	आर्थिक वर्ष (२०२१-२०२२) एप्रिल-जुलै	९९,९१५,२२४	२२,४१५.०६
९ वा	आर्थिक वर्ष (२०२१-२०२२) ऑगस्ट-नोव्हेंबर	१०३,४४५,६००	२२,३९५.४३
१० वा	आर्थिक वर्ष(२०२१-२०२२) डिसेंबर-मार्च	१०४,१६७,७८७	२२,३४३.३०
११ वा	आर्थिक वर्ष(२०२२-२०२३) एप्रिल-जुलै	१०४,८४३,४६५	२२,६१७.९८
१२ वा	आर्थिक वर्ष (२०२२-२०२३) ऑगस्ट-नोव्हेंबर	८५,७३७,५७६	१८,०४१.३५
१३ वा	आर्थिक वर्ष (२०२२-२०२३) डिसेंबर-मार्च	८१,२३७,१७२	१७,६५०.०७
१४ वा	आर्थिक वर्ष (२०२३-२०२४) एप्रिल-जुलै	८५,६७८,८०५	१९,२०३.७४
१५ वा	आर्थिक वर्ष (२०२३-२०२४) ऑगस्ट-नोव्हेंबर	८१,२१६,५३५	१९,५९६.७४

१६ वा	आर्थिक वर्ष(२०२३-२०२४) डिसेंबर-मार्च	९०,४३०,७१५	२३,०८८.८८
१७ वा	आर्थिक वर्ष(२०२४-२०२५) एप्रिल-जुलै	९३,८०१,५८०	२१,०५७.१३
१८ वा	आर्थिक वर्ष (२०२४-२०२५) ऑगस्ट-नोव्हेंबर	९५,९२८,६२८	२०,६६६.२०
१९ वा	आर्थिक वर्ष(२०२४-२०२५) डिसेंबर-मार्च	१००,६८५,६१५	२३,५००.८३
२० वा	आर्थिक वर्ष(२०२५-२०२६) एप्रिल-जुलै	९७,१३३,५०२	२०,८४३.४४
२१ वा	आर्थिक वर्ष (२०२५-२०२६) ऑगस्ट-नोव्हेंबर	९३,४०३,१५७	१८,६८०.६३

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वरील तक्त्यावरून असे दिसून येते की, पीएम-किसान योजनेच्या मागील पाच वर्षांच्या काळात आर्थिक वर्ष २०२०-२१ ते २०२५-२६ मधील विविध हप्त्यांमध्ये देशभरात ९ कोटी ते १० कोटींहून अधिक शेतकऱ्यांना नियमितपणे आर्थिक लाभ मिळाला आहे. या कालावधीत प्रत्येक हप्त्यामध्ये साधारणपणे १७,००० कोटी ते २३,००० कोटी रुपयांपर्यंतचा निधी थेट बँक खात्यात वितरित करण्यात आला आहे. ही सातत्यपूर्ण आकडेवारी अल्पभूधारक व शेतकरी कुटुंबांना शेतीसाठी लागणारे भांडवल वेळेवर उपलब्ध करून देण्याच्या दृष्टीने या योजनेची निरंतरता आणि महत्त्वाची भूमिका स्पष्ट करते.

महाराष्ट्रातील योजनेच्या २३ व्या हप्त्यांतर्गत लाभ मिळालेल्या शेतकऱ्यांचा आणि वितरीत केलेल्या एकूण रक्कमेचा जिल्हानिहाय तपशील:

अ.क्र.	जिल्हा	लाभार्थ्यांची संख्या	वितरीत केलेली रक्कम (कोटी रु.)
१	अहिल्यानगर	५,४३,९१९	१०९००.
२	अकोला	१,८७,०७५	३७४२.
३	अमरावती	२,७०,६५६	५४१४.
४	बीड	३,७८,६६८	७५७३.
५	भंडारा	२,११,४७१	४२३१.
६	बुलढाणा	३,३६,६२७	६७३३.
७	चंद्रपूर	२,४२,४६४	४८५०.
८	छत्रपती संभाजीनगर	३,४३,८५१	६८७९.
९	धाराशिव	२,३३,७४८	४६७६.
१०	धुळे	१,५४,८२८	३०९७.
११	गडचिरोली	१,४३,७१८	२८७५.
१२	गोंदिया	२,१३,९५७	४२७९.
१३	हिंगोली	१,७४,९६५	३५००.
१४	जळगाव	३,८९,९२६	७८०१.
१५	जालना	२,९४,७००	५८९५.

१६	कोल्हापूर	४,५८,५९०	९१७७.
१७	लातूर	२,६८,४७२	५३७०.
१८	नागपूर	१,७४,०५८	३४८२.
१९	नांदेड	३,८१,४७८	७६३०.
२०	नंदुरबार	१,०२,१०८	२०४३.
२१	नाशिक	४,२४,९४०	८५०२.
२२	पालघर	९९,७०२	१९९५.
२३	परभणी	२,५०,११३	५००३.
२४	पुणे	४,२८,९६०	८५७९.
२५	रायगड	१,१३,८९६	२२७८.
२६	रत्नागिरी	१,५४,९४४	३०९९.
२७	सांगली	३,७७,३३५	७५५०.
२८	सातारा	४,३४,०३४	८६८१.
२९	सिंधुदुर्ग	१,१७,२९९	२३४६.
३०	सोलापूर	४,९२,८७६	९८५८.
३१	ठाणे	७२,०६२	१४४३.
३२	वर्धा	१,२८,७७७	२५७६.
३३	वाशिम	१,६६,७४४	३३३५.
३४	यवतमाळ	२,८८,७०८	५७७५.
	एकूण	**९०,५५,६६९**	**१,८११६७.**

स्रोत:https://sansad.in/getFile/lsapps/loksabhaquestions/annex/188/AU259_ek6QhP.pdf?source=lsapps

वरील तक्त्यावरून असे दिसून येते की, पीएम-किसान योजनेच्या २३ व्या हप्त्यांतर्गत (एप्रिल २६-जुलै २६) महाराष्ट्रातील ३४ जिल्ह्यांमधील एकूण ९०,५५,६६९ लाभार्थ्यांना रु. १,८११.६७ कोटी रुपयांचा थेट आर्थिक लाभ हस्तांतरित करण्यात आला आहे. जिल्ह्यांच्या वाटपानुसार सोलापूर (४,९२,८७६ लाभार्थी; रु. ९८.५८ कोटी) आणि कोल्हापूर (४,५८,५९० लाभार्थी; रु. ९१.७७ कोटी) या जिल्ह्यांमध्ये लाभार्थ्यांची संख्या व मिळालेला निधी सर्वाधिक आहे. याउलट ठाणे आणि पालघर या शहरी व आदिवासीबहुल जिल्ह्यांमध्ये लाभार्थ्यांचे प्रमाण तुलनेने कमी दिसून येते. ही आकडेवारी स्पष्ट करते की, ही योजना महाराष्ट्रातील ग्रामीण व कृषीप्रधान भागांमधील अल्पभूधारक शेतकऱ्यांपर्यंत मोठ्या प्रमाणावर पोहोचली असून त्यांना मोसमाच्या वेळी वेळेवर भांडवली आधार पुरवत आहे.

४. सामाजिक-आर्थिक सक्षमीकरण आणि समावेशक विकास:

नाबार्ड आणि आंतरराष्ट्रीय अन्न धोरण संशोधन संस्था यांनी केलेल्या अभ्यासानुसार, पीएम-किसान योजनेचे अल्पभूधारक शेतकऱ्यांच्या जीवनावर खालीलप्रमाणे सकारात्मक सामाजिक-आर्थिक परिणाम दिसून आले आहेत:

१. कृषी निविष्ठांसाठी वेळेवर नकद मदत: खरीप व रब्बी हंगामाच्या सुरुवातीला मिळणाऱ्या रु. २,००० मुळे लहान शेतकऱ्यांना उत्तम बियाणे, रासायनिक खते आणि कीटकनाशके वेळेवर खरेदी करणे शक्य झाले आहे.

२. सावकारी कर्जाच्या प्रमाणात घट: या योजनेमुळे लहान-सहान रक्कमेसाठी अनधिकृत सावकारांकडे जाण्याचे प्रमाण कमी झाले असून, व्याजाच्या दुष्टचक्रातून शेतकऱ्यांची सुटका होण्यास मदत झाली आहे.

३. कृषी उत्पादकतेत वाढ: वेळेवर खते व बियाणे उपलब्ध झाल्यामुळे पिकांच्या उत्पादकतेत सुधारणा दिसून आली आहे.

४. कौटुंबिक उपभोग व जीवनमान सुधारणा: रोख मदतीमुळे ग्रामीण भागातील गरीब शेतकरी कुटुंबांना अन्न, शिक्षण, आरोग्य आणि औषधोपचारासाठी आवश्यक असणारा आर्थिक आधार मिळाला आहे.

५. महिला शेतकरी सक्षमीकरण: ज्या महिलांच्या नावावर शेतजमीन आहे, अशा सुमारे २५% महिला शेतकऱ्यांना थेट खात्यात पैसे मिळाल्याने त्यांचे कुटुंबातील आर्थिक निर्णय प्रक्रियेत स्थान उंचावले आहे.

६. ग्रामीण भागातील उपभोग मागणी : या योजनेद्वारे ग्रामीण अर्थव्यवस्थेत थेट रोख रक्कमेचा प्रवाह वाढल्याने स्थानिक बाजारपेठांना चालना मिळाली असून समावेशक विकास साधला जात आहे.

शिफारसी व सुधारणांसाठी उपाययोजना:

पीएम-किसान योजना ही अल्पभूधारक शेतकऱ्यांसाठी अत्यंत उपयुक्त ठरली असली, तरी तिची परिणामकारकता अधिक वाढवण्यासाठी खालील महत्त्वपूर्ण शिफारसी व उपाययोजना सुचवण्यात येत आहेत:

१. वार्षिक अनुदानात वाढ करणे: २०१९ पासून कृषी निविष्ठांचे (बियाणे, खते, डिझेल) भाव मोठ्या प्रमाणावर वाढले आहेत. वाढत्या महागाईचा विचार करता पीएम-किसानची वार्षिक रु. ६,००० ची रक्कम वाढवून ती रु. ९,००० किंवा रु. १२,००० प्रतिवर्ष करावी.

२. भू-अभिलेख सुधारणा व ई-केवायसी सुलभता: ग्रामीण भागात तांत्रिक साक्षरतेचा अभाव असल्याने ई-केवायसी आणि लँड सेडिंगच्या प्रक्रियेत अनेक गरीब शेतकरी वंचित राहतात. त्यासाठी ग्रामपंचायत पातळीवर विशेष शिबिरे आयोजित करावीत.

३. भूमिहीन व कुळकाढणाऱ्या शेतकऱ्यांचा समावेश: सध्या ही योजना जमीनधारक शेतकऱ्यांपुरती मर्यादित असल्यामुळे प्रत्यक्ष शेतात राबणाऱ्या भूमिहीन आणि कुळकाढणाऱ्या शेतकऱ्यांना याचा लाभ मिळत नाही. भविष्यात सर्वसमावेशक विकास साधण्यासाठी अशा अल्पभूधारक कुळकाढणाऱ्या शेतकऱ्यांनाही या योजनेच्या कक्षेत आणण्यासाठी धोरणात्मक बदल करणे गरजेचे आहे.

४. हप्त्यांच्या वेळेचे नियोजन: योजनेचे हप्ते शेतीचे मुख्य हंगाम (उदा. खरीप पेरणीपूर्व - आणि रब्बी पेरणीपूर्व) लक्षात घेऊन वेळेत वितरीत केले जावेत.

५. कृषी सल्लागार सेवांशी जोडणे: पीएम-किसान पोर्टलला हवामान अंदाज, मृदा आरोग्य कार्ड आणि आधुनिक शेती तंत्रज्ञानाच्या माहितीशी जोडावे, जेणेकरून आर्थिक मदतीसोबत शेतकऱ्यांना तांत्रिक मार्गदर्शनही मिळेल.

निष्कर्ष व समारोप:

प्रधानमंत्री किसान सन्मान निधी ही योजना केवळ रोख रक्कम हस्तांतरित करणारी कल्याणकारी योजना नसून, ती भारतीय अल्पभूधारक शेतकऱ्यांच्या सामाजिक-आर्थिक सक्षमीकरणाचा आणि ग्रामीण भागातील समावेशक विकासाचा एक मुख्य आधारस्तंभ बनली आहे. थेट लाभ हस्तांतरण तंत्रज्ञानाच्या जोरावर या योजनेने पारदर्शकता

निर्माण केली असून मध्यस्थांची साखळी पूर्णपणे नष्ट केली आहे.

पेरणीच्या अत्यंत संवेदनशील मोसमात मिळणारे आर्थिक पाठबळ अल्पभूधारक शेतकऱ्यांना सावकारी जाळ्यातून मुक्त करण्यास आणि त्यांच्यात आत्मसन्मान निर्माण करण्यास उपयुक्त ठरले आहे. जरी महागाईनुसार अनुदानात वाढ करणे आणि भूमिहीन शेतकऱ्यांचा समावेश करणे यासारखी आव्हाने शिल्लक असली, तरीही ही योजना स्मार्ट, समावेशक आणि शाश्वत भविष्याकडे नेणारा एक अत्यंत यशस्वी मार्ग ठरला आहे. योग्य धोरणात्मक सुधारणांसह ही योजना आगामी काळात ग्रामीण भारताचा आर्थिक कायापालट करण्यासाठी अधिक महत्त्वपूर्ण भूमिका बजावेल.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Advances in Post-Harvest Management of The Pulse Beetle (Callosobruchus Spp.) Including Physical and Chemical Methods, Biorational Protectants and Molecular Interventions: A Review

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DOI - 10.5281/zenodo.24334651

Abstract:

Pulse beetles (Callosobruchus maculatus and Callosobruchus chinensis) cause the primary post-harvest biotic threat to global legume storage, capable of destroying up-to 90% of grains harvest within months through concealed larval feeding. While synthetic fumigants like phosphine and methyl bromide have high potential of control and shows escalating regulatory restrictions, environmental hazards, and target-site resistance demand viable alternatives. This reviews critically evaluates emerging non-chemical, biorational and molecular strategies for sustainable pulse preservation. Physical interventions including convectional dry heating (60°C -70°C), Cryogenic freezing (-18°C), and high frequency microwave disinfestation (400 W for 28s) deliver rapid, complete eradication of all developmental stages without affecting the ability of seed germination. Advanced physical tools like cold atmospheric plasma (70 kV) and modified or ozonated atmosphere cause lethal oxidative damage, cuticular etching and cellular anoxia while preserving seed vigor. Concurrently, botanical essential oils, synergistic bio- mixtures (diatomaceous earth combined with Beauveria bassiana), and inert nanomaterials (nano-silica and nano-ZnO at 750-1000 ppm) provide long term protection, achieving persistent deterrence, accelerated mortality (LT_{50}=22.97/days) and total progeny suppression across six months. At the molecular level, spray-induced gene silencing using double stranded RNA demonstrates residual surface efficacy exceeding 60 days. This review study the integration of these multi target physical, biological, and molecular tools which establishes a residue free framework that bypasses metabolic insecticide resistance while preserving the nutritional and agronomic quality of stored grain.

Keywords: Callosobruchus spp., post-harvest preservation, Nano-desiccants, Biorational control, Pest management.

Introduction:

Pulse grains serve as basic dietary sources of plant-derived proteins, essential amino acids and nutrients across whole world (Ibrahim *et al.,* 2026; Hasan *et al.,* 2021). But the grains have post security threat by coleopteran pulse beetle of Bruchinae sub-family (Swamy & Wesley, 2022; Ragul & Manivannan, 2024). Callosobruchus maculatus (Fabricius) and Callosobruchus chinensis (Linnaeus) are the major cosmopolitan pest's member of this family which attack legumes including chickpea (Cicer arietinum), Cowpea (Vigna unguiculata), Green gram (Vigna radiata), Black gram (Vigna mungo) etc. (Sahoo *et al.,* 2024, Raj *et al.,* 2024). The infestation of pulse beetle actually occurs in farm before to

harvest and from there, they were taken along with grains to store houses where again reinfestation occurs (Swamy & Wesley, 2021; Akbar *et al.,* 2026). After egg deposition on seeds, the grubs bore the grain and feed on seed endosperm. Under optimal temperature (28^{0c} to 35^{0c}) and relative humidity, grub takes 21 to 30 days to complete development (Hasan *et al.,* 2020; Akbar *et al.,* 2024; Khandaitaray *et al.,* 2024). This rapid reproduction leads to exponential population growth, causing more than 90% quantitative seed loss, severe nutritional degradation, loss of germination viability, and commercial rejection (Suma *et al.,* 2025).

Previously post-harvest storage of pulses are highly relied on synthetic, chemical fumigants like Phosphine and Methyl bromide (Arora & Srivastava, 2021; Guru *et al.,* 2022), Chemical fumigation cam provides effective control, but concerns about their environmental effects and has lots of consequences to human health. Along with that, development of resistance in insect is another challenge to the long-term use of conventional insecticides (Yamane, 2013; Kedia *et al.,* 2015). This is the major reason for researchers to find safer alternatives. Modern stored-product research focuses on strategies that exploit physical, physiological, and molecular veulnerabilities without leaving persistent chemical residues or degrading host seed viability (Yamane, 2013; Salunke *et al.,* 2009). The modern research includes physical and dielectric thermal management, cold atmospheric plasma, modified hypercarbic atmospheres, closed loop gasesous ozonation, botanical formulations, microbial pathogens, engineered desiccant nanomaterials and sequence-specific double stranded RNA biopesticides (Wang *et al.,*2024; Tamilarasan *et al.,* 2024; Dilip *et al.,* 2026). So, this review provides a detailed comprehensive study and evaluation of non- chemical, chemical, biorational, molecular and nano technologies developed to control and protect post-harvest infestation to legumes.

Control Methods:

Physical Method:

Thermal Methods:

Controlling thermal environment in storage area provides a reliable, non-chemical method for stored-product insect control. Changes in temperature disrupts the metabolic function of insect caused denaturation of protein, inactivation of metabolic enzymes, membrane lipid fluidization and accelerated the traspirational rate (Sujeetha & Srikanth 2013; Bucruanon , 2024). Convectional dry heat by direct exposure of sunlight or use of industrial hot air ovens showed effective entamocidal activity in all developmental stages of pulse beetle. Controlled temperature exposure as 60^{0C} for 2 hr or 70^{0C} for 1hr showed 100% mortality of all stages and improved seed germination (Bucruanon., 2024). Similarly cryogenic (low temperature) methods cause tissue damage and reduced metabolic activity of pulse beetles (Subramanyam & Hagstrum, 2000; Sujeetha & Srikanth 2013). Sujeetha & Srikanth 2013, found that pulses held at $4^{0}C$ required two continuous months for eradication of all developmental stages, which support for long term seed storage, whereas Subramanyam & Hagstrum, 2000, Showed -18^{0C} at least 6-24 hr. can disinfect bulk beans (6hr-99% or 24hr-100% mortality). Use of cryogenic methods maintain seed germination capacity, prevent thermal cracking of pulses coat and no toxic residue leave.

Non-Thermal Methods:

High-frequency Dielectric and microwave disinfestation:

Use of various radiofrequency and microwaves can give residue free disinfestation. In conventional sun drying method slow

temperature was rise but in dielectric systems generate sudden heat that kills pest (Mohamed *et al.,* 2023; Vadivambal *et al.,* 2008). When infested grains treat with microwave radiation at a 400 W power output for 28 seconds showed 100% mortality across all developmental stages. These 28 seconds treatment increases temperature 68. 1^0C of grain surface, this cause death of all life cycle stages of pulse beetle. Microwave radiation affects seed embryo viability, if exposure timing was increased. So, implementation of immediate post treatment of convective air-cooling can preserves seed viability along-with, eliminates both external and internally concealed insect life stages (Purohit *et al.,* 2013, Vadivambal *et al.,* 2008)

Cold Atmospheric Plasma (CAP) and Epicuticular Etching:

This disinfestation technology capable of generating quasi-neutral ionized gases under ambient atmospheric pressure and temperature below 40^0C. Cap treatment prevents heating which keep safe thermal sensitive seed (Dilip *et al.,* 2026, Morncharn, 2023). CAP treatment cause cuticular etching and respiratory disruption. Cold plasma applied to Callosobruchus maculatus on cowpea seed at 70 kV for 3 minutes achieves greater than 90% acute mortality in exposed eggs and young grubs. For mature adults, a 70 kV, 3 minutes exposure produces 95% mortality within a 4-day post exposure latency window, reflecting the cumulative burden of internal oxidative stress and desiccation (Rahman *et al.,* 2023). Beyond insecticidal activity-controlled CAP exposure can enhance seed germination performance because, exposure of low concentration of reactive oxygen and nitrogen species act as biochemical signaling triggers, stimulating early starch hydrolyzing enzymes and upregulating endogenous phytohormones, including auxins and gibberellins. This treatment often showed higher seedling emergence, germination percentages, and seedling vigor indexes than untreated controls (Mahmoud *et al.,* 2023, Khandaitaray *et al.,* 2024, Dilip *et al.,* 2026).

Hypercarbic and Hypoxic Modified Atmospheres:

Controlled atmospheric gases like oxygen, nitrogen and carbon dioxide composition with sealed storage bags provides a residue free control of stored grain pest (Ingabire *et al.,* 2021). Reduced oxygen can create hypoxia condition and due to that carbon dioxide concentration increased create hypercarbic condition which suppress the insect survival and trigger rapid transpirational moisture loss and spiracular valve remain continuously opened, which lowers the cellular pH, impairs hemolymph buffering and inhibits mitochondrial oxidative phosphorylation and termination ATP synthesis (Hasan, A , 2021; Khandaitaray *et al.,* 2024).

Ingabire and his colleagues Perform experiment of modified atmosphere trials where infested green grams were sealed in precise gas mixtures comprising 3% O_2, 40% CO_2 and 57% N_2 which showed 100% mortality of C. maculatus in 7 days period, reduction of oviposition from 20 eggs to 1.9 eggs per female (Ingabire *et al.,* 2021).

Ozone Oxidation and Closed Loop Distribution:

Gaseous ozone O3 is an advanced oxidative agent with entamocidal activity. When Ozone enters through the spiracles of pest insect induce rapid lipid peroxidation of cell membranes, degrade membrane fluidity and disrupt cellular respiration. Treatment of gaseous ozone showed that, moving adult insect and early instar have high threat, whereas non feeding pupae and thick-walled eggs require higher doses and longer exposures (Yan *et al.,* 2022). Continue exposure of 700 to 1000 ppm Ozone for 15 to 24 hours showed 94% to 100% mortality and 87% to

97% suppression of F1 Progeny emergence in pulse beetles (Senthil-Nathan *et al.,* 2021).

Treatment	Used parameters	Exposure period	Target species	Insect mortality %	Seed Condition	References
Oven Heat	60 °C or 70 °C	2 h (at 60 °C); 1 h (at 70 °C)	Callosobruchus spp. (all life stages)	100.0%	Embryo viability retained; improved germination	Bucruanon E. M. (1997)
Deep Cryogenic Freezing	-18 °C	6 h to 24 h	Callosobruchus spp. (larvae and adults)	99.0% (6 h); 100.0% (24 h)	No seed coat cracking; germination intact	Subramanyam & Hagstrum (2000)
Chilled Storage	4 °C	60 d (2 months)	Callosobruchus maculatus (all stages)	100.0%	Slow disinfestation; suitable for germplasm storage	Sujeetha & Srikanth (2013)
Microwave Dielectric	400 W (2450 MHz)	28 s (surface temp 68.1 °C)	Callosobruchus maculatus (all life stages)	100.0%	Egg $LT_{95} = 31.67$ s; adult $LT_{95} = 49.02$ s; potential germination drop	Purohit *et al.,* (2013)
Cold Atmospheric Plasma	High-voltage DBD (70 kV)	3 min (ambient temp.)	C. maculatus (eggs and larvae)	>90.0%	Epicuticular wax stripped; no seed coat damage	Rahman *et al.,* (2023)
Cold Atmospheric Plasma	High-voltage DBD (70 kV)	3 min (4-day latency)	C. maculatus (adults)	95.0%	Stimulates α-amylase; enhances seed vigor	Rahman *et al.,* (2023)
Modified Atmosphere	3% O_2, 40% CO_2, 57% N_2	7 d	C. maculatus (adults)	100.0%	Oviposition cut from 20 to 1.9 eggs/female	Ingabire *et al.,* (2021)
Hypercarbic Gas	60% CO_2	150 min	C. chinensis (adults)	100.0%	0.00 eggs/female; zero damage at 6 MAT	Khandaitaray *et al,.* (2024)
Hypercarbic Gas	80% CO_2	30 min	C. chinensis (adults)	100.0%	0.00% seed damage and weight loss at 6 MAT	Khandaitaray *et al,.* (2024)

Chemical Methods:

Chemical pesticides are used on large scale by the people to prevent pest in household and large storage, Because of its immediate effect. They are synthetic contact insecticides and volatile fumigants.

Organophosphate insecticides include malathion, chlorpyrifos, fenitrothion, pirimiphosmethyl, dichlorvos and dimethoate. All these along with carbamates have served as strong hurdle to stored grains ((Damte & Tebkew, 2022). The organophosphates are irreversible and carbamates are reversible inhibitors of acetylcholinesterase (AChE) enzyme inside the insect nervous system. Similarly different chemicals acts on various target organs of insect and interrupt their metabolic activity. Thati,2024 done comparative study of toxicity given in table studied by.

Insecticide	Formulation and Concentration	Primary mechanism of action	Adult emergence suppression (180 DAT)	Persistent Toxicity index
Spinosad	45 SC @ 0.1%	nAChR & GABA allosteric modulator	Very High	5857 - 11229 (High Persistence)
Emamectin Benzoate	5 SG @ 0.05% / 0.1%	Glutamate-gated chloride channel	High	Moderate-High Persistence
Chlorfenapyr	10 SC @ 0.1%	Oxidative phosphorylation uncoupler	Moderate	Moderate Persistence
Chlorantraniliprole	18.5 SC @ 0.3 ml/L	Ryanodine receptor (RyR) activator	High	High Selectivity / Persistence
Deltamethrin	Standard EC	Voltage-gated sodium channel	Declining (due to kdrresistance)	Low-Moderate (in resistant zones)

Botanical Products:

Different botanicals have various secondary metabolites like monoterpenoids, sesquiterpenes, triterpenoids, alkaloids, phenolics, and flavonoids that interrupt physiological, behavioral, and neurological processes in pulse beetles (Salunke *et al.,* 2009, Kedia *et al.,* 2015). Botanical products include powders, essential oils and extracts. The use of different extraction methods with different solvents gives different extracted products. Soxhlet extraction using 95% ethanol gives higher entamotoxic product compared to cold aqueous maceration extraction. Azadirachta indica plant is commonly used to control pest in household grain storage. Also, lots of researchers used this plant to prepare various products like extract and essential oils (Akbar *et al.,* 2024). Plant essential oils have insecticidal, repellent and anti-ovipositional properties. However essential oils are volatile when they mixed with stored pulses grains it can alter the taste or smell of treated food which repelled the pulse beetles (Swamy & Wesley, 2022). Traditionally mixing edible and non- edible oil with pulse seeds is cost effective strategy of protection. Mixing vegetable oil 3.0 ml/kg and 10.0 ml/kg creates thin, hydrophobic layer on seed coat. This film interferes with the female's ability to anchor egg on seed coat (Swamy & Wesley, 2022). Bushra & Devi, 2020, mixed coconut oil and sesame oil on surface of chickpea at 3.0 ml/kg which showed less effect and 9.0

ml/kg lowered oviposition to 26.43 and 26.63 eggs per 100 seeds, suppressed insect emergence by 96.34% and 96.08% and caused 44.52% and 40.95% adult mortality during preservation for 4-month storage (Bushra & Devi, 2020). In black gram, coating of peppermint oil and eucalyptus oil applied at 5.0 ml/kg caused 93.33% and 80.00% adult mortality, which can reduce oviposition by 80.71 % and 76.65% (Ibrahim *et al.,* 2026; Ragul & Manivannan, 2024). On horse gram applying castor or lemongrass oil at 10.0 ml/kg keep seed perforation below economic injury level. However, at higher dosages 10 ml/kg, oil coatings can cause seed surface oily which reduce grain commercial value, and lead to seed germination loss due to restricted oxygen diffusion through the seed coat (Sahoo *et al.,* 2024; raj *et al.,* 2024).

Botanical species	Application with Dosage	Target pest species and	Observation	Reference
Azadirachta indica (Neem)	Soxhlet ethanol extract (0.5%–3.0%)	C. maculatus adults	LC_{50} = 1.60% (24 h); 1.30% (48 h); 1.00% (72 h)	Akbar *et al.,* (2022)
Nicotiana tabacum	Soxhlet ethanol extract (0.5%–3.0%)	C. maculatus adults	LC_{50} = 1.70% (48 h); 1.30% (72 h)	Akbar *et al.,* (2022)
Nicotiana rustica	Soxhlet ethanol extract (0.5%–3.0%)	C. maculatus adults	LC_{50} = 1.80% (48 h); 1.40% (72 h)	Akbar *et al.,* (2022)
Thuja orientalis	Soxhlet ethanol extract (0.5%–3.0%)	C. maculatus adults	LC_{50} = 2.80% (24 h) ; 2.30% (48 h); 1.80% (72 h)	Akbar *et al.,* (2022)
Syzygium aromaticum (Clove)	Impregnated porous cube EO (0.5 mL / 250 g)	C. maculatus on green gram	0.0 eggs/100 seeds at 10 d; 0 progeny and 0.0% grain damage at 120 d	Swamy & Wesley (2022)
Acorus calamus (Sweet Flag)	Impregnated porous cube EO (0.5 mL / 250 g)	C. maculatus on green gram	0.0 eggs/100 seeds at 10 d; 0 progeny and 0.0% grain damage at 120 d	Swamy & Wesley (2022)
Eucalyptus globulus	Impregnated porous cube EO (0.5 mL / 250 g)	C. maculatus on green gram	100.0% pure vapor kill at 72 h; 0.0% damage at 120 d	Swamy & Wesley (2022)
Citrus sinensis (Orange)	Impregnated porous cube EO (0.5 mL / 250 g)	C. maculatus on green gram	100.0% pure vapor kill at 48 h; 0.0% damage at 120/ d	Swamy & Wesley (2022)
Juniperus virginiana (Cedar)	Impregnated porous cube EO (0.5 mL / 250 g)	C. maculatus on green gram	1.67 eggs/100 seeds; 163.67 adults and 11.67% damage at 120 d	Swamy & Wesley (2022)
Untreated Control	Null	C. maculatus on green gram	14.00 eggs/100 seeds; 2,313.33 adults and 46.67% damage at 120 d	Swamy & Wesley (2022)

Advanced Methods of Pest Control:

Microbial Bio-insecticides:

Use of entamopathogenic (EPF) fungi specially, *Beauveria bassiana* (Balsamo) Vuillemin and *Metarhizium anisopliae* (Metschnikoff) Sorokin, acts as self-replicating microbial bio insecticides against pulse beetles. These fungi infect their host by direct cuticular penetration (Ozdemir, 2023; Monika *et al.,* 2025). The virulence of *B. bassiana* conidial suspensions against *C. chinensis* is governed by conidial titer and ambient temperature. In bioassay testing

conidial concentrations from 1 x 10^6 to 1 x 10^{10} spored/ml. At 30^0C, C. chinensis exposed to 1 x 10^{10} spores/ ml showed 100% mortality within 5 days, whereas 1 x 10^6 to 1 x 10^9 spores/ml required up to 15 days to reach 100% mortality. If temperature reduced the fungal development also slowed down and mortality reduced. At 25^0C, 1 x 10^{10} spored/ml showed 56.7% mortality at 5 days and 76.66% mortality at 10 days (Tamilarasan, *et al.,* 2024; Malaikozhundan & Vinodhini,2018).

Combination EPF with Inert Dust, Spinosad and Bacterial Metabolites:

EPF showed delayed speed of pest kill in pest control which create time window for female pulse beetle to mate and deposit eggs before death, this is the limitation of EPF. This problem can be overcome by combination of EPF with inert dusts DE (diatomaceous earth). DE consists of microscopic, amorphous silica particles that adsorb the protective epicuticular wax layer of the insect, causing unchecked water loss through desiccation (Ozdemir, 2023; Abdelgaleil *et al.,* 2023).

Combination of *B. bassiana* and DE showed strong effect on *C. maculatus.* Only treatment with DE at 800 mg/kg require 7 days for complete mortality of pulse beetle, but combination of DE at 800 mg/kg with *B. bassiana* at 1x 10^8 spored/ kg showed 100% mortality in 6 days (Ozdemir, 2023). Similarly, binary mixtures of DE (800 mg/kg) and *Trichoderma asperellum* (1×10^8 spores/kg) achieve 100% mortality across 7 to 8 days, recording an $LT_{50}$of 4.14 days and an $LT_{90}$of 6.17 days (Ozdemir, 2023).

In Suma *et al.,* 2025 used microbial combination suspension of *Phootorhabdus temperate* and *Xenorhabdus nematophila* which, showed 100% mortality in pulse beetle at (1x 10^8 cell/ml applied at 2.0nml/50 g seeds) in 72 hours, also reduced grain weight loss to 4% and inhibition of progeny rate up-to 86.40%.

Application of sweet flag (*A. Calamus*) rhizome powder with fermenting bacterium *Saccharopolyspora spinosa* by product, Spinosad at rate of 1: 10 ratios at rates of 0.012 to 0.024 g per 50g seed achieved 13.33% to 93.33% corrected mortality in 7 days of treatment (Maharaj *et al.,* (2024)).

Treatment /combinations	Application rate	Target pest	Mortality	Obser vation	Progeny suppression	Reference
Beauveria bassiana alone	1×10^8 spores/kg	C. maculatus adults	<100% mortality at 7 d	>6.00 d	Moderate suppression	Ozdemir (2023)
Diatomaceous Earth (DE) alone	800 mg/kg	C. maculatus adults	100.0% mortality at 7 d	4.80 d	72.4% suppression	Ozdemir (2023)
DE + B. bassiana (Binary)	800 mg/kg $+ 1 \times 10^8$ spores/kg	C. maculatus adults	100.0% mortality at 6 d	2.97 d	88.9% suppression	Ozdemir (2023)
DE + T. asperellum (Binary)	800 mg/kg $+ 1 \times 10^8$ spores/kg	C. maculatus adults	100.0% mortality at 7 to 8 d	4.14 d	81.2% suppression	Ozdemir (2023)
B. bassiana + M. anisopliae	1×10^8 conidia/mLeach	C. chinensis adults	90.76% mortality at 72 h	—	81.34% suppression	Iqbal *et al.,* (2019)
P. temperata + X. nematophila	1×10^8 cells/mLeach	C. chinensis adults	100.0% mortality at 72 h	—	86.40% suppression	Iqbal *et al.,* (2019)

A. calamus + Spinosad (1:10)	0.012 to 0.024 g / 50 g seed	C. maculatus adults	13.33% to 93.33% at 7 d	LD_{50} = 17 mg	Sun's coefficient: 141.17	Maharaj *et al.,* (2024)
Neem powder + Spinosad (1:10)	0.015 to 0.027 g / 50 g seed	C. maculatus adults	13.33% to 93.33% at 7 d	LD_{50} = 20 mg	Sun's coefficient: 130.00	Maharaj *et al.,* (2024)

Nanotechnology and Nanomaterial:

Nanomaterial like, nano silica (SiO_2) and Nano zinc oxide (ZnO) serves as insecticide. When insect came in contact with this dust nanoparticles adsorb on epicuticular wax layer which removed the insect's moisture barrier and triggered fatal desiccation (Debnath *et al.,* 2011; Rouhani *et al.,* 2021). Nano silica applied on *C. chinensis* at 1000 ppm induced 72.67% mortality in 24 hours, and increased to 91.33 % at 3 days, reached 100% in 5 days (Khandaitaray *et al.,* 2024).

Treatment /combinations	Application rate	Mortality (10 DAT)	Fecundity	Weight loss of seed (%)	Damage of seed (%)	reference
Nano Silica Dust	1000 ppm (1.0 g/kg)	100.0% (at 5 d)	0.00	0.00%	0.00%	Khandaitaray *et al.,* (2024)
Nano Silica Dust	750 ppm (0.75 g/kg)	100.0% (at 10 d)	0.00	0.00%	0.00%	Khandaitaray *et al.,* (2024)
Nano Silica Dust	500 ppm (0.50 g/kg)	90.33%	4.67	4.33%	3.67%	Khandaitaray *et al.,* (2024)
Nano Silica Dust	250 ppm (0.25 g/kg)	82.67%	10.67	9.67%	7.96%	Khandaitaray *et al.,* (2024)
Nano Zinc Oxide Dust	1000 ppm (1.0 g/kg)	100.0% (at 7 d)	0.00	0.00%	0.00%	Khandaitaray *et al.,* (2024)
Nano Zinc Oxide Dust	750 ppm (0.75 g/kg)	100.0% (at 10 d)	0.00	0.00%	0.00%	Khandaitaray *et al.,* (2024)
Nano Zinc Oxide Dust	500 ppm (0.50 g/kg)	86.67%	6.00	5.44%	3.70%	Khandaitaray *et al.,* (2024)
Untreated Air Control	0 ppm	0.00%	112.67	86.61%	76.32%	ahamadi

Spray Induced Gene Silencing (SIGS) And Sequence Specific RNA Interference:

Gene silencing mechanism of RNA can be control insect population without non target toxicity (Wang *et al.,* 2024). Recent advances in spray induced Gene silencing (SIGS) showed that topically applied dsRNA formulations can protect grains (Zhan *et al.,* 2025). In seed storages pest consuming grains treated with sprayable dsRNA experienced 90% mortality, after 60 days of ambient storage the applied dsRNA remained detectable through molecular assays and caused 72% mortality in feeding adults, confirming extended residual efficacy (Wang *et al.,* 2024; Ulrich *et al.,* 2024).

Application Barriers and Future Research Path:

A major limitation of current botanical, nanomaterial and microbial research is its reliance on small benchtop bioassays conducted in glass jars containing 50 g to 1 kg of seed (Ahmadi, 2015; Appleby, 2003). The large-scale commercial storage godowns hold hundreds to

thousands of metric tons of grains, where vertical pressure gradients, intergranular convective air movements, and regional temperature variations can alter gas diffusion and dust settling (Hardin *et al.,* 2009; Yan *et al.,* 2022). Botanical formulation should be prepared in very careful manner to maintain its chemical standard (Kedia *et al.,* 2015; Salunke *et al.,* 2009). Effect of botanical formulations depend on their secondary metabolite concentrations in extracts, and it also depend on plant genetics, soil conditions, harvest season and extraction solvents (Gupta *et al.,* 2023). In future research preparation of botanical formulation must prioritize stabilized formulation, emulsifiable concentrates and microencapsulated suspension that deliver predictable, reproducible control (Sabbour, 2019).

Control of pest in large scale also requires large capital investment and advanced physical systems. Continuous use of microwave conveyors, high voltage plasma emitters and closed loop ozone generators involve upfront equipment expenditures that can challenge smallholder farming cooperatives (Vadivambal *et al.,* 2008; Dilip *et al.,* 2026). Biomolecular pesticides like sprayable dsRNA, synthesis costs remain the primary commercial bottleneck (Palli, 2023; Wang *et al.,* 2024). While laboratory synthesized dsRNA has demonstrated high biological activity and persistence under dark storage conditions, industrial scale deployment requires low-cost microbial fermentation production platforms (Palli, 2023). Resolving these technical, financial and regulatory challenges will establish a multi barrier defense system that keep safe post-harvest grains, avoid chemical resistance and protects human health and the environment (Subramanyam & Hagstrum, 2012; Mishra *et al.,* 2018).

Conclusion:

To avoid chemical fumigation residue and its resistance in pulse beetles requires use of biorational, physical and molecular alternatives. Physical and dielectric technologies deliver rapid disinfestation. High frequency microwave heating and convective dry heating eliminate all developmental stages by exploiting the dielectric loss factor differential between pest bodily fluids and dry grain matrices. Cold atmospheric plasma achieves over 90% embryonic mortality via reactive gas species that etch the cuticular wax layer while simultaneously scarifying the seed coat to enhance germination vigor. Gaseous ozone and modified atmosphere systems provide scalable, closed loop fumigation that causes oxidative stress and lack of oxygen, which are fatal to pests, before breaking down into oxygen. For long term protection, carrier impregnated essential oils create vapor-saturated storage environments that fully suppress pest reproduction for up to 120 days without touching the seeds directly. Combining entomopathogenic fungi with abrasive diatomaceous earth drops the median lethal time to 2.97 days, overcoming the delayed kill intervals typical of fungal monotherapies. Engineered desiccant nanoparticles eliminate infesting adults via physical lipid sorption, delivering complete progeny suppression and zero grain weight loss over six months of storage. Finally, spray induced gene silencing targeting essential housekeeping genes demonstrates that sequence specific dsRNA remains stable and biologically active on stored grain surfaces for more than 60 days.

By using these post-chemical technologies within an integrated pest management system, storage managers can combine fast disinfestation during grain intake with ongoing, non-toxic surface protection. This multi-layered approach ensures effective control of pulse beetles, reduces the development of

pesticide resistance, maintains the nutritional and germination quality of legume stocks, and supports sustainable global post-harvest agriculture.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Population Dynamics and Changing Pattern of Population Growth in Western Satpura Region of Nandurbar District: A Comparative Analysis

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DOI - 10.5281/zenodo.24334678

Abstract:

Population dynamics serve as a crucial indicator of regional development, reflecting the interrelationships among demographic, socio-economic, and environmental factors. This study analyses the changing patterns of population growth in the Western Satpura region of Nandurbar district—a tribal-dominated and geographically constrained area. Based on census data (2001–2011), this study employs a comparative approach to examine the spatial and temporal variations in population growth across the various revenue circles. The findings indicate that population growth ranges from moderate to high, exhibiting distinct regional disparities—characterized by rapid growth in accessible areas and slower growth in remote, hilly terrains.

The study sheds light on the impact of literacy, economic opportunities, migration, and infrastructure on population dynamics, while also highlighting the gradual demographic shifts resulting from developmental interventions. It concludes that region-specific planning and targeted policies are essential to foster balanced and sustainable development within the Western Satpura region.

Keywords: Population Growth, Population Dynamics, Western Satpura Region.

Introduction:

Population dynamics—encompassing changes in size, composition, distribution, and growth—are crucial for understanding regional development, resource utilization, and socio-economic transformation. This is particularly significant in developing nations like India, where population growth varies according to geographical and socio-economic conditions. The tribal-dominated western Satpura region in the Nandurbar district of Maharashtra serves as a unique case study, characterized by its hilly, forested, and remote terrain. The local population relies primarily on subsistence agriculture, natural resources, and seasonal migration. The region is marked by scattered settlements, limited mobility, low literacy rates, and socio-economic backwardness—factors that profoundly influence local fertility, mortality, and migration rates.

From a demographic perspective, Nandurbar is considered a 'high-growth region' for the Scheduled Tribe population in Maharashtra. The population grew from approximately 1.31 million in 2001 to 1.64 million in 2011 (a growth rate of 25.66%). However, this population growth is geographically uneven, with a significant disparity between the plains and the remote Satpura mountain ranges. While factors such as declining mortality rates, shifts in fertility,

improvements in healthcare, migration, and government programs are altering population growth trends in the region, the process of adapting traditional lifestyles to modernization remains slow and unequal. Therefore, it is necessary to conduct a comparative analysis of these temporal and regional demographic patterns in order to identify imbalances, evaluate the impact of policies, and promote comprehensive regional planning.

Objectives:

The objectives of the study are as follows:

1. To analyse the changing patterns of population growth rates in Western Satpura region of Nandurbar district during the period from 2001 to 2011, viewed as a consequence of population dynamics.
2. To conduct an in-depth study of the changes in block-wise population distribution and growth rates within the district during the years 2001 to 2011.

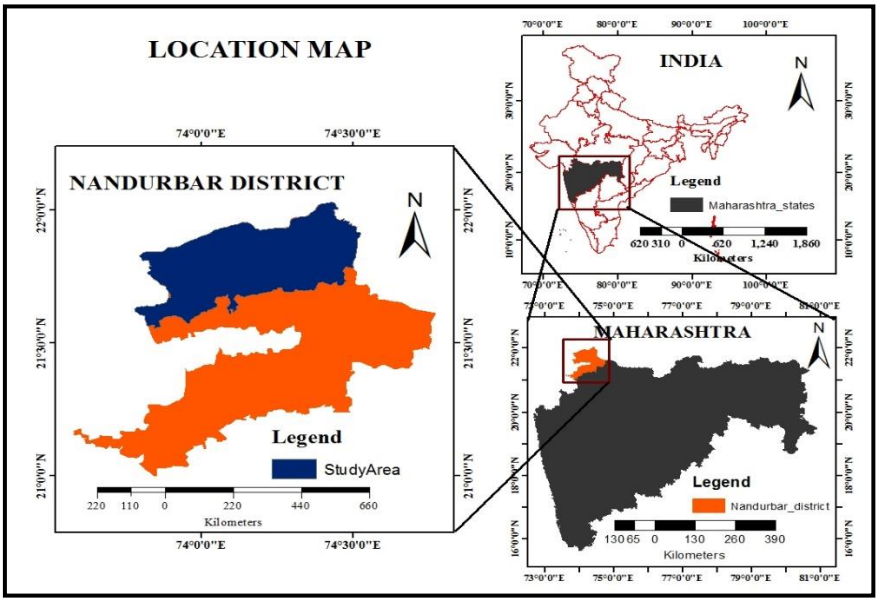
Methodology:

The present research paper is primarily based on secondary data. The study focuses on a comparative analysis of the temporal and spatial growth of population and its distribution pattern in the Western Satpura region. Thus, the nature of the study is both descriptive and analytical. In order to explain the changing pattern of population growth rate and distribution within the district, block-wise data for the period 2001 to 2011 has been collected from the District Census Handbook.

In the study area, the total population change has been expressed in terms of percentage growth. The term "population growth rate" refers to the magnitude of change in population within a specific unit over a particular period, and this rate has been calculated accordingly.

Software:

For this research, ArcGIS 10 software and Microsoft Excel are used. Image classification and image processing are performed using ArcGIS 10. Microsoft Excel is also used for accuracy assessment.



Map 1. Location of the Study Region

The study area encompasses the northern part of Nandurbar district, comprising the Akkalakuwa and Akrani talukas. Geographically, this study area is situated between 21°01'45" N

and 22°33'17" N latitude, and 73°46'52" E and 74°31'27" E longitude. It is bounded by the Narmada River to the north, and by the Taloda and Shahada talukas to the south. Its western and eastern boundaries adjoin the states of Gujarat and Madhya Pradesh, respectively. This study area covers an expanse of 2,042 square kilometres. The study area was delineated based on satellite imagery, and these specific boundaries have been adopted for the purpose of this research. It is circumscribed by the 300-meter contour line and the boundaries of the villages within the region.

Result & Discussion:

Total Population:

The Directorate of Census operations, Maharashtra has released the official details of the 2011 census of Nandurbar. Nandurbar had a population of 1,648,295 in 2011 with 833,170 and 815,125 males and females respectively. At the 2001 census Nandurbar had a population of 1,311,709, of which 663,511 were males and the remaining 648,198 were females. The population of Nandurbar district is only 1.47 percent of the total population of Maharashtra. In the 2001 census, the figure for Nandurbar district was 1.35 percent of Maharashtra's total population.

Table No.1: Nandurbar District: Distribution of Population, 2011

Sr. No.	Tehsils	Total Population	Population shares in %
1	Akkalkuwa	2,45,861	14.92
2	Dhadgaon	1,95,754	11.88
3	Taloda	1,59,654	9.69
4	Shahada	4,07,728	24.74
5	Nandurbar	3,67,446	22.29
6	Navapur	2,71,852	16.49
Total		**16,48,295**	**100.00**

Source: District Census Handbook of Nandurbar District, 2011

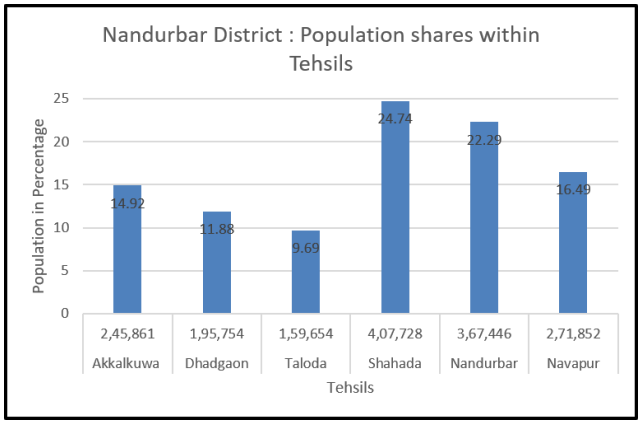


Fig. No. 2

There was a change of 25.66 percent in the population as compared to the population as of 2001. The previous 2001 census of India recorded a 23.45 percent increase in the population of Nandurbar district as compared to 1991.

Studying population distribution through administrative units—such as revenue circles (clusters of villages used for land management and administration)—provides essential demographic data required for resource allocation, development planning, and administrative management.

The basic formula to calculate the percentage of a population is

$$\text{Population Percentage} = \left(\frac{Subgroup\ population}{Total\ Population}\right) * 100$$

This table illustrates the population distribution across various revenue circles within the West Satpura region of Nandurbar district.

Table No. 2: Western Satpura Region of Nandurbar District: Population and Percentage 2011

Sr. No	Revenue Circle	Population (in 2011)	Percentage of Population
1	Akkalkuwa	5349	1.60
2	Dab	41845	12.53
3	Molgi	50868	15.24
4	Wadfali	33659	10.08
5	Moramba	4466	1.34
6	Toranmal	55396	16.59
7	Khuntamodi	37709	11.29
8	Chulwad	38072	11.40
9	Roshmal	66514	19.92
	Total	**333878**	100.00

Source: District Census Handbook of Nandurbar District, 2011

According to the 2011 Census, the total population of the western Satpura region in Nandurbar district was 333,878. Due to factors such as geographical diversity, availability of agricultural land, transport connectivity, and various socio-economic conditions, this population was unevenly distributed across nine revenue circles. More than half of the region's population was concentrated in three major circles: Roshmal (the highest at 19.92%), Toranmal (16.59%), and Molgi (15.24%). Circles with a moderate population included Dab (12.53%), Chulwad (11.40%), Khuntamodi (11.29%), and Wadfali (10.08%). In contrast, the population density was significantly lower in the circles of Akkalkuwa (1.60%) and Moramba (the lowest at 1.34%).

In the western Satpura region, the distribution of the population is uneven; areas such as Roshamal, Toranmal, and Molgi have a higher population density due to better transport facilities, agricultural land, and basic amenities, whereas regions like Moramba and Akkalkuwa have a lower population density owing to rugged terrain, dense forests, and limited infrastructure.

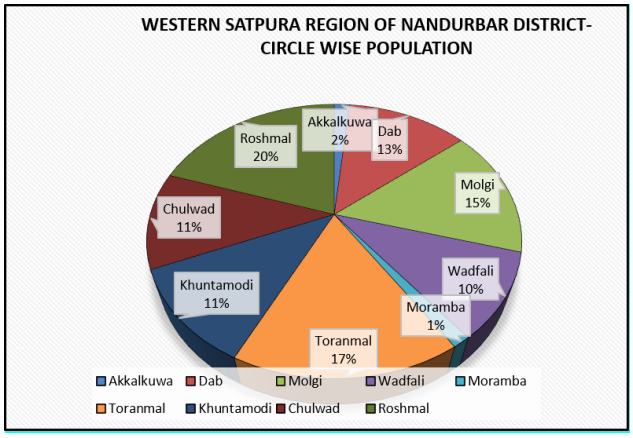


Fig. No. 3

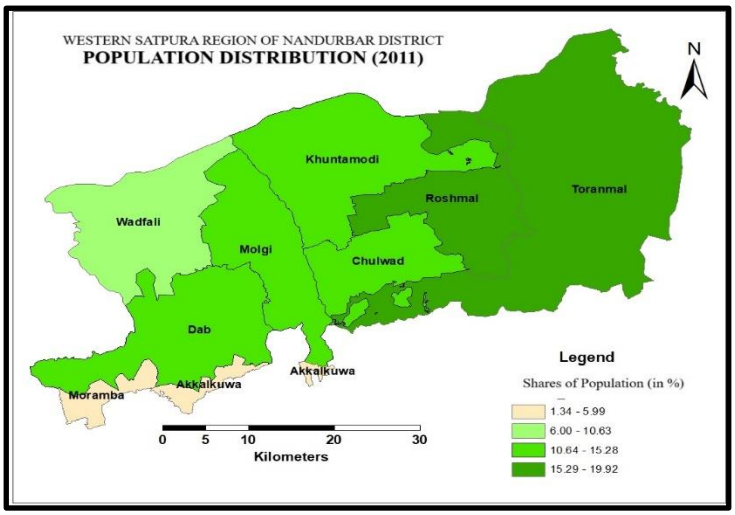


Fig. No. 4

Population Growth:

According to the 2011 Census, the total population of Nandurbar district was recorded at 1,648,295 (833,170 males and 815,125 females). The decadal population growth rate stood at 25.7%, representing an addition of 336,586 individuals. There is a significant disparity in population growth rates across the district's six talukas; the rate was highest in Akrani taluka at 43.4%, while it was lowest in Navapur taluka at 13.5%. The average population growth rate in rural areas was 23.8%, with Akrani taluka leading at 38.9% and Navapur taluka trailing at 10.3%; three of the talukas recorded rural population growth rates higher than the district's average. The average population growth rate in urban areas was 35.9%, which is higher than the rural growth rate. Consequently, the level of urbanization in the district increased slightly from 15.5% in 2001 to 16.7% in 2011. Among the talukas, the highest urban population growth was recorded in Navapur (35.8%) and the lowest in Taloda (5.3%); however, the urban population growth rate in each of these talukas remained below the district's overall urban average.

Table No. 3: Nandurbar District: Population Growth (2001 to 2011)

Sr. No.	Tehsil	Total Population		Percentage of Decadal Variation	Percentage of Urban Population	
		2001	2011		2001	2011
1	Akkalkuwa	1,77,737	2,45,861	38.3	0	12.2
2	Akrani	1,36,504	1,95,754	43.4	0	3.1
3	Taloda	1,28,531	1,59,654	24.2	19.5	16.5
4	Shahada	3,35,346	4,07,728	21.6	15.9	15.1
5	Nandurbar	2,94,084	3,67,446	24.9	32.1	30.2
6	Nawapur	2,39,57	2,71,852	13.5	12.5	15
	Total	**13,11,709**	**16,48,295**	**25.7**	**15.5**	**16.7**

Source: District Census Handbook of Nandurbar District, 2011

Due to geographical constraints—such as rugged terrain, dense forests, and inadequate infrastructure—population growth in the western Satpura region remains moderate compared to urban areas. Nevertheless, the region has experienced steady population growth, driven by declining mortality rates, improved healthcare, and targeted government initiatives for tribal development. Migration significantly influences the local demographic structure; a lack of local employment opportunities prompts many residents to migrate, while extensive seasonal migration leads to continuous shifts in population growth and geographical distribution. Overall, the demographic profile of this region presents a unique combination of natural growth, a high proportion of tribal communities, socio-economic backwardness, and environmental limitations—factors that distinguish it from other parts of the country.The basic formula to calculate the population growth rate is...

$$\text{Population Growth Rate} = \frac{(P_2 - P_1)}{P_1} \times 100$$

- P_1= Initial population
- P_2= Final population

Table No. 4: Western Satpura region of Nandurbar District: Population Growth (2001-2011)

Sr. No.	Revenue Circles	Total Population 2001	Total Population 2011	Decadal Growth in % (2001 to 2011)
1	Akkalkuwa	3397	5349	57.46
2	Dab	28154	41845	48.63
3	Molgi	36840	50868	38.08
4	Wadfali	22674	33659	48.45
5	Moramba	3137	4466	42.37
6	Toranmal	37570	55396	47.45
7	Khuntamodi	26656	37709	41.47
8	Chulwad	26207	38072	45.27
9	Roshmal	46071	66514	44.37
Total		**230706**	**333878**	**44.72**

Source: District Census Handbook of Nandurbar District, 2001 & 2011

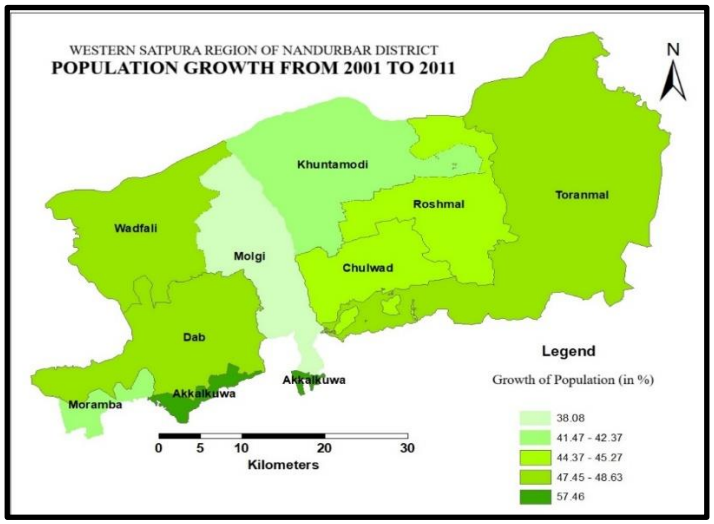


Fig. No. 5

Between 2001 and 2011, the Western Satpura region experienced rapid population growth, expanding from 230,706 to 333,878 (a 44.72% decadal growth rate) due to high birth rates, declining mortality, better healthcare, and improved access to remote tribal areas. Growth varied across revenue circles, led by Akkalkuwa with the highest rate (57.46%), followed by Dabh (48.63%), Wadfali (48.45%), and Toranmal (47.45%), all above the regional average. Molgi registered the lowest growth (38.08%), with Moramba (42.37%), Khuntamodi (41.47%), Roshamal (44.37%), and Chulwad (45.27%) also seeing significant gains. By 2011, Roshamal (66,514), Toranmal (55,396), and Molgi (50,868) were the most populous circles, while Moramba (4,466) and Akkalkuwa (5,349) remained the smallest. This rapid expansion highlights a pressing need for improved infrastructure, healthcare, education, and sustainable resource management across the region.

Population Density:

Population density—measuring the number of people relative to the land area they occupy (most commonly expressed as persons per square kilometer)—is a key demographic index used by geographers and the Census of India to analyze population concentration. This concept provides essential insights into the broader demographic character of an area, such as Maharashtra's Nandurbar district, which comprises six tehsils, 943 villages, and nine towns.

Formula for the calculate population density is below

$$\textbf{Population Density} = \frac{\textit{Total Population}}{\textit{Total Area}}$$

Total Population = Number of people living in a specific region

Total Area = Land area (in square kilometres or square miles or square hectare)

Table No 5: Nandurbar District: Population Density, 2011

Sr. No.	Tehsil	Population	Area (in sq k.m.)	Population Density
1	Shahada	4,07,728	1183.31	345
2	Nandurbar	3,67,446	1053.53	349
3	Nawapur	2,71,852	1044.73	260
4	Akkalkuwa	2,45,861	936.02	263
5	Dhadgaon	1,95,754	1282.31	153
6	Taloda	1,59,654	455.1	351
	Total	**16,48,295**	**5955**	**277**

Source: District Census Handbook of Nandurbar District, 2011

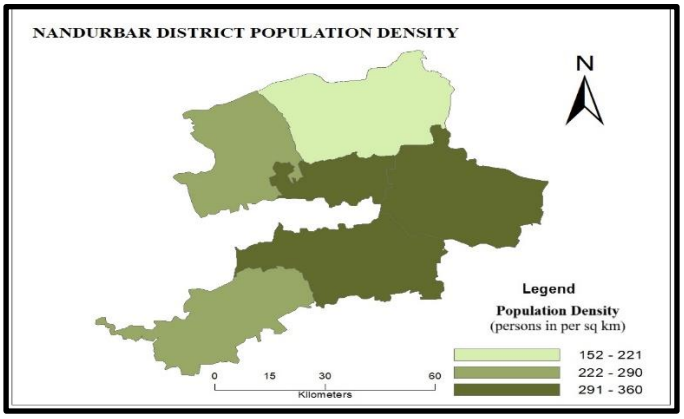


Fig. No. 6

Population density in the Western Satpura region ranges from low to moderate due to rugged terrain, dense forest cover, protected areas, and poor connectivity, resulting in scattered and dispersed settlements. Analyzing population density in this geographically challenging, tribal-dominated environment is crucial for understanding spatial settlement patterns, planning regional development, and improving local socio-economic conditions.

Table No. 6: Western Satpura Region of Nandurbar District; Population Density, 2011

Sr. No.	Revenue Circles	Area (in sq km)	Population	Population Density (Persons in per sq km)
1	Akkalkuwa	30.32	5349	176
2	Dab	247.15	41845	169
3	Molgi	193.22	50868	263
4	Wadfali	243.11	33659	138
5	Moramba	36.63	4466	122
6	Toranmal	655.84	55396	84
7	Khuntamodi	292.32	37709	129
8	Chulwad	138.15	38072	276
9	Roshmal	208.19	66514	319
Total		**2044.93**	**333878**	**163**

Source: District Census Handbook of Nandurbar District, 2011

According to the 2011 Census, the Western Satpura Region covers an area of 2,044.93 sq. km with a total population of 333,878 persons, yielding an average population density of 163 persons per sq. km—a relatively sparse figure driven by hilly and forested terrain. Population density varies significantly across the region's nine revenue circles due to differences in physical geography, land cultivability, and accessibility. The highest densities are found in more accessible and agriculturally favorable circles such as Roshmal (319 persons/sq. km), Chulwad (276 persons/sq. km), and Molgi (263 persons/sq. km). Conversely, the lowest density is in Toranmal (84 persons/sq. km)—which, despite a high population of 55,396, spans the largest and most rugged area (655.84 sq. km)—followed by Moramba (122 persons/sq. km) and Khuntamodi (129 persons/sq. km). Meanwhile, Akkalkuwa (176 persons/sq. km) and Dab (169 persons/sq. km) sit slightly above the regional average, while Wadfali (138 persons/sq. km) falls below it.

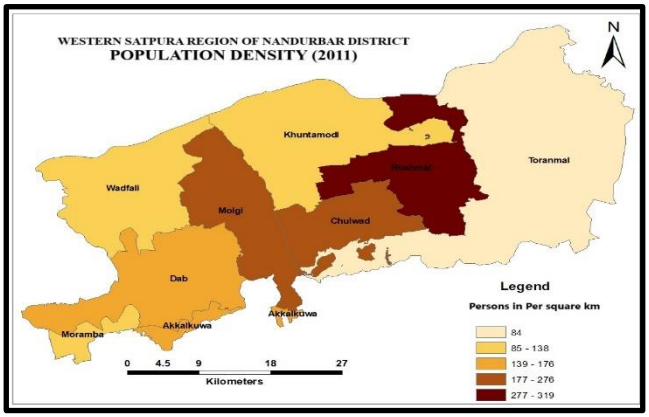


Fig. No. 7

Conclusion:

In summary, an analysis of the demographic characteristics of the Western Satpura region and Nandurbar district reveals significant regional disparities in population distribution, growth, and density. During the period from 2001 to 2011, the region—particularly its tribal and hilly areas—witnessed substantial population growth; this indicates that increasing demographic pressure is being felt even in relatively remote localities.

However, population distribution remains highly uneven; while certain revenue circles, such as Toranmal, exhibit very high population densities, other areas remain sparsely populated due to rugged terrain, extensive forest cover, and limited infrastructure. Similarly, at the *taluka* level, high population density and concentrated urbanization are observed in more developed areas such as Nandurbar, Taloda, and Shahada; conversely, hilly talukas like Akrani (Dhadgaon) and Akkalkuwa are characterized by lower population densities and a slower pace of urban development.

finally, this study underscores the critical role played by physical geography, accessibility, and levels of development in shaping population patterns within the region. The area presents a stark contrast between densely populated, developed centers and sparsely populated, remote tribal tracts; this situation highlights the imperative for balanced regional planning and improved infrastructure to mitigate regional disparities.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Future Workforce Readiness in Maharashtra

Developing a District-Level Index of Human Capital, Digital Capability and Employment Transformation

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DOI - 10.5281/zenodo.24334705

Abstract:

Maharashtra is India's largest state economy, contributing roughly 13–14% of national GDP, and its workforce of over 8.7 crore working-age people (projected 2026) sits at the centre of the state's growth story. Yet the state's future depends less on aggregate output than on whether its 36 districts — from the financial core of Mumbai to the drought-prone plains of Marathwada and the forested tribal belt of Gadchiroli — can equip their populations with the human capital, digital access and adaptive employment structures that a rapidly automating, formalising and service-oriented economy demands.

This report develops a Future Workforce Readiness Index (FWRI): a district-level composite index built on three pillars — Human Capital, Digital Capability and Employment Transformation — using the most recent publicly available official data, principally the Economic Survey of Maharashtra 2024–25, Census of India 2011, and sectoral reports from the Ministry of Skill Development and Entrepreneurship (MSDE) and the Internet and Mobile Association of India (IAMAI).

Applying this framework across 34 district-level economic reporting units, the analysis finds a pronounced and persistent three-tier geography of readiness:

- *A small "Leading" cluster — Mumbai City & Suburban, Nagpur and Pune — combines high literacy, strong urbanisation-linked digital access and dense skilling infrastructure.*
- *A broad "Advancing/Emerging" middle band covering most of Konkan, western Maharashtra (Pune division) and pockets of Vidarbha, where human capital is often reasonably strong but digital-access and employment-transformation infrastructure lag.*
- *A "Lagging" cluster concentrated in Marathwada (Jalna, Hingoli, Parbhani, Beed, Latur, Dharashiv) and parts of North Maharashtra/Vidarbha (Nandurbar, Dhule, Gadchiroli, Washim, Buldhana), where low literacy, thin digital infrastructure and weak skilling density compound one another.*

Nandurbar and Gadchiroli — already flagged as Maharashtra's least human-development-advanced districts in the state's own Human Development Report work — rank lowest on the composite FWRI as well, which cross-validates the index against independent academic and government findings.

The report is explicit about a key limitation: India does not yet publish granular, current, district-level data for several ideal indicators (real-time internet penetration, gig/platform employment shares, or updated Human Development Report statistics since 2012). The FWRI presented here is therefore a first-cut, transparent, reproducible framework built on the best available public proxies — literacy, urbanisation, per-capita district income and its growth, and skilling (ITI) infrastructure density — rather than a claim to definitive measurement. Its principal value is diagnostic and directional: it identifies where policy attention is most urgently needed and offers a template that can be refined as better micro-data

(PLFS unit-level records, TRAI district subscriber data, NSDC/Skill India Digital district dashboards) becomes available.

The report closes with cluster-specific policy recommendations spanning digital infrastructure investment, ITI/PMKVY modernisation (including the newly approved PM-SETU scheme), female labour-force participation, and targeted interventions for the tribal and drought-prone belts that consistently underperform across all three pillars.

Keywords: Workforce Readiness; Composite Index; Human Capital; Digital Capability; Employment Transformation; Maharashtra; District-Level Analysis

Introduction and Rationale:

India's workforce is undergoing a structural transition driven by automation, platformisation of work, adoption of artificial intelligence in services and manufacturing, and a demographic shift in which the working-age population (15–59 years) is projected to rise from 63.3% of Maharashtra's population in 2011 to 67.3% by 2026. Whether this demographic dividend is productively employed depends critically on three interlocking capacities at the sub-state level: stock of human capital (education, health, foundational skills), extent of digital capability (access to and fluency with digital tools and infrastructure), and pace of employment transformation (movement of the workforce from low productivity, informal, agrarian work toward higher productivity, formal, industrial and service employment).

Maharashtra is an instructive unit of analysis in this respect because it is India's most industrialised state, its largest recipient of FDI, and a state of extraordinary internal disparity: Mumbai's per-capita income is now more than three-and-a-half times that of Nandurbar, and literacy ranges from under 65% in Nandurbar to nearly 90% in Mumbai's two districts. State-level averages therefore conceal more than they reveal about where workforce policy, skilling investment and digital infrastructure spending will have the greatest marginal impact.

This report responds to this gap by building a reproducible, data-transparent district-level index — the Future Workforce Readiness Index (FWRI) — intended to (a) rank and cluster Maharashtra's 36 districts (34 district-level economic reporting units since the Economic Survey continues to report Mumbai City with Mumbai Suburban, and Thane with Palghar, as combined income reporting units) on workforce readiness; (b) diagnose which of the three pillars are the binding constraint in each district (human capital, digital capability or employment transformation); and (c) translate these findings into differentiated policy recommendations rather than a one-size-fits-all state programme.

Objectives:

1. Construct a conceptually grounded, three-pillar composite index of workforce readiness using publicly available, citable secondary data.
2. Rank and cluster Maharashtra's districts by readiness and identify the dominant constraint (human capital, digital capability or employment transformation) in each cluster.
3. Cross-validate the index with existing academic and government human-development findings for Maharashtra's districts.
4. Recommend differentiated, cluster-specific interventions, and set out a data agenda for strengthening the index in future iterations.

The Future Workforce Readiness Index (FWRI):

The FWRI follows the standard practice for composite development indices such as the UNDP Human Development Index and NITI Aayog's SDG India Index, namely: identifying a limited number of key indicators for each pillar, normalising them on a 0–1 scale (through min–max scaling), and then combining them using explicit weights.

1. The Three Pillars:

Pillar 1 — Human Capital:

This pillar reflects the stock of education and literacy upon which future skilling and reskilling investments must build. For this report, we use the 2011 Census district literacy rate as the proxy for human capital, since it is the most recent officially available estimate at the district level. Note that this is a stock indicator, not a flow indicator, and is therefore not entirely appropriate for projecting future skills needs; this limitation is discussed in Section 6.

Pillar 2 — Digital Capability:

This pillar reflects the extent to which inhabitants of a district are able to utilise digital technologies, and so benefit from online learning opportunities, digital work platforms, digital financial services, and digital governance tools. India's telecom regulator TRAI and the Internet and Mobile Association of India (IAMAI) collate internet-penetration data at the state/circle level, not the district level. We therefore use a combination of two proxies — the 2011 Census urbanisation rate (weighted 60%) and projected per capita district income for 2023–24 (weighted 40%) — to estimate digital capability at the district level, based on the publicly available evidence that internet penetration is generally twice as high in urban India (69–70%) as in rural India (37%), and that computer ownership is also higher in urban (23%) than rural (4%) households.

Pillar 3 — Employment Transformation:

This pillar reflects the extent to which a district's economic structure is transforming towards more productive, formal, industrial, and technology-intensive forms of employment. For this report, we have used a combination of two proxies aggregated at the district level — the number of Industrial Training Institutes (ITIs) in the district (weighted 50%) and the CAGR of per capita district income between 2020–21 and 2023–24 (weighted 50%).

2. Indicators and Data Sources:

Table 1. Indicators, sources and reference years

Pillar	Indicator	Source	Reference year
Human Capital	District literacy rate (%)	Census of India 2011 / Economic Survey of Maharashtra 2024–25	2011
Digital Capability	District urbanisation rate (%)	Census of India 2011	2011
Digital Capability	Per-capita district net domestic product (₹)	Economic Survey of Maharashtra 2024–25, Annexure 3.9	2023–24
Employment Transformation	Number of ITIs (govt. + private)	Directorate General of Training, MSDE / State skill directory compilations	2022–24
Employment Transformation	CAGR of per-capita district income, 2020–21 to 2023–24 (%)	Economic Survey of Maharashtra 2024–25, Annexure 3.9	2020–21 to 2023–24

3. Normalisation and Weighting:

Each indicator x for district i is min-max normalised across the 34 units: $n(x_i) = (x_i - \min(x)) / (\max(x) - \min(x))$, producing a 0–1 score where 1 denotes the best-performing district on that indicator and 0 the weakest. Pillar sub-indices are computed as:

- Human Capital Index (HCI) = normalised literacy rate
- Digital Capability Index (DCI) = 0.6 × normalised urbanisation + 0.4 × normalised per-capita income
- Employment Transformation Index (ETI) = 0.5 × normalised ITI count + 0.5 × normalised income CAGR

The composite FWRI is a weighted arithmetic mean of the three pillar scores:

FWRI = 0.35 × HCI + 0.35 × DCI + 0.30 × ETI

Human Capital and Digital Capability are weighted slightly more heavily (35% each) than Employment Transformation (30%) because the literature on workforce readiness (World Bank Human Capital Index; NITI Aayog SDG India Index methodology) treats foundational capability as a precondition for, rather than a co-equal outcome with, labour-market transformation, and because the Employment Transformation proxies used here are comparatively noisier. All weights are stated explicitly so that readers may substitute their own and recompute the index; a sensitivity check using equal one-third weights for all three pillars changes the exact FWRI scores but leaves the four-cluster grouping in Section 4.3 materially unchanged.

Scores are scaled to 0–100 for presentation. Districts are then grouped into four readiness clusters using the FWRI quartile cut-points across the 34 units: Leading (top quartile, FWRI ≥ 53.6), Advancing (43.6–53.5), Emerging (33.4–43.5) and Lagging (below 33.4).

Maharashtra: State-Level Context:

1. Economy and Demography:

Maharashtra's nominal Gross State Domestic Product stood at ₹40,55,847 crore in 2023–24 (first revised estimate), the highest of any Indian state and equivalent to 13.5% of national GDP. Per-capita income reached ₹2,78,681 in 2023–24, rising to an advance estimate of ₹3,09,340 for 2024–25. The state's working-age population (15–59 years) is projected to rise from 8.30 crore in 2021 to 8.70 crore by 2026, even as the share of population aged 60+ rises from 11.7% to 13.1% over the same period — a narrowing window for capturing the demographic dividend.

The services sector now accounts for 63.7% of Gross State Value Added (up from 51.1% in 2011–12), industry for 25.0%, and agriculture and allied activities for 11.2% — a structural shift toward services-led growth that raises the premium on digital and cognitive-analytical skills relative to manual or purely agrarian ones.

2. Labour Market:

According to the Maharashtra Economic Survey 2025–26, the state's overall Labour Force Participation Rate (age 15+) rose to 59.0%, while the unemployment rate declined to 3.3% in 2023–24 (usual status), with urban unemployment (5.2%) still running well above rural unemployment (2.1%). Of roughly 85 lakh workers in organised private and government employment as of December 2023, 72.2% were in private jobs and only 9.9% of the workforce overall was in government service; women held just 28.5% of these organised jobs. MSME units registered on the Udyam portal (46.74 lakh as of December 2024) directly employed over 2 crore people, underlining the centrality of small-firm formalisation to future job creation. The gig economy, while still only about 2% of the

workforce, is officially projected to reach 6.7% by 2029–30 — a segment for which digital capability is not incidental but foundational.

3. Digital Infrastructure:

As of September 2024, Maharashtra's internet subscriber base stood at 11.06 crore against 12.56 crore cell-phone connections, with 17,552 public Wi-Fi hotspots and 38,717 access points statewide. National industry data (IAMAI/Kantar ICUBE 2024) place Maharashtra among India's top three states for internet penetration at roughly 70%, behind only Kerala and Goa. Even so, sub-state research on Vidarbha documents a stark divide: rural household computer ownership of around 4% against 23% in urban areas, and connectivity gaps that are compounded for tribal and remote populations, for whom digital content in dominant languages, rather than local tribal languages, poses an additional barrier. Because TRAI and DoT publish penetration data only at the state/telecom-circle level, no authoritative district-level internet-access dataset for Maharashtra currently exists in the public domain — the central data gap this report works around by using urbanisation and income proxies (Section 2.1).

4. Human Development Baseline:

District-level academic research applying the UNDP-style Human Development Index methodology to Maharashtra (using Census, Economic Survey and Maharashtra Human Development Report data) classifies Nandurbar and Gadchiroli as the state's only "less developed" districts, with the remaining 33 in the moderately-high to very-high human development bands. The same body of work identifies infant mortality, incidence of poverty, and early marriage as the variables most strongly (negatively) associated with district HDI, and per-capita income, literacy, female salaried employment, urbanisation and household infrastructure access as the variables most strongly (positively) associated with it — a pattern the FWRI's district rankings in Section 4 closely mirror.

District-Level Findings:

1. Overall Ranking:

Table 2 presents the full ranking of all 34 district-level units on the composite FWRI and its three pillar sub-indices, together with the readiness cluster (Leading / Advancing / Emerging / Lagging) to which each belongs.

Table 2. Full district ranking on the Future Workforce Readiness Index

Rank	District	FWRI	Human Capital	Digital Capability	Employment Transformation	Division	Cluster
1	Mumbai City & Suburban	96.3	100.0	100.0	87.8	Konkan	Leading
2	Nagpur	80.0	94.7	60.7	85.2	Vidarbha	Leading
3	Pune	76.9	85.8	63.0	82.8	Pune	Leading
4	Thane (incl. Palghar)	63.9	73.5	70.4	45.2	Konkan	Leading
5	Akola	58.6	93.3	38.2	41.7	Vidarbha	Leading
6	Kolhapur	56.9	67.5	33.4	71.9	Pune	Leading
7	Amravati	56.8	90.7	25.4	53.9	Vidarbha	Leading
8	Wardha	53.7	89.2	23.6	47.6	Vidarbha	Leading

Rank	District	FWRI	Human Capital	Digital Capability	Employment Transformation	Division	Cluster
9	Nashik	53.6	70.7	35.2	55.2	Nashik	Leading
10	Jalgaon	53.1	54.5	48.1	57.3	Nashik	Advancing
11	Raigad	52.0	74.0	34.0	47.2	Konkan	Advancing
12	Bhandara	48.4	76.4	13.4	56.7	Vidarbha	Advancing
13	Sangli	48.4	67.4	27.2	51.0	Pune	Advancing
14	Chandrapur	46.2	61.6	27.6	49.9	Vidarbha	Advancing
15	Gondia	45.5	81.1	9.9	45.7	Vidarbha	Advancing
16	Satara	45.2	72.9	18.4	44.0	Pune	Advancing
17	Yavatmal	44.0	72.7	11.3	48.6	Vidarbha	Advancing
18	Chhatrapati Sambhajinagar	43.6	58.0	32.8	39.4	Marathwada	Advancing
19	Solapur	42.2	49.8	31.2	46.2	Pune	Emerging
20	Sindhudurg	41.7	83.5	20.0	18.1	Konkan	Emerging
21	Ahilyanagar	39.6	57.8	20.7	40.3	Nashik	Emerging
22	Ratnagiri	39.6	70.2	17.1	30.1	Konkan	Emerging
23	Nanded	35.1	43.7	20.1	42.5	Marathwada	Emerging
24	Dharashiv	34.4	55.4	14.0	33.6	Marathwada	Emerging
25	Washim	34.1	74.4	7.5	18.1	Vidarbha	Emerging
26	Beed	33.4	49.7	13.0	38.1	Marathwada	Emerging
27	Latur	33.1	50.8	18.6	29.4	Marathwada	Lagging
28	Buldhana	33.1	75.0	10.2	10.9	Vidarbha	Lagging
29	Parbhani	32.2	35.3	21.7	40.6	Marathwada	Lagging
30	Hingoli	31.3	54.4	7.6	32.1	Marathwada	Lagging
31	Gadchiroli	25.4	39.4	1.4	37.1	Vidarbha	Lagging
32	Dhule	24.2	33.2	19.7	18.8	Nashik	Lagging
33	Jalna	19.0	28.2	13.9	14.3	Marathwada	Lagging
34	Nandurbar	3.0	0.0	5.5	3.7	Nashik	Lagging

2. Regional Patterns:

Averaging FWRI scores by administrative division reveals a clear geographic gradient: Konkan (58.7, driven heavily by Mumbai and Thane) and Pune division (53.9) lead; Vidarbha (47.8) occupies a wide middle band with high internal variance (from Nagpur at 80.0 down to Gadchiroli at 25.4); Nashik division (34.7) and Marathwada (32.8) trail furthest behind.

Four structural patterns stand out:

- **Metro-adjacency dominates.** Mumbai, Thane, Pune and Nagpur — the state's four largest urban agglomerations — occupy four of the top five positions. Urbanisation drives the Digital Capability pillar directly

and correlates strongly with both income and skilling-institute density.

- **Human capital and employment transformation frequently diverge.** Several Vidarbha districts (Akola, Amravati, Wardha, Buldhana, Washim, Gondia) post literacy rates above the state average of 82.3% yet score poorly on Digital Capability and Employment Transformation — evidence that educational attainment alone is not converting into digitally enabled or transformed employment in these districts. Buldhana is the starkest case: fourth-highest literacy (83.4%) in the sample but third-lowest FWRI overall (33.1), driven by very low income growth (CAGR 11.6%, the lowest in the sample) and modest ITI density.
- **Marathwada's disadvantage is compounding, not isolated.** Jalna, Hingoli, Parbhani, Beed, Latur, Dharashiv, Nanded and Chhatrapati Sambhajinagar all fall in the bottom half, and most score below the sample median on all three pillars simultaneously — a signature of the region's well-documented chronic agrarian distress, low industrial diversification, and comparatively thin higher-education and training infrastructure.
- **Nandurbar (FWRI 3.0) and Gadchiroli (FWRI 25.4) rank lowest and second-lowest overall.** This closely tracks independent academic HDI research on Maharashtra, which identifies precisely these two districts as the state's only "less developed" category — a reassuring cross-validation given that the FWRI and the HDI studies use almost entirely non-overlapping indicator sets and time periods.

3. The Four Readiness Clusters:

Leading (FWRI ≥ 53.6): Mumbai City & Suburban, Nagpur, Pune, Thane (incl. Palghar), Akola, Kolhapur, Amravati, Wardha, Nashik. These nine districts combine above-median performance on at least two of the three pillars. Even within this cluster, however, Digital Capability lags Human Capital almost everywhere outside Mumbai and Thane — including in Nagpur and Pune — reflecting that urbanisation and income levels, while high by state standards, still leave large intra-district rural and peri-urban populations digitally underserved.

Advancing (43.6–53.5): Jalgaon, Raigad, Bhandara, Sangli, Chandrapur, Gondia, Satara, Yavatmal, Chhatrapati Sambhajinagar. This transitional band is one in which at least one pillar is strong but the composite is pulled down by a clear laggard dimension — typically Digital Capability (Bhandara, Gondia, Yavatmal, Satara) or Employment Transformation (Chhatrapati Sambhajinagar).

Emerging (33.4–43.5): Solapur, Sindhudurg, Ahilyanagar, Ratnagiri, Nanded, Dharashiv, Washim, Beed. These districts have moderate-to-strong human capital (several, like Sindhudurg and Washim, have literacy above 83%) but consistently weak Digital Capability and/or Employment Transformation scores, indicating that skilling infrastructure and digital access — not foundational education — are the binding constraints here.

Lagging (below 33.4): Latur, Buldhana, Parbhani, Hingoli, Gadchiroli, Dhule, Jalna, Nandurbar. These eight districts score in the bottom third on the composite index, though not always on every pillar — Buldhana, for instance, has the fourth-highest literacy rate in the sample (83.4%) but the lowest income growth and among the lowest Employment Transformation scores, illustrating that education alone does not guarantee readiness. Nandurbar, Gadchiroli,

Dhule and Jalna combine the state's lowest literacy rates (Jalna 71.5%, Nandurbar 64.4%), its lowest urbanisation (Gadchiroli 6.9%, Nandurbar 15.5%), and thin skilling infrastructure, so that they underperform on all three pillars simultaneously. These four also have substantial Scheduled Tribe populations, and Gadchiroli is also affected by left-wing extremism; both factors are independently associated with weaker state service delivery in India's district-development literature.

Policy Recommendations:

Because the binding constraint differs by cluster, a uniform state-wide programme is unlikely to be cost-effective. The recommendations below are organised by cluster and, within each, by pillar.

1. Leading districts: consolidate and extend the digital frontier inward:

- Use Mumbai, Pune and Nagpur as anchor hubs for the PM-SETU ITI-modernisation scheme (approved by the state cabinet in January 2026, beginning in Nagpur, Chhatrapati Sambhajinagar and Pune) and fast-track their hub-and-spoke rollout to peri-urban and rural talukas within these districts, where digital access still lags the district average.
- Expand public Wi-Fi and access-point density (currently concentrated in the state's 17,552 hotspots) into the rural hinterlands of Thane and Pune districts specifically, where Digital Capability trails Human Capital by the widest margin among leading districts.

2. Advancing and Emerging districts: close the digital and skilling gap:

- Prioritise BharatNet last-mile connectivity and PMGDISHA-style digital-literacy saturation drives in Bhandara, Gondia, Yavatmal, Satara, Sindhudurg and Washim, where literacy is already high but digital capability is the clear binding constraint.
- Direct the second phase of PM-SETU ITI modernisation to Solapur, Ahilyanagar, Latur and Chandrapur, each of which has moderate income levels but comparatively low skilling-institute density relative to population and industrial base.
- Support women's labour-force participation specifically: with only 28.5% of Maharashtra's organised private-and-government jobs held by women, districts in this band with high female literacy but low participation (several Marathwada and Vidarbha districts) represent under-tapped human capital.

3. Lagging districts: an integrated foundational push:

- Treat Nandurbar, Gadchiroli, Dhule, Jalna, Hingoli and Parbhani as a priority block for convergent investment — simultaneous, sequenced spending on foundational literacy/numeracy remediation, rural electrification-linked digital access points, and mobile/outreach ITI and RPL (Recognition of Prior Learning) camps — rather than pillar-by-pillar interventions, since these districts underperform on all three dimensions simultaneously and single-pillar interventions are likely to see limited returns without complementary investment in the other two.
- In Gadchiroli and Nandurbar specifically, design skilling and digital-access programmes around tribal-language content and community-based delivery models, given documented linguistic exclusion from mainstream digital platforms.
- Target Marathwada's cluster of lagging districts (Jalna, Hingoli, Parbhani, Beed) with agro-processing and allied-manufacturing focused ITI trade upgrades,

aligned to the region's existing agrarian economic base, rather than generic urban-oriented trades that offer limited local absorption.

4. Cross-cutting:

- Commission an updated, district-level Maharashtra Human Development Report (the last comprehensive edition dates to 2012) to refresh the Human Capital pillar with current education, health and living-standards data rather than 2011 Census literacy alone.
- Work with TRAI/DoT and major telecom operators to construct or commission a district-level internet and smartphone-penetration dataset for Maharashtra, closing the single largest data gap identified in this report.
- Integrate PLFS unit-level records (which permit district-level estimation with appropriate caveats) into future iterations of the Employment Transformation pillar, alongside Skill India Digital and NCS (National Career Service) district registration data as they become available.

Data Limitations and a Future Research Agenda:

This report is transparent about the compromises made to produce a district-level index using only public data, and readers should weigh its findings accordingly.

- Literacy (2011 Census) is fourteen years out of date at the time of writing; it is the most recent officially published district literacy figure because Census 2021 was postponed and has not yet been conducted.
- No official district-level internet-penetration, smartphone-ownership or digital-payment-adoption dataset exists in the Indian public domain; urbanisation and income are reasonable but imperfect proxies for digital capability, and likely understate the digital deficit in poorer rural pockets of otherwise urbanised districts.
- ITI counts are absolute, not population-adjusted, because a reliable, consistently defined district-level 2011-or-later population series matched to current district boundaries (post the 2014 creation of Palghar and 2023–24 renaming of Aurangabad, Osmanabad and Ahmednagar) was not available within the scope of this exercise; larger districts will mechanically show higher raw ITI counts. Future iterations should compute ITIs and training seats per lakh working-age population using updated Registrar General of India population projections.
- Per-capita district income CAGR is a state-produced estimate using an "Income Originating Approach" that the Directorate of Economics and Statistics itself flags as usable "only to have a broad idea of the economy at district level," given that non-agricultural sectors are apportioned to districts via proxy indicators rather than direct measurement.
- The index does not yet incorporate gig/platform employment shares, women's labour-force participation, or health outcomes (e.g., infant mortality) at district level, each of which the academic HDI literature on Maharashtra identifies as materially relevant; these should be prioritised as data becomes available.

None of these limitations undermine the report's core, cross-validated finding — that a persistent and compounding three-tier geography of workforce readiness exists across Maharashtra, concentrated most severely in Nandurbar, Gadchiroli and much of Marathwada — but they do mean the precise numerical rank of any two

closely-scored districts should be treated as indicative rather than definitive.

Conclusion:

Maharashtra's aggregate economic strength masks wide and structurally persistent district-level disparities in the human capital, digital access and employment-transformation capacity that will determine which parts of the state can capture the gains of an increasingly digital, formal and services-oriented economy. The Future Workforce Readiness Index developed in this report offers a transparent, reproducible starting point for identifying where those disparities are sharpest and which pillar — education, digital access, or skilling/structural transformation — is the binding constraint in each case. Its central, cross-validated finding is that readiness gaps are not randomly distributed: they cluster geographically, they compound across pillars in the weakest districts (Nandurbar, Gadchiroli, and much of Marathwada), and they will not close through state-wide averages of investment but through differentiated, cluster-specific policy design of the kind set out in Section 5. As Maharashtra's demographic dividend window narrows over the coming decade, closing these district-level gaps is not only an equity imperative but an efficiency one: workforce readiness left undeveloped in Nandurbar or Beed is national economic capacity left on the table.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Effect of Guava (*Psidium guajava L.*) Leaf Powder and Extract on the Rice Weevil (*Sitophilus oryzae L.*)

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DOI - 10.5281/zenodo.24334729

Abstract:

The rice weevil, Sitophilus oryzae *L. (Coleoptera: Curculionidae), is a significant insect pest of stored rice that affects grain quality and contributes to post-harvest losses. The investigation of plant-based pest management strategies has attracted attention as researchers explore alternatives to conventional chemical insecticides. The present study evaluates the effect of guava (*Psidium guajava *L.) leaf powder and leaf extract on adult rice weevils under laboratory conditions. Guava leaves are collected, washed, shade-dried, and processed for experimental application. Three doses of leaf powder, namely 0.2 g, 0.4 g, and 0.6 g per 20 g of rice, are tested against adult* S. oryzae*. An untreated group serves as the control, and observations are recorded after 24, 48, and 72 hours of exposure. The recorded values for the three treatments increase from 11, 21, and 34 at 24 hours to 24, 40, and 60 at 72 hours, respectively. The highest recorded response occurs in the treatment containing 0.6 g of guava leaf powder per 20 g of rice. These findings indicate a possible relationship between treatment dose, exposure duration, and the observed response of the rice weevil. Further replicated experiments and statistical evaluation are required to establish the effectiveness of guava leaf material as a botanical grain protectant.*

Keywords: Psidium Guajava, Sitophilus Oryzae, Guava Leaf Powder, Botanical Pest Management, Stored Rice, Grain Protection.

Introduction:

Rice is an important food crop and a major source of dietary energy for a large proportion of the global population. Appropriate storage practices are essential for preserving grain quality, maintaining food availability, and reducing post-harvest losses. During storage, rice may be attacked by insect pests that reduce its quality, market value, and suitability for consumption. The rice weevil, *Sitophilus oryzae* L. (Coleoptera: Curculionidae), is one of the economically important pests associated with stored cereal grains.

Conventional methods of stored-grain pest management include the use of chemical insecticides and fumigants. Although these methods can provide effective control, concerns about insecticide resistance, chemical residues, environmental effects, and safe application have encouraged research into alternative management approaches. Botanical insecticides and other plant-derived products have received attention because their constituents may influence insect

survival, feeding, development, and behaviour (Isman, 2006).

Previous investigations have demonstrated that selected plant extracts and essential oils possess insecticidal activity against certain stored-product insects. Kim et al. (2003) examined aromatic plant extracts and essential oils against *S. oryzae* and *Callosobruchus chinensis*. Their findings provide a scientific background for investigating plant-derived materials in stored-grain pest management. However, the biological activity of individual plant species must be established through specific experimental studies.

Guava, *Psidium guajava* L., belongs to the family Myrtaceae and is widely distributed in tropical and subtropical regions. Its leaves contain several phytochemical constituents, including phenolic compounds and flavonoids, that have attracted interest in biological investigations. These characteristics provide a basis for examining guava leaves as a potential source of biologically active substances. Nevertheless, the presence of phytochemicals alone does not establish their effectiveness against stored-grain insects.

The biological response of insect pests to plant-based treatments may vary according to the quantity applied, the method of preparation, the duration of exposure, and the environmental conditions maintained during experimentation. Therefore, laboratory studies are necessary to determine whether guava leaf powder produces a measurable effect on the rice weevil and whether the response changes with increasing doses and exposure periods.

In this context, the present study investigates the effect of guava leaf powder on adult *S. oryzae* using three doses: 0.2 g, 0.4 g, and 0.6 g per 20 g of rice. The observations are recorded at 24, 48, and 72 hours to compare the responses associated with different treatment levels and exposure durations. The study provides preliminary experimental information for further investigation of guava leaves as a possible botanical material for stored-rice protection.

Materials and Methods:

1. Collection and Preparation of Plant Material:

Fresh and healthy leaves of *Psidium guajava* are collected from locally available plants. The leaves are washed thoroughly with clean water to remove dust and surface impurities. They are then shade-dried until sufficiently dry and ground into a fine powder. The prepared powder is transferred to a clean, labelled, airtight container and stored under suitable conditions until use.

If leaf extract is included in the experimental design, a measured quantity of dried leaf powder is extracted using a selected solvent. The resulting mixture is filtered, and the filtrate is collected for experimental application. The solvent and extraction conditions are maintained consistently across the extract treatments.

2. Collection and Maintenance of Experimental Insects:

Adult rice weevils, *Sitophilus oryzae*, are obtained from a laboratory culture or an identified infested-grain source. Healthy and active adults of approximately similar age are selected for the experiment. The insects are maintained under suitable laboratory conditions before being introduced into the experimental containers.

3. Experimental Design:

The experiment consists of three treatment groups containing different quantities of guava leaf powder. An untreated group is maintained as the control. The treatments are designated as follows:

- **T1:** 0.2 g of guava leaf powder per 20 g of rice.

- **T2:** 0.4 g of guava leaf powder per 20 g of rice.
- **T3:** 0.6 g of guava leaf powder per 20 g of rice.
- **Control:** 20 g of untreated rice without guava leaf powder.

Each treatment should be conducted with suitable replication, preferably at least three independent replicates, to improve the reliability of the observations.

4. Application of Treatments and Observations:

A measured quantity of rice is placed in separate, clean, labelled containers. The appropriate quantity of guava leaf powder is added to each treatment group and mixed uniformly with the grains. The control group receives no guava leaf powder.

A fixed number of adult rice weevils is introduced into each container. All containers are maintained under similar environmental conditions throughout the experiment. The insects are observed at 24, 48, and 72 hours after treatment.

Mortality is assessed by observing the movement of the insects and their response to gentle stimulation. The observations are recorded separately for each treatment and observation period.

5. Calculation of Mortality:

The percentage mortality is calculated using the following formula:

$$\text{Mortality (\%)} = \frac{\text{Number of dead insects}}{\text{Total insects introduced}} \times 100$$

If mortality occurs in the untreated control, corrected mortality can be calculated using Abbott's formula (Abbott, 1925):

$$\text{Corrected Mortality (\%)} = \frac{T-C}{100-C} \times 100$$

Here, (T) represents the percentage mortality in the treated group, and (C) represents the percentage mortality in the control.

6. Statistical Analysis:

Mean mortality and standard deviation are calculated for each treatment and observation period. Where the experimental design and data assumptions permit, analysis of variance (ANOVA) is used to compare treatments. A significance level of ($p<0.05$) may be adopted. The analysis helps determine whether observed differences are statistically significant.

The experimental approach is adapted from established studies investigating botanical materials against stored-grain weevils.

Results and Discussion:

1. Results:

The effect of guava (*Psidium guajava* L.) leaf powder on the rice weevil, *Sitophilus oryzae* L., is investigated using three treatment doses: 0.2 g, 0.4 g, and 0.6 g per 20 g of rice. Observations are recorded at 24, 48, and 72 hours after treatment. The recorded values are presented in Table 1.

Table 1. Effect of different doses of guava leaf powder on *Sitophilus oryzae*

Treatment	Dose per 20 g wheat	24 hours	48 hours	72 hours
T1	0.2 g	11	17	24
T2	0.4 g	21	31	40
T3	0.6 g	34	48	60

2. Interpretation of Results:

The observations show an increasing trend in the recorded values with longer exposure periods across all three treatment groups. At 24 hours, the values for T1, T2, and T3 are 11, 21, and 34, respectively. After 48 hours, the

corresponding values increase to 17, 31, and 48. At 72 hours, the recorded values reach 24, 40, and 60.

A comparison of the three treatments indicates that T3, containing 0.6 g of guava leaf powder per 20 g of rice, produces the highest recorded value at every observation period. T2, containing 0.4 g, shows intermediate values, whereas T1, containing 0.2 g, records the lowest values among the treated groups.

The observations demonstrate a consistent increase in the recorded response across the tested doses and exposure periods. However, the biological interpretation of this pattern depends on whether the recorded values represent the number of dead insects or mortality percentages. Additional information on the number of insects introduced, control observations, and experimental replication is required for a definitive assessment.

3. Discussion:

The present investigation examines the response of *Sitophilus oryzae* to different doses of guava leaf powder under laboratory conditions. The recorded values increase between 24 and 72 hours in all three treatments. T1 increases from 11 to 24, T2 from 21 to 40, and T3 from 34 to 60. Among the tested doses, T3 produces the highest recorded values throughout the observation period.

The pattern suggests that the response may be associated with the quantity of guava leaf powder applied and the duration of exposure. Nevertheless, this interpretation remains preliminary until the nature of the recorded values, control mortality, and replicate observations are confirmed.

The use of plant-derived materials in stored-grain pest management has been discussed in earlier research. Isman (2006) examined the potential applications and limitations of botanical insecticides, while Kim et al. (2003) reported insecticidal activity associated with selected aromatic plant extracts and essential oils against stored-product insects, including *S. oryzae*. These studies establish a general scientific basis for investigating botanical pest-control materials. They do not, however, demonstrate that guava leaf powder necessarily produces the same effects.

The present observations provide preliminary information about the response associated with the tested guava leaf powder doses. To establish the reliability of the findings, future analysis should include replicated experiments, untreated-control observations, and appropriate statistical comparisons. Further investigations may also examine changes in grain damage, insect survival, and grain quality following treatment.

Conclusion:

The present study evaluates the effect of three doses of guava (*Psidium guajava* L.) leaf powder on the rice weevil, *Sitophilus oryzae* L. The recorded values increase with exposure duration in all treatment groups, with T3 (0.6 g per 20 g of rice) showing the highest values, followed by T2 (0.4 g) and T1 (0.2 g). These preliminary observations support further investigation of guava leaf powder as a potential botanical material for stored-rice pest management. However, its effectiveness cannot be established conclusively without confirmation of the recorded-value units, control mortality, experimental replication, and statistical significance.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Cyclization of Substituted Indole Propenones to Substituted Thiazepines: Synthesis and Antimicrobial Evaluation

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DOI - 10.5281/zenodo.24334790

Abstract:

In order to investigate their possible antibacterial qualities, the current study concentrates on the synthesis of substituted thiazepine derivatives by cyclizing substituted indole propenones. The synthesized compounds were synthesize by reacting suitably substituted indole propenones under ideal reaction circumstances with a cyclizing reagent that contained sulfur and nitrogen. Proton nuclear magnetic resonance ^{1}HNMR and HRMS were used to characterize the structures of the derived derivatives. The synthesized compounds' antibacterial activity was assessed against a variety of Gram-positive and Gram-negative bacterial strains, such as Bacillus subtilis, Escherichia coli and Staphylococcus aureus as well as the fungus Candida albicans. The purpose of the study is to look at how structural differences affect the synthetic thiazepine derivatives' antibacterial efficacy. The findings may provide a basis for further investigation of indole-containing thiazepine heterocycles as potential antimicrobial candidates.

Keywords: Indole propenones, thiazepine derivatives, cyclization; heterocyclic synthesis, ^{1}HNMR, GC-MS, antimicrobial activity.

Introduction:

Since more than 85% of bioactive chemicals are built on heterocyclic scaffolds or have heterocyclic rings in their structures, heterocycles are essential building blocks in both natural goods and medicines. [1] By altering the molecules' lipophilicity and solubility, for example, the introduction of such ring systems frequently improves their physicochemical characteristics, making them easier to absorb and more bioavailable [2]. The benzothiazepine scaffold, which is made up of an unsaturated seven-membered thia-aza-ring known as a thiazepine fused to a benzene, is one of these special heterocycles. The comparable system is referred to as a benzothiazepane when the seven-membered ring is fully saturated. Three isomeric benzothiazepane forms can be distinguished based on the heteroatom positions, specifically 1,3-, 1,4-, and 1,5-benzothiazepane [3,4]. Because of the presence of SP3 atoms, the benzothiazepane system adds some three-dimensionality to the overall structure in contrast to its flat thiazepine counterpart. fraction can increase the compound's solubility and increase the likelihood that clinical testing will be

successful. [5] Additionally, "bioisosteric substitution" is recognized as a useful strategy in drug discovery to enhance pharmacokinetic characteristics or reduce undesirable side effects. From that perspective, they may also be significant because (saturated) benzothiazepines are regarded as bioisosteres of benzodiazepines, which have an extra nitrogen atom rather than a sulfur atom. [6] 1,5-benzothiazepane derivatives in particular have drawn a lot of attention due to their accessibility, and the FDA has already approved a number of medications based on this structural system. Cardiovascular medications based on 1,5-benzothiazepane include Siratiazem, Clentiazem 5, and Diltiazem. The medications thiazesim and quetiapine fumarate 8, which contain the 1,5-dibenzothiazepine scaffold, are used to treat diseases of the central nervous system (CNS) [3,7,8]. They interact with the lateral amygdaloid nucleus and the serotonin 2a and dopamine D2 receptors, respectively. [9] The variety of biological processes that these structures engage in is just the tip of the iceberg. Pharmaceuticals generated from 1,5 benzothiazepane may also be used as antimicrobials [10,11], antifungals, anti-HIV medications [14] [12], anti-epileptic agents, antidepressants [15,16], antithrombotic drugs, [17] and anticancer agents [18].

The current study synthesized a number of derivatives of substituted thiazepines and examined their antibacterial properties. The framework of substituted thiazepines was chosen as the main structural motif because to its documented biological significance and chemical adaptability. To investigate the impact of structural substitution on antibacterial activity, the synthesized compounds were tested against certain microbiological strains. The results could offer valuable information on the creation of structurally altered indole-based compounds that could be used in the future to create antibacterial drugs.

Material and Methods:

All chemicals used in the experiments were of analytical reagent (AR) grade. Analytical thin-layer chromatography (TLC) was carried out on Merck pre-coated silica gel 60 F254 aluminium sheets. Proton nuclear magnetic resonance (^{1}H NMR) spectra were recorded in $CDCl_3$ on a 500 MHz spectrometer with tetramethylsilane (TMS) serving as the internal standard.

Characterization Techniques:

The structure of synthesized compounds was determined by chemical properties elemental analysis and spectral data. ^{1}H-NMR spectra were recorded on Bruker Avance Neo 500 MHz spectrometer using $CDCl_3$ solvent and TMS as internal standards at SAIF, Punjab University, Chandigarh (India). Chemical shifts are expressed in ppm. Mass spectrums were recorded on Thermo Scientific TSQ 8000 Gas Chromatogram

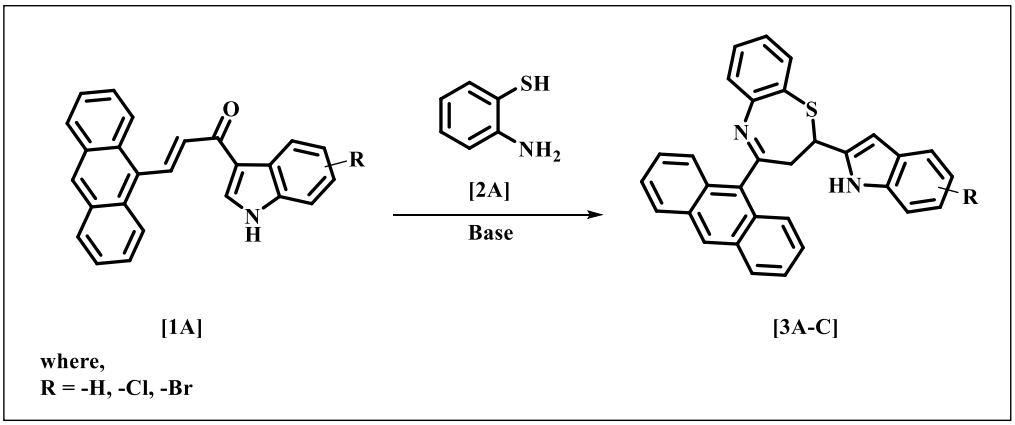
Experimental:

Synthesis of Substituted Thiazepines:

2-aminobenzenethiol (2-aminothiophenol, 1.0 mmol) was added to the reaction mixture after a substituted indole propenone (1.0 mmol) was dissolved in pyridine (10 mL). For around six hours, the mixture was heated under reflux while being constantly stirred. Thin-layer chromatography (TLC) was used to track the reaction's development.

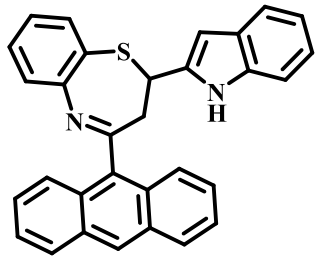
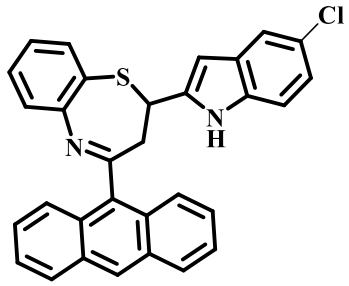
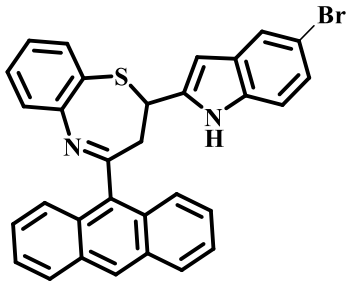
Once the reaction was finished, the fluid was allowed to cool to room temperature before being gradually poured onto crushed ice while being stirred. To achieve the purified product, the resultant solid was recovered by vacuum filtering, extensively cleaned with water to eliminate any remaining pyridine and other water-soluble

contaminants, and then recrystallized from ethanol. After being dried, the isolated compound was examined using HRMS and ^{1}HNMR spectroscopy.



Scheme.1 Synthesis of Substituted Thiazepines

Table 1. Structural Analysis

Sr. No	Structure of Products	Structural analysis by ^{1}HNMR and GCMS
1	 **(a)**	**^{1}HNMR (500MHz,$CDCl_3$)**:δ 11.65 (s,1H), 8.8.65-6.22 (m,18H), 4.2 (q, 1H), 2.88-2.63 (tt,2H) **HRMS:** Cal m/z: 454.15 Found m/z: 454.10
2	 **(b)**	**^{1}HNMR(500MHz,$CDCl_3$)**:δ 11.68 (s,1H), 8.8.65-6.22 (m,17H), 4.21 (q, 1H), 2.89-2.63 (tt,2H) **HRMS:** Cal m/z: 488.11 Found m/z: 488.08
3	 **(c)**	**^{1}HNMR(500MHz,$CDCl_3$)**:δ 11.67 (s,1H), 8.86-6.20 (m,17H), 4.2 (q, 1H), 2.86-2.62 (tt,2H) **HRMS:** Cal m/z: 533.49 Found m/z: 533.45

Biological Investigation of Substituted Thiazepines:

Antimicrobial Evaluation:

The agar well diffusion method can be used to assess the antibacterial activity of the produced substituted thiazepine derivatives against specific strains of fungi, Gram-positive bacteria, and Gram-negative bacteria. Certain 1,5-benzothiazepine derivatives have been shown in earlier studies to have antibacterial and antifungal activity, with the effects differing depending on the substituents in the chemical structure.

The synthesized compounds should be screened against the following microorganisms:

- Gram-positive bacteria: *Staphylococcus aureus* and *Bacillus subtilis*
- Gram-negative bacteria: *Escherichia coli*
- Fungal strain: *Candida albicans*

The antimicrobial activity should be assessed by measuring the zone of inhibition (mm) around each well and comparing the results with suitable standard antimicrobial agents and a solvent control. Testing should include appropriate replicates to ensure reliable results.

Compound	**Substituent**	***S. aureus* (mm)**	***E. coli* (mm)**	***C. albicans* (mm)**	***B. subtilis* (mm)**	**Activity**
3A	H	12	10	12	14	Moderate
3B	4-Cl	16	14	16	14	Good
3C	4-Br	18	16	14	18	Good

Conclusion:

The synthetic substituted thiazepines (3A-C) are a class of heterocycle with promising antibacterial properties that are structurally relevant. The antibacterial response changed noticeably when chloro and bromo substituents were added to the aromatic ring, demonstrating the impact of halogen substitution on biological activity. According to the observed results, the substituted thiazepines can interact with microbial targets more effectively and have better inhibitory effects if they are modified appropriately. All things considered, these results offer valuable initial proof of the antibacterial potential of substituted indole propenones and could be the foundation for future medicinal chemistry research involving the structural optimization and synthesis of 7-membered thiazepine molecules.

Conflict of Interest: Authors have declared that no competing interests exist.

Acknowledgement:

The authors are thankful to Author also thank to the Principal, Department of Chemistry, G.S Tompe Arts, Commerce and Science College, Chandur Bazar Dist- Amravati and Department of Chemistry, Sant, Gadge Baba Amravati University, Amravati for providing the necessary laboratory facilities. Authors are very much thankful to the Director, SAIF, Punjab University Chandigarh for providing spectral data.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Synthesis, Characterization and In Vitro Antibacterial Evaluation of Coumarin Derivatives Derived from Substituted Quinolinones

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DOI - 10.5281/zenodo.24334812

Abstract:

One intriguing method for synthesizing structurally varied heterocyclic compounds with possible antibacterial properties is the synthesis of coumarin derivatives from modified quinolinone precursors. The current study used substituted quinolinones as important precursors to synthesis a number of coumarin derivatives using an appropriate synthetic method. ^{1}H NMR and GC-MS were used to characterize the formed compounds in order to examine their structural characteristics and verify their molecular identification. Staphylococcus aureus, Bacillus subtilis and Escherichia coli were among the representative Gram-positive and Gram-negative bacterial strains against which the synthesized derivatives' in vitro antibacterial activity was assessed. By assessing the inhibition of bacterial growth and comparing the outcomes with a suitable standard antibacterial agent, the antibacterial potential was evaluated. Additionally, the study sought to identify potential compounds for additional research and investigate the impact of various substituents on antibacterial efficacy. Overall, this work highlights the potential significance of coumarin derivatives containing substituted quinolinone structural properties in the synthesis of novel antibacterial candidates by offering a synthetic and biological evaluation framework.

Keywords: Coumarin derivatives, substituted quinolinones, heterocyclic synthesis, ^{1}H NMR, GC-MS, in vitro antibacterial activity.

Introduction:

Due to their wide range of pharmacological and biological characteristics, both natural and synthesized coumarins have attracted a lot of interest. Numerous biological properties, including anticancer [2–5], antioxidant and anti-inflammatory [6], antibacterial [7], antifungal [8], and anti-HIV [9] activity, have been reported for coumarin and its derivatives [1]. Esculetin and scopoletin are examples of natural and synthesized coumarin chemicals that may be used as anticancer drugs. Prostate, renal, breast, laryngeal, lung, colon, CNS, leukemia, and melanoma are just a few of the malignancies that coumarin naturally showed antiproliferative effects on [10–11]. Coumarins are used to treat several diseases, including leukemia, renal cell carcinoma, and prostate cancer, as well as to stop tumors from spreading [12]. Coumarins' broad range of biological activities and their therapeutic

effects on a number of illnesses have drawn a lot of attention. Additionally, coumarins' solubility and stability are intriguing factors that are crucial for the creation of new drugs [13].

Microorganisms were shown to be inhibited in their proliferation by natural quinones like juglone and plumbagin [14]. Benzoquinones are crucial for bioenergetic transport and oxidative phosphorylation electron transfer pathways [15]. Quinones exhibited a variety of pharmacological characteristics, including anti-inflammatory [16], antibacterial [17], and anticancer [18–20]. Derivatives of 1,4-benzoquinone have been used as anticoagulants [27], antibacterial [21–22], anticancer [23–25], and antimalarial [26]. Many therapeutically significant antitumor medications, such as anthracyclines, mitoxantrones, and saintopin, are based on quinone scaffolds, and the anticancer effects of quinones are well documented [28].

Quinoline, which has drawn a lot of attention as a crucial element in medication development and research, has been the focus of this article. To ascertain the medical importance of quinolone hybrids as a possible therapeutic agent, it was believed to be advantageous to synthesize a particular physiologically active molecule.

Material and Methods:

All chemicals used in the experiments were of analytical reagent (AR) grade. Analytical thin-layer chromatography (TLC) was carried out on Merck pre-coated silica gel 60 F254 aluminium sheets. Proton nuclear magnetic resonance (^{1}H NMR) spectra were recorded in $CDCl_3$ on a 500 MHz spectrometer with tetramethylsilane (TMS) serving as the internal standard.

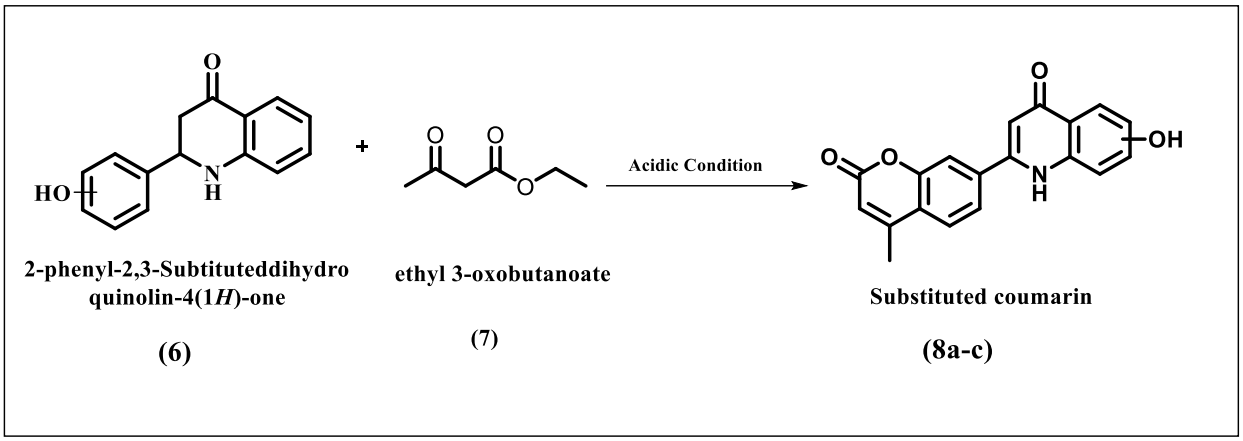
Characterization Techniques:

The structure of synthesized compounds was determined by chemical properties elemental analysis and spectral data. ^{1}H-NMR spectra were recorded on Bruker Avance Neo 500 MHz spectrometer using $CDCl_3$ solvent and TMS as internal standards at SAIF, Punjab University, Chandigarh (India). Chemical shifts are expressed in ppm. Mass spectrums were recorded on Thermo Scientific TSQ 8000 Gas Chromatogram.

Experimental:

General Reaction for synthesis of Coumarin:

A dry reaction flask with a magnetic stirrer was filled with an appropriate substituted phenolic precursor (6) (1 mmol) and ethyl acetoacetate (7) (1–1.2 mmol). After adding the proper acid catalyst, like alumina sulfuric acid, the reaction mixture was heated to around 100 °C for 30 minutes while being continuously stirred. Thin-layer chromatography (TLC) was used to track the reaction's development until the initial material was used up. Following completion, the reaction mixture was allowed to cool to ambient temperature, and if necessary, the solid catalyst was filtered off. A appropriate work-up process was used to separate the crude product, which was then purified using silica-gel column chromatography or recrystallization from ethanol. depending on the solubility and stability of the product (8a-c). The reaction conditions were adjusted as necessary according to the nature of the substituted precursor.



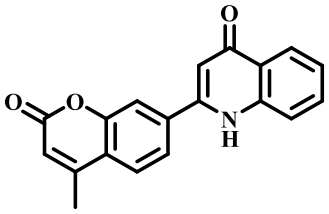
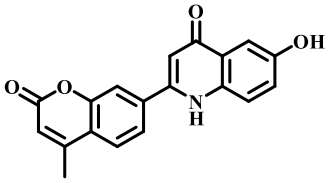
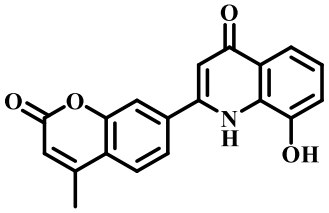
Scheme1. Synthesis of Coumarin

8a: 2-(4-methyl-2-oxo-2H-chromen-7-yl)quinolin-4(1H)-one

8b: 6-hydroxy-2-(4-methyl-2-oxo-2H-chromen-7-yl)quinolin-4(1H)-one

8c: 8-hydroxy-2-(4-methyl-2-oxo-2H-chromen-7-yl)quinolin-4(1H)-one

Table 1. Structural Analysis

Sr. No	Structure of Products	Structural analysis by ^{1}HNMR and GCMS
1	 **(a)**	**^{1}HNMR(500MHz,$CDCl_3$)**:δ 11.64 (s,1H), 7.79-7.77 (m, 2H), 7.47-6.22 (m,7H), 2.39 (s,3H) **GCMS:** Cal m/z: 303.32 Found m/z: 303.28
2	 **(b)**	**^{1}HNMR(500MHz,$CDCl_3$)**:δ 11.66 (s,1H), 9.42 (s,1H), 7.79-7.78 (m, 2H), 7.63-6.24 (m,7H), 2.39 (s,3H) **GCMS:** Cal m/z: 319.32 Found m/z: 319.29
3	 **(c)**	**^{1}HNMR(500MHz,$CDCl_3$)**:δ 11.19 (s,1H), 10.01 (s,1H), 7.79-7.76 (m, 2H), 7.46-6.25 (m,7H), 2.41 (s,3H) **GCMS:** Cal m/z: 319.32 Found m/z: 319.28

Biological Investigation:

Antibacterial Activity:

Staphylococcus aureus, Bacillus subtilis and *Escherichia coli* were among the representative Gram-positive and Gram-negative bacterial strains used to test the synthetic coumarin derivatives' in vitro antibacterial activity. Using the agar well diffusion method, the compounds' antibacterial potential was evaluated by measuring the zones of inhibition in

millimeters (mm). The solvent was utilized as a negative control and a common antibacterial agent as a positive control. To ascertain the impact of structural differences and substituent groups on antibacterial activity, the results were compared. When confirmed by experimental findings, the reported inhibitory zones can be used to find interesting coumarin compounds for more antibacterial research.

Compound	***S. aureus***	***E. coli***	***B. subtilis***	**Activity**
8a	13 mm	14 mm	12mm	Moderate
8b	17 mm	18 mm	16mm	High
8c	14 mm	15 mm	16mm	Moderate
Standard drug	22 mm	20 mm	20mm	High

Conclusion:

The synthetic series of substituted coumarin one is a promising moiety that exhibits strong antibacterial activity in the current work. Additionally, the structure's benzo ring inflection purposefully incorporates methoxy (para-OH) and hydroxyl (ortho-OH) groups over the ring. This demonstrates the robust and encouraging biological activity. In summary, our findings demonstrate potent antibacterial activity and greatly aid in the development of a structural moiety and interaction connection. Future drug design will benefit from this.

Conflict of Interest: Authors have declared that no competing interests exist.

Acknowledgement:

The authors are thankful to Author also thank to the Principal, Department of Chemistry, G.S Tompe Arts, Commerce and Science College, Chandur Bazar Dist- Amravati and Department of Chemistry, Sant, Gadge Baba Amravati University, Amravati for providing the necessary laboratory facilities. Authors are very much thankful to the Director, SAIF, Punjab University Chandigarh for providing spectral data.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Synthesis and Characterization of Substituted Chalcones from Naphthalenones with Evaluation of Antifungal Activity

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DOI - 10.5281/zenodo.24334861

Abstract:

A base-catalyzed Claisen-Schmidt condensation reaction was used to synthesize a number of substituted chalcone derivatives from naphthalenone derivatives and suitably substituted aromatic aldehydes. The synthetic method offers a practical way to synthesize structurally varied chalcones with a naphthalenone framework. In order to promote structural elucidation and evaluate compound identity, the synthesized compounds were evaluated using appropriate spectroscopic techniques, including ^{1}H NMR and GC–MS. Aspergillus niger, Aspergillus flavus and Candida albicans were among the fungus strains used to test the antifungal efficacy of the produced compounds. The goal of the study was to establish early structure-activity relationships and investigate how different aromatic substituents affect antifungal efficacy. The results could help identify interesting chalcone compounds based on naphthalenone for additional research as possible antifungal medicines.

Keywords: Naphthalenones, substituted chalcones, Claisen–Schmidt condensation, ^{1}H NMR, GC–MS, antifungal activity, structure-activity relationship.

Introduction:

Human health is increasingly at risk from fungal infections. There are numerous explanations for this, but two significant ones are the rise in HIV-positive individuals and the number of cancer patients receiving chemotherapy.[1] This has prompted researchers to look for new molecular targets for antifungal medications. Even though several new antifungal medications have been developed in the past five years, treating certain patients is still challenging.[2] Intrinsic or acquired antifungal resistance is one of the numerous causes of this.

Additionally, a large number of recently created antifungal medications have detrimental side effects. Therefore, there is a constant need for novel antifungal medications that can target fungus specifically without interfering with the host's metabolic processes. Chalcones, also known as 1,3 diaryl 2-propen-1 ones, are polyhydroxylated in the aryl rings [4,5] and are reported to have a variety of biological properties [6], such as anti-inflammatory, antibacterial, antifungal, antioxidant, and anticancer activity. [7,8] While some phenolic synthesized chalcones have antifungal characteristics, chalcones'

antibacterial capabilities are caused by a reactive unsaturated keto function in the molecule [9]. [4,10,11] Chalcones inhibit the enzymes called β(1,3) glucan and chitin synthases, which catalyze the formation of the fungal cell wall's β(1,3) glucan and chitin polymers, respectively. [12] Because they might not harm the host, chalcones and their derivatives could be a good option to research as a safe antifungal agent. The antifungal activity of a number of chalcone derivatives against the fungi *Candida albicans, Aspergillus niger* and *Aspergillus flavus* was assessed.

Material and Methods:

All chemicals used in the experiments were of analytical reagent (AR) grade. Analytical thin-layer chromatography (TLC) was carried out on Merck pre-coated silica gel 60 F254 aluminium sheets. Proton nuclear magnetic resonance (^{1}H NMR) spectra were recorded in $CDCl_3$ on a 500 MHz spectrometer with tetramethylsilane (TMS) serving as the internal standard.

Characterization Techniques:

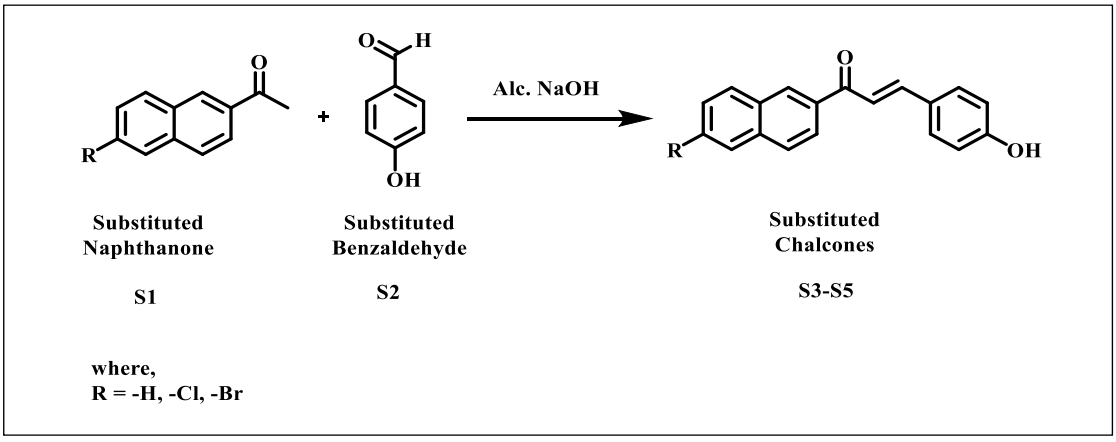
The structure of synthesized compounds was determined by chemical properties elemental analysis and spectral data. ^{1}H-NMR spectra were recorded on Bruker Avance Neo 500 MHz spectrometer using $CDCl_3$ solvent and TMS as internal standards at SAIF, Punjab University, Chandigarh (India). Chemical shifts are expressed in ppm. Mass spectrums were recorded on Thermo Scientific TSQ 8000 Gas Chromatogram.

Experimental:

Synthesis of Substituted Chalcones:

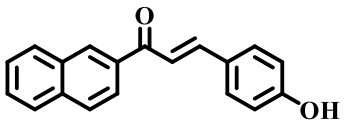
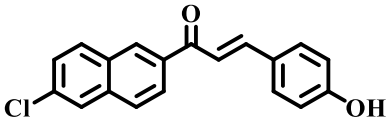
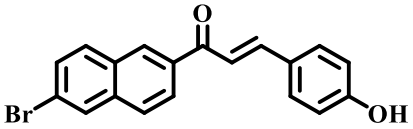
The Claisen–Schmidt condensation is widely recognized as a simple and efficient method for the synthesis of chalcones. In this procedure, equimolar quantities of Naphthalenones (S1) and benzaldehyde (S2) derivatives are subjected to reaction in the presence of aqueous alcoholic alkali.

Typically, an alkali concentration of 10–60% is employed. The reaction is usually carried out at approximately 55 °C for 14–16 hours or at ambient temperature for about one week. However, under these reaction conditions, the Cannizzaro reaction can occur as a side reaction, resulting in a decreased yield of the desired chalcone (S3-5). To suppress aldehyde disproportionation during the reaction, benzylidene-diacetate has been proposed as an appropriate alternative to aldehyde substrates.



Scheme 1. Synthesis of Substituted Chalcone

Table 1. Structural Analysis

Sr. No	Structure of Products	Structural analysis by ^{1}HNMR and GCMS
1	 **(a)**	**^{1}HNMR(500MHz,$CDCl_3$)**:δ 9.68 (s,1H), 8.40 (s, 1H), 8.10-8.06 (m, 4H), 7.83-7.45(m, 6H), 5.60(dd,2H) **GCMS:** Cal m/z: 274.32 Found m/z: 274.30
2	 **(b)**	**^{1}HNMR(500MHz,$CDCl_3$)**: δ 9.69 (s,1H), 8.41 (s, 1H), 8.11-8.09 (m, 4H), 7.84-7.49(m, 5H), 5.61(dd,2H) **GCMS: Cal m/z:** 308.76 Found m/z: 308.72
3	 **(c)**	**^{1}HNMR(500MHz,$CDCl_3$)**::δ δ 9.69 (s,1H), 8.39 (s, 1H), 8.01-8.06 (m, 4H), 7.82-7.44(m, 6H), 5.59(dd,2H) **GCMS:** Cal m/z: 353.22 Found m/z: 353.20

S3: (E)-3-(4-hydroxyphenyl)-1-(naphthalen-2-yl)prop-2-en-1-one
S4: (E)-1-(6-chloronaphthalen-2-yl)-3-(4-hydroxyphenyl)prop-2-en-1-one
S5: (E)-1-(6-bromonaphthalen-2-yl)-3-(4-hydroxyphenyl)prop-2-en-1-one

Biological Investigation of Substituted Chalcones:

Antifungal Evaluation:

Using the agar well diffusion method, the antifungal activity of the synthesized substituted chalcones was assessed against specific fungal strains, such as *Candida albicans, Aspergillus niger* and *Aspergillus flavus.* Each compound's antifungal potential was evaluated by calculating the zone of inhibition in millimeters (mm). The solvent was utilized as a negative control and fluconazole as a reference antifungal drug. The impact of various substituents on antifungal activity was examined by comparing the results.

S. No.	Compound	*C. albicans*	*A. niger*	*A. flavus*
1	S3	16 ± 0.5	18 ± 0.6	15 ± 0.5
2	S4	19 ± 0.6	22 ± 0.5	18 ± 0.6
3	S5	18 ± 0.5	20 ± 0.6	17 ± 0.5
4	Fluconazole (standard)	19 ± 0.5	24 ± 0.5	22 ± 0.5

Conclusion:

The antifungal capabilities of a number of substituted chalcone derivatives were successfully synthesized and examined in the current investigation. A useful structural motif with a great deal of potential for biological applications is the chalcone framework. Specifically, the antifungal activity changed noticeably when halogen substituents like bromine (–Br) and chlorine (–Cl) were added to the benzo-fused ring. These findings imply that the substituent's nature may affect the chalcone's biological reaction by altering its electronic and physicochemical characteristics. Overall, the

results show that substituted chalcone derivatives have the potential to be helpful structural frameworks for antifungal research and serve as a foundation for additional structural modification and study in the direction of future antimicrobial drug-design studies.

Conflict of Interest: Authors have declared that no competing interests exist.

Acknowledgement:

The authors are thankful to Author also thank to the Principal, Department of Chemistry, G.S Tompe Arts, Commerce and Science College, Chandur Bazar Dist- Amravati and Department of Chemistry, Sant, Gadge Baba Amravati University, Amravati for providing the necessary laboratory facilities. Authors are very much thankful to the Director, SAIF, Punjab University Chandigarh for providing spectral data.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

रावेर तालुक्यातील मोटार वाहन विमा ग्राहकांच्या जागरूकता पातळी व समाधानाचे एक विश्लेषणात्मक अध्ययन

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DOI - 10.5281/zenodo.24334898

सारांश:

मोटार वाहन विमा सेवांबाबत ग्राहकांची जागरूकता आणि समाधान यांचे मूल्यमापन करण्यासाठी रावेर तालुक्यातील 50 विमाधारक ग्राहकांची स्वतंत्र पूर्वचाचणी करण्यात आली. मुख्य पीएच.डी. संशोधनातील 850 प्रतिसादकांचा या विश्लेषणात समावेश नाही. प्रश्नावलीतील जागरूकता आणि समाधान या प्रश्नसमूहांच्या पाच-बिंदू मापनश्रेणीवरील प्रतिसादांपासून समान वजनाचे संयुक्त सरासरी गुण तयार करण्यात आले. विश्लेषणासाठी वर्णनात्मक सांख्यिकी, माहितीच्या विश्लेषणासाठी क्रॉनबॅक अल्फा आणि तटस्थ मूल्य ३ विरुद्ध वन-टेल्ड वन-सॅम्पल टी-टेस्ट वापरण्यात आली.

जागरूकतेची सरासरी 3.684 (SD = 0.695; क्रॉनबॅक अल्फा = 0.8424), तर समाधानाची सरासरी 3.467 (SD = 0.816; क्रॉनबॅक अल्फा = 0.7910) आढळली. दोन्ही सरासरी तटस्थ पातळीपेक्षा सांख्यिकीयदृष्ट्या लक्षणीय अधिक होत्या (जागरूकता: $t(49) = 6.956$, $p < .001$; समाधान: $t(49) = 4.041$, $p < .001$). त्यामुळे दोन्ही गृहीतकांना प्राथमिक सांख्यिकीय समर्थन मिळाले. तथापि, निष्कर्ष प्रतिसादांवर आणि मर्यादित सोयीस्कर नमुन्यावर आधारित असल्याने संपूर्ण रावेर तालुक्यासाठी सामान्यीकृत करता येत नाहीत. तसेच क्रॉनबॅक अल्फा वरून प्रश्नावलीची संपूर्ण वैधता सिद्ध होत नाही.

मुख्यशब्द: मोटार वाहन विमा, ग्राहक जागरूकता, ग्राहक समाधान, प्रश्नावलीची पूर्वचाचणी, रावेर तालुका.

प्रस्तावना:

वाहनाचा वापर करताना अपघात, वाहनाचे नुकसान आणि तृतीय पक्षाप्रती दायित्व यांमुळे आर्थिक जोखीम उद्भवू शकते. मोटार वाहन विमा पॉलिसीच्या अटी, संरक्षणाची व्याप्ती आणि मर्यादांनुसार या जोखमींपासून आर्थिक संरक्षण मिळण्यास मदत होते. विम्यासंबंधी ग्राहकांचा अनुभव पॉलिसी खरेदीपुरता मर्यादित नसून माहिती मिळविणे, नूतनीकरण, दावा नोंदणी आणि तक्रार निवारण यांसारख्या सेवांशीही संबंधित असतो. म्हणून विमा सेवांच्या संदर्भात ग्राहकांची जागरूकता आणि समाधान यांचा अभ्यास महत्त्वाचा ठरतो.

ग्राहक जागरूकतेमध्ये पॉलिसीचा प्रकार, संरक्षण मिळणाऱ्या व न मिळणाऱ्या बाबी, दावा प्रक्रिया आणि तक्रार निवारण व्यवस्था यांविषयी ग्राहकांचे स्वमूल्यमापन विचारात घेतले जाते. या प्रतिसादांतून ग्राहक स्वतःला कितपत जागरूक मानतात हे समजू शकते; मात्र त्यावरून त्यांच्या वस्तुनिष्ठ विमाविषयक ज्ञानाची पडताळणी होत नाही.ग्राहक समाधानामध्ये पॉलिसी खरेदी किंवा

नूतनीकरणाच्या वेळी मिळालेल्या सेवा, विमा कंपनीशी संवाद आणि एकूण सेवा-अनुभवांविषयीचे ग्राहकांचे मूल्यमापन महत्त्वाचे ठरते. ग्राहकांच्या अपेक्षा आणि प्रत्यक्ष अनुभवांवर आधारित या प्रतिसादांमधून विमा कंपन्यांच्या सेवांविषयीचे त्यांचे मत समजते; मात्र याला स्वतंत्रपणे तपासलेली प्रत्यक्ष सेवागुणवत्ता मानता येत नाही.

या पार्श्वभूमीवर जळगाव जिल्ह्यातील 15 तालुक्यांचा समावेश असलेल्या मुख्य पीएच.डी. संशोधनापूर्वी रावेर तालुक्यातील 50 मोटार वाहन विमाधारक ग्राहकांची स्वतंत्र पूर्वचाचणी करण्यात आली. मुख्य संशोधनातील 850 प्रतिसादकांमध्ये या पूर्वचाचणीतील ग्राहकांचा समावेश नाही. प्रस्तुत लेखात प्रश्नावलीत जागरूकतेसाठी आणि समाधानासाठी काही प्रश्न विचारले गेले आहे. या प्रश्नांवरील प्राथमिक प्रतिसादांचे स्वरूप आणि अंतर्गत सुसंगतता तपासून मुख्य संशोधनातील संबंधित मापनघटकांच्या मूल्यमापनासाठी प्राथमिक संदर्भ मिळविणे हा पूर्वचाचणीचा उद्देश आहे. पूर्वचाचणीच्या या निष्कर्षांवरून संपूर्ण प्रश्नावलीची वैधता किंवा रावेर तालुक्यातील सर्व ग्राहकांचे प्रतिनिधित्व सिद्ध होत नाही.

संशोधनाची पार्श्वभूमी व साहित्याचे पुनर्विलोकन:

मोटार वाहन विम्याच्या अभ्यासात आर्थिक संरक्षणाबरोबरच पॉलिसीविषयक जागरूकता आणि विमा कंपन्यांकडून मिळणाऱ्या सेवांविषयीचे ग्राहक समाधान महत्त्वाचे ठरते. प्रस्तुत अभ्यासात या दोन मापनघटकांचा स्वतंत्रपणे विचार करण्यात आला आहे.

1. Mallik & Suhaib (2018): यांनी कर्नाटकातील शिवमोग्गा शहरात यूनायटेड इंडिया इन्शुरेंस च्या 150 कार विमाधारकांची जागरूकता अभ्यासली. सर्वसाधारण जागरूकता असूनही काही ग्राहकांना पॉलिसीच्या अटी, शर्ती आणि घोषित विमामूल्याविषयी पुरेशी माहिती नसल्याचे आढळले. यावरून पॉलिसीची ओळख आणि तिच्या विशिष्ट तरतुदींचे ज्ञान यांतील फरक स्पष्ट होतो.

2. Kitunzi & सहकारी (2016): यांनी युगांडातील कंपाला जिल्ह्यातील 384 वाहनचालकांचा अभ्यास केला. तृतीय-पक्ष मोटार विम्यातील अधिकार आणि अपघातानंतरच्या जबाबदाऱ्यांविषयी माहितीचा अभाव आढळला. तसेच अपघातात सहभागी झालेल्या अनेक वाहनचालकांनी भरपाईसाठी दावा केला नव्हता.

3. Singla & Sawhney (2023): यांनी पंजाबमधील मोटार विम्याचे दावे केलेल्या 400 पॉलिसीधारकांचा अभ्यास केला. विश्वास, बांधिलकी, संवाद आणि मतभेद हाताळण्याची पद्धत या घटकांचा दावा निवारणाविषयीच्या समाधानाशी सकारात्मक व सांख्यिकीयदृष्ट्या लक्षणीय संबंध आढळला.

4. Kulkarni (2018): यांनी जळगाव शहरातील 100 प्रतिसादकांच्या तरुणकेंद्रित नमुन्यात वाहन विमा सेवांविषयीच्या धारणा अभ्यासल्या. समाधानाच्या पातळ्यांमध्ये विविधता आढळली; तसेच काही प्रतिसादकांनी माहितीची उपलब्धता आणि सेवेच्या तत्परतेबाबत असमाधान व्यक्त केले. मात्र सर्व प्रतिसादक विमाधारक नसल्यामुळे हे निष्कर्ष विमाधारक ग्राहकांना थेट लागू करता येत नाहीत.

5. Van Teijlingen & Hundley (2001): यांनी मुख्य संशोधनापूर्वी प्रश्नावलीची शब्दरचना, प्रश्नक्रम, उत्तरपर्याय आणि माहिती संकलनाची व्यवहार्यता तपासण्यासाठी पूर्वचाचणीचे महत्त्व स्पष्ट केले. पूर्वचाचणी संभाव्य अडचणी ओळखण्यास उपयुक्त असली, तरी ती मुख्य संशोधनाच्या यशाची हमी देत नाही.

वरील अभ्यास मोटार विम्याविषयीची जागरूकता, ग्राहक समाधान आणि पूर्वचाचणीचे महत्त्व स्पष्ट करतात.

तथापि, अभ्यासक्षेत्र, नमुने व मापनघटक भिन्न असल्यामुळे त्यांचे निष्कर्ष रावेर तालुक्याला थेट लागू करता येत नाहीत. या पार्श्वभूमीवर प्रस्तुत 50 प्रतिसादकांची पूर्वचाचणी स्थानिक जागरूकता व समाधानाच्या प्राथमिक मूल्यमापनासाठी उपयुक्त ठरते.

संशोधनाची उद्दिष्टे:

O1. रावेर तालुक्यातील मोटार वाहन विमाधारक ग्राहकांच्या मोटार वाहन विम्याबाबतच्या जागरूकतेचा प्राथमिक अभ्यास करणे.

O2. रावेर तालुक्यातील मोटार वाहन विमाधारक ग्राहकांचे विमा कंपन्यांद्वारे पुरवल्या जाणाऱ्या सेवांबाबतचे समाधान प्राथमिक स्वरूपात अभ्यासणे.

संशोधनाची गृहीतके:

H1. रावेर तालुक्यातील पूर्वचाचणी अभ्यासातील मोटार वाहन विमाधारक ग्राहकांची मोटार वाहन विम्याबाबतची जागरूकता तटस्थ पातळीपेक्षा अधिक आहे.

H2. रावेर तालुक्यातील पूर्वचाचणी अभ्यासातील मोटार वाहन विमाधारक ग्राहकांचे विमा कंपन्यांद्वारे पुरवल्या जाणाऱ्या सेवांबाबतचे समाधान तटस्थ पातळीपेक्षा अधिक आहे.

संशोधन कार्यपद्धती:

प्रस्तुत अभ्यास हा मुख्य पीएच.डी. संशोधनापूर्वी करण्यात आलेला स्वतंत्र, वर्णनात्मक पूर्वचाचणी अभ्यास आहे. फेब्रुवारी 2024 मध्ये जळगाव जिल्ह्यातील रावेर तालुक्यातील 50 मोटार वाहन विमाधारक ग्राहकांची गैर-संभाव्यता सोयीस्कर नमुना निवड पद्धतीने निवड करण्यात आली. उपलब्ध व स्वेच्छेने सहभागी झालेल्या वैयक्तिक दुचाकी आणि खासगी चारचाकी ग्राहकांना प्रत्यक्ष भेटून 44 प्रश्नांची संरचित मराठी प्रश्नावली भरून घेण्यात आली.

या लेखात ग्राहक जागरूकतेसाठी आणि ग्राहक समाधानासाठी काही प्रश्नांचा वापर करण्यात आला.दोन्ही घटकांचे मापन संबंधित पाच-बिंदू मापनश्रेणीद्वारे करण्यात आले. तटस्थ मूल्य 3 ठेवून प्रत्येक प्रतिसादकाचे संयुक्त गुण संबंधित प्रश्नांच्या समान वजनाच्या सरासरीने काढण्यात आले.

माहितीच्या विश्लेषणासाठी वारंवारता, टक्केवारी, सरासरी आणि नमुना प्रमाणविचलन वापरण्यात आले. प्रश्नसमूहांच्या प्राथमिक अंतर्गत सुसंगततेसाठी क्रॉनबॅक अल्फा आणि H1 व H2 या गृहीतकांच्या परीक्षणासाठी तटस्थ मूल्य 3 विरुद्ध स्वतंत्र एक-बाजूची वन-सॅम्पल टी-टेस्ट वापरण्यात आली ($N = 50, df = 49, \alpha = 0.05$).

प्रश्नावलीचे स्वरूप आणि पूर्वचाचणीची प्रक्रिया:

पूर्वचाचणीसाठी वापरलेल्या संरचित मराठी प्रश्नावलीत एकूण 44 प्रश्न होते. त्यामध्ये प्रतिसादकांची वैयक्तिक माहिती, गाव, वाहन व विमा पॉलिसीचे तपशील , जागरूकता, अपेक्षा , सेवा-वापर व अनुभव,वचनबद्धता व प्रत्यक्ष कामगिरीचे मूल्यमापन, ग्राहक समाधान , तसेच डिजिटल सेवा, दावा व तक्रार अनुभव आणि सामाजिक-आर्थिक संरक्षणाविषयी धारणा यांचा समावेश होता.'कोणत्या सेवा प्रत्यक्ष वापरल्या आहेत?'

या प्रश्न मध्ये एकापेक्षा अधिक पर्याय निवडता येत होते, तर काही ठिकाणी होय/नाही उत्तरांनुसार संबंधित पुढील प्रश्न लागू होत होते.

प्रस्तुत लेखात जागरूकतेसाठी(1= पूर्णपणे असहमत ते 5= पूर्णपणे सहमत) आणि ग्राहक समाधानासाठी (1= अत्यंत असमाधानी ते 5= अत्यंत समाधानी) वापरण्यात आले. दोन्ही मापनश्रेणींचे तटस्थ मूल्य 3 होते. फेब्रुवारी 2024 मध्ये रावेर

तालुक्यातील 50 उपलब्ध व स्वेच्छेने सहभागी झालेल्या विमाधारक ग्राहकांना प्रत्यक्ष भेटून प्रश्नावली भरून घेण्यात आली. प्राप्त प्रतिसादांचा उपयोग निवडलेल्या मापनघटकांच्या प्राथमिक परीक्षणासाठी करण्यात आला.

रावेर तालुक्यात केलेल्या स्वतंत्र पूर्वचाचणीतील 50 प्रतिसादांचे वर्णनात्मक विश्लेषण पुढे दिले आहे. लिंग, वाहनप्रकार, जागरूकता आणि समाधानाशी संबंधित सर्व प्रश्नांसाठी वैध प्रतिसाद 50 असून अपूर्ण किंवा श्रेणीबाह्य नोंदी आढळल्या नाहीत.

प्राथमिक माहितीचे सांख्यिकीय विश्लेषण आणि तक्ते:

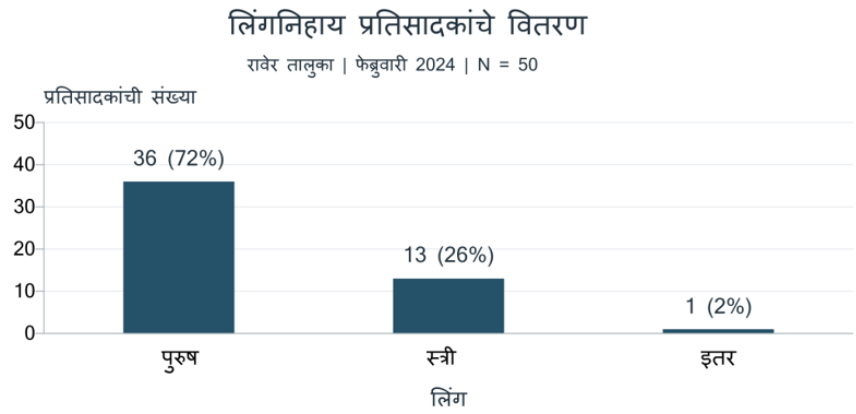
प्रतिसादकांची प्राथमिक माहिती:

तक्ता 1 — प्रतिसादकांची प्राथमिक माहिती

घटक	गट	संख्या	टक्केवारी
लिंग	पुरुष	36	72.0
	स्त्री	13	26.0
	इतर	1	2.0
लिंग	**एकूण**	**50**	**100.0**
वाहनप्रकार	दुचाकी	34	68.0
	चारचाकी	16	32.0
वाहनप्रकार	**एकूण**	**50**	**100.0**

स्रोत : प्राथमिक क्षेत्रीय माहिती, रावेर तालुका

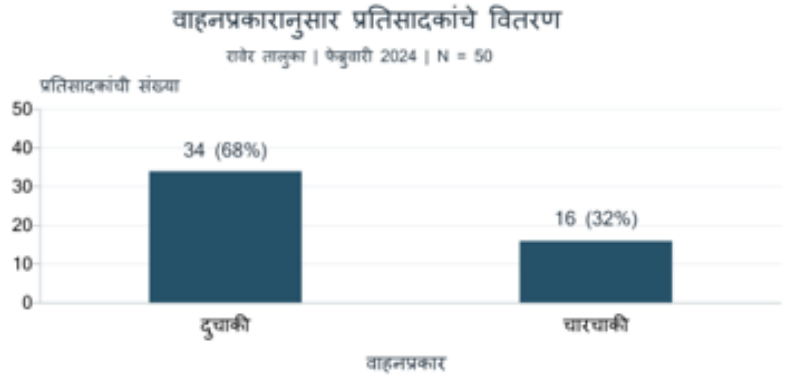
आलेख 1 — लिंगनिहाय प्रतिसादकांचे वितरण



स्रोत : प्राथमिक क्षेत्रीय माहिती, रावेर तालुका

आलेख 1 नुसार पूर्वचाचणीतील 50 प्रतिसादकांपैकी 36 पुरुष (72.0%), 13 स्त्रिया (26.0%) आणि 1 इतर गटातील प्रतिसादक (2.0%) आहे. या नमुन्यात पुरुषांचे प्रमाण सर्वाधिक आहे. इतर गटाचा सहभाग एका प्रतिसादकापुरता मर्यादित आहे.

आलेख 2 — वाहनप्रकारानुसार प्रतिसादकांचे वितरण



स्रोत : प्राथमिक क्षेत्रीय माहिती, रावेर तालुका, फेब्रुवारी 2024 (N=50).

आलेख 2 नुसार नमुन्यात दुचाकी मोटार विमाधारक ग्राहकांची संख्या 34 (68.0%) असून, खासगी चारचाकी ग्राहकांची संख्या 16 (32.0%) आहे. दोन्ही वाहनगटांचा समावेश असला, तरी त्यांचे नमुन्यातील प्रमाण समान नाही. हे वितरण पूर्वचाचणीतील सहभागी ग्राहकांपुरते मर्यादित आहे.

ग्राहक जागरूकता:

तक्ता 2 — ग्राहक जागरूकता (Q11–Q15)

प्रश्न	1	2	3	4	5	सरासरी	नमुना SD
Q11	0 (0.0%)	3 (6.0%)	18 (36.0%)	17 (34.0%)	12 (24.0%)	3.760	0.894
Q12	0 (0.0%)	4 (8.0%)	12 (24.0%)	23 (46.0%)	11 (22.0%)	3.820	0.873
Q13	2 (4.0%)	4 (8.0%)	19 (38.0%)	19 (38.0%)	6 (12.0%)	3.460	0.952
Q14	0 (0.0%)	2 (4.0%)	17 (34.0%)	20 (40.0%)	11 (22.0%)	3.800	0.833
Q15	1 (2.0%)	2 (4.0%)	22 (44.0%)	17 (34.0%)	8 (16.0%)	3.580	0.883

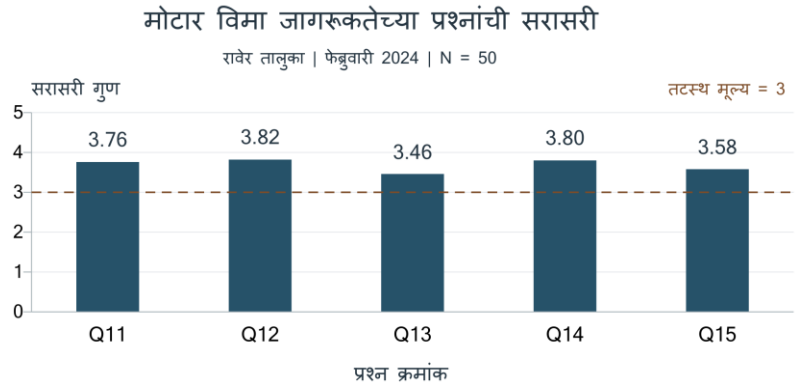
स्रोत : प्राथमिक क्षेत्रीय माहिती, रावेर तालुका

टीप : प्रत्येक रकान्यात वारंवारता व कंसात टक्केवारी दिली आहे.

प्रश्नांचा आशय : Q11 पॉलिसीचा प्रकार; Q12 संरक्षण मिळणारे नुकसान; Q13 संरक्षण न मिळणाऱ्या प्रमुख बाबी; Q14 दावा नोंदणी; Q15 तक्रार नोंदणी.

सहमत किंवा पूर्णपणे सहमत प्रतिसादांचे प्रमाण Q12 मध्ये सर्वाधिक 68.0% आहे. Q13 आणि Q15 मध्ये हे प्रमाण प्रत्येकी 50.0% आहे. Q15 मध्ये तटस्थ प्रतिसादांचे प्रमाण 44.0% असल्यामुळे सर्व प्रतिसादकांची जागरूकता सारखी असल्याचे मानता येत नाही.

आलेख 3 — मोटार विमा जागरूकतेच्या प्रश्नांची सरासरी



स्रोत : प्राथमिक क्षेत्रीय माहिती, रावेर तालुका

आलेख 3 मध्ये पॉलिसीअंतर्गत कोणत्या नुकसानाला विमासंरक्षण मिळते याविषयीच्या Q12 ची सरासरी सर्वाधिक 3.82 आहे. विमासंरक्षण न मिळणाऱ्या प्रमुख बाबींविषयीच्या Q13 ची सरासरी सर्वात कमी 3.46 आहे. दावा कसा नोंदवायचा याविषयी Q14 ची सरासरी 3.80, पॉलिसीच्या प्रकाराविषयी Q11 ची 3.76 आणि तक्रार कशी नोंदवायची याविषयी Q15 ची 3.58 आहे. सर्व सरासरी तटस्थ मूल्य 3 पेक्षा अधिक, परंतु सहमती दर्शविणाऱ्या 4 या गुणापेक्षा कमी आहेत. वर्णनात्मक पातळीवर संरक्षणाच्या अपवादांबाबत आणि तक्रार नोंदणीबाबत तुलनेने कमी सहमती दिसते.त्यामुळे सरासरींच्या आधारे प्रत्येक ग्राहकाला संबंधित बाबींचे अचूक ज्ञान आहे, असे मानता येत नाही.

ग्राहक समाधान:

तक्ता 3 — ग्राहक समाधान (Q30–Q32)

प्रश्न	1	2	3	4	5	सरासरी	नमुना SD
Q30	2 (4.0%)	5 (10.0%)	17 (34.0%)	19 (38.0%)	7 (14.0%)	3.480	0.995
Q31	2 (4.0%)	8 (16.0%)	15 (30.0%)	18 (36.0%)	7 (14.0%)	3.400	1.050
Q32	1 (2.0%)	4 (8.0%)	18 (36.0%)	22 (44.0%)	5 (10.0%)	3.520	0.863

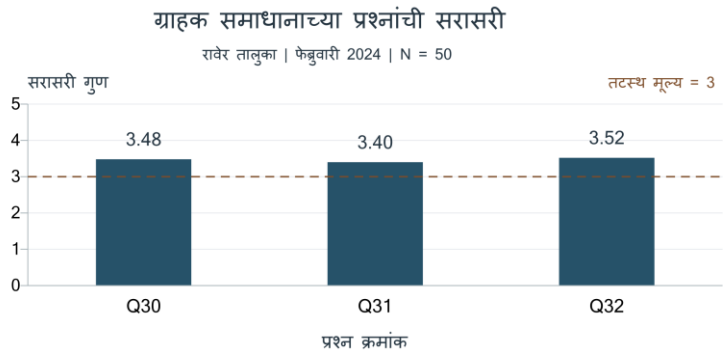
स्रोत : प्राथमिक क्षेत्रीय माहिती, रावेर तालुका

टीप : प्रत्येक रकान्यात वारंवारता व कंसात टक्केवारी दिली आहे.

प्रश्नांचा आशय : Q30 पॉलिसी खरेदी/नूतनीकरण व नियमित सेवा; Q31 कंपनीसोबत संवाद; Q32 कंपनीच्या एकूण सेवा.

समाधानी किंवा अत्यंत समाधानी प्रतिसादांचे प्रमाण Q30, Q31 आणि Q32 साठी अनुक्रमे 52.0%, 50.0% आणि 54.0% आहे. असमाधानी प्रतिसादांच्या दोन्ही श्रेणी एकत्रित केल्यास Q31 मध्ये त्यांचे प्रमाण सर्वाधिक 20.0% आहे.

आलेख 4 — ग्राहक समाधानाच्या प्रश्नांची सरासरी



स्रोत : प्राथमिक क्षेत्रीय माहिती, रावेर तालुका

आलेख 4 नुसार विमा कंपनीच्या एकूण सेवांबाबतच्या Q32 ची सरासरी 3.52 असून ती तीन प्रश्नांमध्ये सर्वाधिक आहे. पॉलिसी खरेदी किंवा नूतनीकरण व नियमित सेवांबाबतच्या Q30 ची सरासरी 3.48 आहे. कंपनीसोबत झालेल्या संवादाबाबतच्या Q31 ची सरासरी सर्वात कमी 3.40 आहे. एकूण सेवा आणि संवाद यांतील वर्णनात्मक फरक 0.12 गुणांचा आहे. तिन्ही सरासरी तटस्थ मूल्य 3 पेक्षा अधिक, मात्र समाधानी दर्शविणाऱ्या 4 या गुणापेक्षा कमी आहेत. त्यामुळे नमुन्यात समाधानाकडे झुकणारे प्रतिसाद दिसतात; सर्व ग्राहक समाधानी आहेत असे म्हणता येत नाही.

संयुक्त मापनघटकांची वर्णनात्मक तुलना:

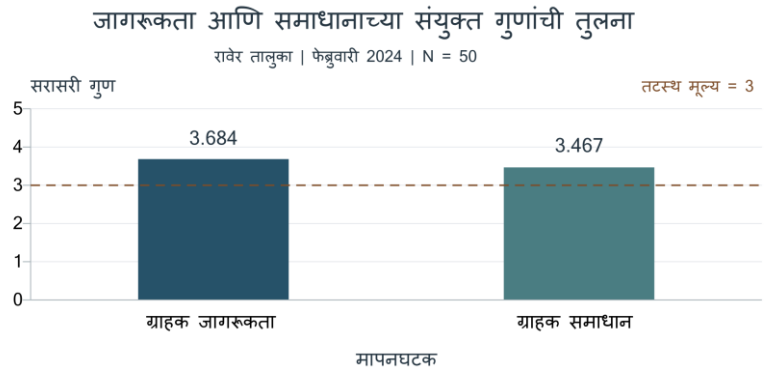
तक्ता 4 — संयुक्त मापनघटकांची तुलना

मापनघटक	वैध N	प्रश्नसंख्या	संयुक्त सरासरी	नमुना SD	तटस्थ मूल्य
ग्राहक जागरूकता	50	5	3.684	0.695	3
ग्राहक समाधान	50	3	3.467	0.816	3

स्रोत : प्राथमिक क्षेत्रीय माहिती, रावेर तालुका

टीप : जागरूकतेचा संयुक्त गुण Q11–Q15 च्या आणि समाधानाचा संयुक्त गुण Q30–Q32 च्या समान वजनाच्या सरासरीने प्रत्येक प्रतिसादकासाठी काढला आहे. नमुना SD या 50 संयुक्त गुणांवरून n−1 या भाजकासह काढला आहे; तो प्रश्ननिहाय प्रमाणविचलनांची सरासरी नाही.जागरूकतेचे नमुना प्रमाणविचलन 0.695 & समाधानाचे 0.816 आहे.त्यामुळे नमुन्यात समाधानाच्या संयुक्त गुणांमध्ये जागरूकतेपेक्षा अधिक विखुरलेपणा दिसतो. हा प्रतिसादांतील बदलाचा वर्णनात्मक निर्देश आहे

आलेख 5 — जागरूकता आणि ग्राहक समाधानाच्या संयुक्त गुणांची तुलना



स्रोत : प्राथमिक क्षेत्रीय माहिती, रावेर तालुका.

आलेख 5 मध्ये ग्राहक जागरूकतेची संयुक्त सरासरी 3.684 आणि ग्राहक समाधानाची संयुक्त सरासरी 3.467 आहे. या सरासरी संबंधित प्रश्नांवरील समान वजनाच्या प्रतिसादकनिहाय सरासरी गुणांवर आधारित आहेत. दोन्ही मूल्ये तटस्थ पातळी 3 पेक्षा अधिक असून, जागरूकतेची सरासरी समाधानापेक्षा सुमारे 0.217 गुणांनी अधिक आहे. हा फरक केवळ वर्णनात्मक आहे; जागरूकतेची सहमती श्रेणी आणि समाधानाची समाधान श्रेणी भिन्न आशय मोजतात, म्हणून समान संख्यात्मक श्रेणी असूनही त्यांचा अर्थ एकसारखा नाही. ही तुलना पूर्वचाचणीतील ग्राहकांच्या प्रतिसादांपुरती मर्यादित आहे.या वर्णनात्मक विश्लेषणातून पूर्वचाचणीतील प्रतिसादांचे वितरण & दोन्ही मापनघटकांवरील प्राथमिक प्रवृत्ती स्पष्ट होतात.

मापनघटकांचे विश्वासार्हता परीक्षण:

ग्राहक जागरूकता आणि ग्राहक समाधान या प्रश्नसमूहांची प्राथमिक अंतर्गत सुसंगतता तपासण्यासाठी क्रॉनबॅक अल्फा वापरण्यात आला. दोन्ही मापनघटकांसाठी पूर्वचाचणीतील 50 प्रतिसादकांच्या उत्तरांवर स्वतंत्र गणना करण्यात आली.

तक्ता 5 — मापनघटकांचे विश्वासार्हता परीक्षण

मापनघटक	प्रश्न क्रमांक	प्रश्नसंख्या	N	क्रॉनबॅक अल्फा	अर्थनिर्णयन
ग्राहक जागरूकता	Q11–Q15	5	50	0.8424	चांगली अंतर्गत सुसंगतता
ग्राहक समाधान	Q30–Q32	3	50	0.7910	समाधानकारक अंतर्गत सुसंगतता

स्रोत : प्राथमिक क्षेत्रीय माहिती, रावेर तालुका

तक्ता 5 नुसार जागरूकतेचा क्रॉनबॅक अल्फा 0.8424 आणि समाधानाचा 0.7910 असून, दोन्ही प्रश्नसमूहांची प्राथमिक अंतर्गत सुसंगतता स्वीकारार्ह आहे. त्यामुळे संबंधित प्रश्नांच्या संयुक्त गुणांच्या वापरास प्राथमिक विश्वासार्हतेचा आधार मिळतो. तथापि, हे निष्कर्ष केवळ अंतर्गत सुसंगततेशी संबंधित असून, त्यांवरून संपूर्ण प्रश्नावलीची वैधता सिद्ध होत नाही.

गृहीतकांचे परीक्षण:

ग्राहक जागरूकता आणि ग्राहक समाधान यांच्या समान वजनाच्या संयुक्त गुणांवर H1 व H2 तपासण्यासाठी तटस्थ मूल्य 3 विरुद्ध स्वतंत्र वन-टेल्ड वन-सॅम्पल टी-टेस्ट वापरण्यात आली.

तक्ता 6 — गृहीतकांच्या सांख्यिकीय परीक्षणाचे निष्कर्ष

गृहीतक	मापनघटक	N	Mean	Sample SD	t(49)	p-value (एक-बाजूचे)	निर्णय
H1	ग्राहक जागरूकता	50	3.684	0.695	6.956	$p < .001$	H_0 नाकारले; H1 ला प्राथमिक समर्थन
H2	ग्राहक समाधान	50	3.467	0.816	4.041	$p < .001$	H_0 नाकारले; H2 ला प्राथमिक समर्थन

टीप : चाचणी मूल्य = 3; $\alpha = .05$; $df = 49$. दोन्ही चाचण्यांसाठी $H_0 : \mu \leq 3$ आणि $H_a : \mu > 3$.

स्रोत : प्राथमिक क्षेत्रीय माहिती, रावेर तालुका

H1 — ग्राहक जागरूकता: अर्थनिर्णयन

जागरूकतेची संयुक्त सरासरी 3.684 असून ती तटस्थ मूल्यापेक्षा अधिक आहे. तक्ता 6 मधील निकालानुसार H_0 नाकारण्यात आले आणि H1 ला प्राथमिक सांख्यिकीय समर्थन मिळाले. हा निष्कर्ष ग्राहकांच्या जागरूकतेपुरता मर्यादित असून, त्यावरून त्यांचे वस्तुनिष्ठ विमाविषयक ज्ञान सिद्ध होत नाही.

H2 — ग्राहक समाधान: अर्थनिर्णयन

ग्राहक समाधानाची संयुक्त सरासरी 3.467 असून ती तटस्थ मूल्यापेक्षा अधिक आहे. चाचणीच्या निकालानुसार H_0 नाकारण्यात आले आणि H2 ला प्राथमिक सांख्यिकीय समर्थन मिळाले. हे मापन ग्राहकांच्या समाधानावर आधारित आहे; प्रत्यक्ष सेवागुणवत्तेचे स्वतंत्र प्रमाणीकरण नाही.समाधानाच्या संयुक्त गुणांसाठी Shapiro–Wilk चाचणीत सामान्यतेपासून विचलनाचा संकेत आढळला ($W = 0.952$, $p = .042$). तटस्थ मूल्य 3 शी केलेल्या पूरक एक-बाजूच्या Wilcoxon Signed-Rank चाचणीचा परिणामही सकारात्मक दिशेचा होता ($p < .001$). ही चाचणी सरासरीची चाचणी करणाऱ्या t-चाचणीपेक्षा वेगळा परीक्षणाधार वापरते. दोन्ही गृहीतकांना मिळालेले समर्थन हे सोयीस्कर पद्धतीने निवडलेल्या 50 प्रतिसादकांच्या मर्यादेत समजावे. या निष्कर्षांचे संपूर्ण रावेर तालुक्यातील विमाधारक ग्राहकांसाठी सामान्यीकरण करता येत नाही.

निष्कर्ष:

रावेर तालुक्यातील 50 मोटार वाहन विमाधारक ग्राहकांच्या स्वतंत्र पूर्वचाचणीत ग्राहक जागरूकता (सरासरी 3.684) आणि समाधान (सरासरी 3.467) या दोन्हींच्या संयुक्त सरासऱ्या तटस्थ मूल्य 3 पेक्षा सांख्यिकीयदृष्ट्या लक्षणीय अधिक आढळल्या. त्यामुळे H1 व H2 या गृहीतकांना प्राथमिक सांख्यिकीय समर्थन मिळाले. जागरूकतेमध्ये विमा-संरक्षणाविषयीच्या Q12 ची सरासरी सर्वाधिक, तर संरक्षणातील अपवादांविषयीच्या Q13 ची सर्वात कमी होती. समाधानामध्ये एकूण सेवांविषयीच्या Q32 ची सरासरी सर्वाधिक, तर कंपनीशी संवादाबाबतच्या Q31 ची सर्वात कमी आढळली. हे फरक वर्णनात्मक स्वरूपाचे असून, त्यांवरून प्रत्यक्ष ज्ञानातील कमतरता किंवा सेवांमधील दोष सिद्ध होत नाहीत.

जागरूकता (क्रॉनबॅक अल्फा = 0.8424) आणि समाधान (क्रॉनबॅक अल्फा = 0.7910) या प्रश्नसमूहांची प्राथमिक अंतर्गत सुसंगतता स्वीकारार्ह आढळली. पूर्वचाचणीनंतर मुख्य पीएच.डी. संशोधनातील ८५० प्रतिसादकांसाठी वापरलेल्या प्रश्नावलीत कोणताही बदल करण्यात आला नाही. तथापि, यावरून प्रश्नावलीची संपूर्ण वैधता सिद्ध होत नाही. तसेच सोयीस्कर नमुना निवड आणि स्व-अहवालित प्रतिसादांमुळे हे निष्कर्ष संपूर्ण रावेर तालुक्यातील विमाधारक ग्राहकांसाठी सामान्यीकृत करता येत नाहीत.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Spatial Analysis of Access to Basic Amenities among Scheduled Tribes in Raver Tehsil, Jalgaon District (Maharashtra)

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DOI - 10.5281/zenodo.24334926

Abstract:

Basic amenities are crucial for people and essential for their development, as they significantly influence a community's standard of living, health, education, and socio-economic status. Scheduled Tribes (STs) living in rural and tribal areas often face disparities in accessing essential services such as safe drinking water, sanitation, electricity, housing, transportation, healthcare, and educational facilities. In the Raver tehsil of Jalgaon district, Maharashtra, there is a large population of Scheduled Tribes, most of whom reside in geographically scattered rural settlements. Despite the implementation of various government initiatives, disparities in the availability of and access to basic amenities continue to affect the standard of living of tribal families.

The purpose of this study is to evaluate the status of basic amenities available to Scheduled Tribe families in Raver tehsil. The study is primarily based on household-level data collected through structured questionnaires; additionally, secondary data from the Census of India, government publications, and other relevant sources have been utilized. The objective is to identify existing gaps in the provision of infrastructure and services and to propose strategic recommendations for improving the standard of living of the tribal population.

It is expected that the findings from this study will help in understanding disparities in rural infrastructure and facilitate evidence-based planning for inclusive tribal development. Furthermore, the study emphasizes the necessity of ensuring equitable access to basic amenities as a vital component of sustainable human development in tribal regions.

Keywords: Scheduled Tribes, Basic Amenities, Human Development, Rural Infrastructure, Drinking Water, Sanitation, Housing, Raver Tehsil.

Introduction:

Basic amenities refer to the public services essential for leading a healthy and productive life. The availability of these amenities facilitates poverty reduction, educational progress, a decrease in the incidence of disease, and an overall boost to human development. The availability of basic amenities is a crucial component of human well-being, as it directly impacts health, education, productivity, and the overall quality of life. Families with access to safe drinking water, sanitation facilities, electricity, quality housing, transportation, healthcare, and educational facilities generally enjoy a better standard of living and gain access to greater socio-economic opportunities.

The Scheduled Tribe population in India represents one of the most socially and economically disadvantaged segments of society. Historically, as tribal communities inhabit forest-

covered, hilly, and geographically remote regions, the level of physical infrastructure and public services in these areas has remained relatively underdeveloped. Despite the implementation of constitutional safeguards and various development programs by the central and state governments, a significant disparity persists between tribal and non-tribal populations regarding access to essential services. Geographical remoteness and limited institutional support are the primary reasons for this, making it difficult to avail the benefits of public amenities.

Initiatives such as the Rural Drinking Water Programme, sanitation drives, rural electrification, rural housing schemes, all-weather road connectivity projects, and the 'Jal Jeevan Mission' have led to a significant expansion of infrastructure across many parts of the country. However, there are notable regional disparities regarding the availability, quality, and regularity of these services. Maharashtra has a significant tribal population, primarily distributed across the districts of Nandurbar, Dhule, Nashik, Palghar, Gadchiroli, Chandrapur, Amravati, and Jalgaon. Within Jalgaon district, the tribal population is concentrated particularly in the Raver, Yawal, and Chopda tehsils. Raver tehsil is characterized by fertile plains and terrain situated at the foothills of the Satpura mountain ranges, hosting numerous tribal villages. While agriculture is the primary occupation here, seasonal migration, wage labor, and forest-based activities provide supplementary support for the livelihoods of these families. The standard of living of tribal families in these villages depends not only on income but also on the availability of basic public amenities and essential services.

While numerous studies have been conducted on tribal development in India, the majority focus primarily on issues such as poverty, literacy, income, agriculture, or health. However, there is a noticeable lack of studies that comprehensively evaluate-at the household level—the availability of and access to basic amenities in tribal villages at the tehsil level. Local-level studies are crucial because significant disparities in infrastructure availability are often observed even among villages falling under the same administrative unit. Such studies help identify regional inequalities and empower local self-government bodies to formulate need-based development plans.

This study attempts to evaluate the availability of and access to basic amenities for Scheduled Tribe households in the Raver tehsil of Jalgaon district. The analysis is based on primary data from a household survey, supplemented by secondary data from government publications. The study examines aspects such as drinking water, sanitation, electricity, housing, cooking fuel, access to education and health facilities, road connectivity, and transport services. It also seeks to identify gaps or deficiencies in infrastructure that impact the living standards of tribal households.

The findings of this study are expected to contribute to the existing body of literature regarding tribal and human development at the local level. These findings will provide planners, policymakers, local self-government bodies, and development agencies with the empirical evidence needed to formulate more inclusive and area-specific development policies. Equitable access to basic amenities is essential not only for improving the living standards of Scheduled Tribe communities in Raver tehsil but also for achieving sustainable and inclusive development.

Review of Literature:

A literature review provides the theoretical and empirical foundation for any research study. It helps in identifying the current state of knowledge, key findings from previous studies, research gaps, and the scope for future

research. Since the present study focuses on the basic amenities available to Scheduled Tribes in Raver Taluka, this literature review incorporates studies related to human development, rural infrastructure, tribal development, and the availability of basic services.

The **United Nations Development Programme (UNDP)** introduced the 'Human Development Index' (HDI) in 1990; this index evaluates development based on three key dimensions: health, education, and standard of living. Although the HDI does not directly include the availability of basic amenities, these facilities significantly influence all three dimensions.

According to **Amartya Sen,** development should be evaluated not merely on the basis of income, but by the extent to which people have the freedom to lead the lives they value. The availability of amenities such as safe water, sanitation, healthcare, education, housing, and electricity enhances individuals' capabilities and enables them to participate more effectively in economic and social activities.

Naik Kirtisilan (2007) conducted a study on groundwater usage in the Raver tehsil of Jalgaon district, Maharashtra. This study utilized field surveys, data pertaining to groundwater resources, and secondary information. The researchers found that the extraction of groundwater for banana cultivation has increased significantly, leading to the classification of Raver tehsil as an 'over-exploited' area. While this study sheds light on the status of water resources in Raver, it does not examine the availability of drinking water, sanitation, electricity, housing, and other amenities for households belonging to Scheduled Tribes. To address this gap, the present study evaluates the availability of these facilities specifically for Scheduled Tribe communities.

Arjun Kumar (2015), in his research titled "Rural Households' Access to Basic Amenities in India: Deprivation and Socio-economic Exclusions" examined the availability of basic amenities to rural households in India and the associated socio-economic disparities. The study employed econometric and decomposition methods, utilizing data from the 2001 and 2011 Censuses as well as statistics on housing conditions from the National Sample Survey (NSS). The findings revealed that Scheduled Tribes, Scheduled Castes, the poor, and laborer households were the most deprived in terms of access to basic amenities. The author emphasized the need to provide basic amenities through policies that are both inclusive and targeted at specific groups.

Research Gap:

There has been very limited research at the household level regarding the basic amenities available to Scheduled Tribes in the Raver tehsil of Jalgaon district. Existing studies primarily analyze tribal development at broad geographical levels-such as district, state, or regional-and often overlook significant disparities at the village level. Furthermore, there is a scarcity of studies that incorporate various aspects of basic amenities-such as Drinking water, Sanitation, Electricity, Housing, Cooking fuel, Access to education and Healthcare, Road connectivity, and Transport facilities-into a single analytical framework.

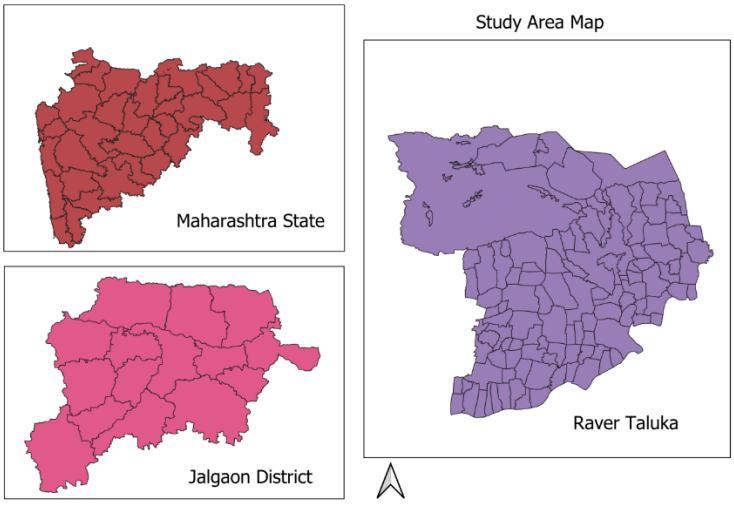
This study seeks to address this gap by conducting a comprehensive, household-level assessment of the basic amenities available to Scheduled Tribe families in selected villages of Raver tehsil. The study is expected to generate empirical evidence at the local level; such evidence will assist planners and policymakers in formulating need-based interventions to improve living standards in tribal areas and foster inclusive human development.

Objectives of the Study:

The study has been undertaken with the following objectives:

1. To examine the availability of basic amenities for Scheduled Tribe families in Raver Tehsil.
2. To assess the extent of families' access to drinking water, sanitation, electricity, housing, cooking fuel, and other essential amenities.
3. To analyze the availability of and access to educational institutions, healthcare facilities, and transport and communication services.
4. To suggest appropriate measures for improving the quality of basic infrastructure and fostering inclusive development within Scheduled Tribe communities.

Study Area:



Raver Tehsil is situated in the northern part of the Jalgaon district in Maharashtra. It is part of the Tapi River basin and the Khandesh region. The tehsil is bordered by Yawal Tehsil to the west, the state of Madhya Pradesh to the north, Muktainagar Tehsil to the east, and Bhusawal Tehsil to the south. The tehsil lies between 21° 25’ North and 21° 50’ North latitude and 75° 80’ East and 76° 30’ East longitude. The total geographical area of the tehsil is 910.36 sq. km., and according to the 2011 census, the total population is 3,12,082, of which the Scheduled Tribe population is 53,512, constituting 17.14% of the total population of Raver tehsil. The majority of tribal families reside in rural areas, where agriculture, farm labor, forest-based livelihoods, and seasonal migration serve as the primary sources of income. Due to geographical location, settlement patterns, and socio-economic conditions, the availability of infrastructure and public services varies across the region.

This study focuses on Scheduled Tribe families in four selected villages within Raver Tehsil. The analysis is based on household-level data collected through direct field surveys.

Database and Sources of Data:

The study is based on both primary and secondary sources of data.

1. Primary Data:

Primary data was collected during the field survey using a structured questionnaire. Information regarding household characteristics, drinking water, sanitation, housing, electricity,

cooking fuel, the availability of educational and health facilities, as well as communication and transport systems, was obtained directly from the respondents.

Direct observation and informal discussions with villagers were also utilized to verify the data collected during the survey.

2. Secondary Data:

Secondary information has been obtained from:

- Census of India (2011)
- District Census Handbook, Jalgaon
- Government of Maharashtra publications
- Ministry of Tribal Affairs
- Ministry of Rural Development
- Jalgaon District Statistical Handbook
- Published books, research articles, reports, and official websites

Research Methodology:

This study adopts a descriptive and analytical research design. Both qualitative and quantitative methods have been used to understand the availability of and access to basic amenities among Scheduled Tribe households.

1. Sampling Design:

For this purpose, the 'multi-stage purposive sampling' method was adopted. Raver Tehsil was selected due to its significant Scheduled Tribe population. Sample villages were chosen based on the proportion of the tribal population, and household-level surveys were conducted using a structured questionnaire.

The present study is based on primary data collected from **155 Scheduled Tribe households** selected from **four Tribal Sub-Plan (TSP) villages** of Raver Tehsil, namely Pimpri, Sahastraling, Janori, and Nimadya. The villages were selected using purposive sampling, and the collected data were analysed using frequency, percentage, comparative tables, and village-wise analysis.

2. Data Analysis:

The collected data will be classified, coded, tabulated, and analysed using appropriate statistical techniques.

The following analytical tools will be used:

- ❖ Frequency Distribution
- ❖ Percentage Analysis
- ❖ Cross-tabulation
- ❖ Composite Basic Amenities Index (CBAI)

To assess the overall availability and status of basic amenities among the respondents, a Composite Basic Amenities Index (CBAI) was constructed. Seven key indicators representing housing quality, sanitation, clean fuel, connectivity, and essential infrastructure were selected from the surveyed data. Since all variables are expressed as percentages (0 to 100%), they were normalized into a scale ranging from 0 to 1 by dividing the percentage by 100 (X_{norm} = % /100). An Equal Weight Method was applied, assigning a uniform weight of $W_i = 1/7 \approx 0.142857$ to each selected indicator. The final CBAI score was calculated using the weighted sum formula:

$$CBAI = \sum_{i=1}^{n} (W_i \times X_{i,norm})$$

Where:

- $X_{i,norm}$ = Normalized value of indicator i
- W_i = Weight assigned to indicator i (0.142857)
- n = Total number of selected indicators (7)

❖ **Tables and Graphs:**

The analysed data will be interpreted in relation to the objectives and hypotheses of the study.

Results and Findings:

An analysis of basic amenities for Scheduled Tribe families in Raver Tehsil has

been conducted using primary data collected at the household level. The findings are presented in sections covering various aspects such as drinking water, sanitation, housing, electricity, cooking fuel, access to education and healthcare facilities, and road and transport infrastructure. Each section reviews the availability of these basic amenities, the extent of access to them, and the disparities observed across different villages.

1. Socio-economic Profile of the Respondents:

Table 1: Distribution of Respondents by Age Group

Age Group	Respondents	Percentage
18 to 30	37	23.88
31 to 45	72	46.27
46 to 60	42	26.87
Above 60	4	2.98
Total	155	100.00

Source: Field Survey Data

The majority of the respondents belong to the 31 to 45 age group, accounting for 46.27 % of the total. A significant proportion falls within the 46 to 60 age group and the 18 to 30 age group, indicating that most respondents are part of the active working-age population. Senior respondents above 60 years of age represent the smallest share at only 2.98% out of the total 155 participants.

Table 2: Distribution of Respondents by Educational Status

Educational Level	Respondents	Percentage
Illiterate	35	22.39
Primary	46	29.85
Secondary	51	32.84
Higher Secondary	23	14.92
Graduate & Above	00	0
Total	155	100.00

Source: Field Survey Data

The largest share of respondents has attained secondary and primary education, making basic literacy and school-level education dominant among the population. A notable section of the respondents is illiterate, highlighting a deficit in basic educational attainment. A smaller group has completed higher secondary education, whereas graduate and higher educational qualifications are completely absent among the surveyed respondents.

2. Drinking Water Facilities

Table 3: Availability of Drinking Water Throughout the Year

Response	Respondents	Percentage
Available	155	100
Not Available	00	00
Total	155	100.00

Source: Field Survey Data

All surveyed households report having access to drinking water throughout the year, indicating complete and uninterrupted coverage of water facilities in the study area. No households reported a seasonal or permanent non-availability of drinking water, highlighting reliable local water infrastructure.

3. Housing Conditions:

Table 4: Type of House

Type	Respondents	Percentage
Kutcha	26	16.77
Semi-Pucca	44	28.39
Pucca	85	54.84
Total	155	100

Source: Field Survey Data

The majority of respondents reside in pucca houses, reflecting relatively stable structural living conditions and better socio-economic status in the study area. A considerable portion of households lives in semi-pucca structures, indicating moderate housing stability.

The smallest group of respondents stays in kutcha houses, highlighting a residual need for housing infrastructure improvement.

4. Sanitation Facilities:

Table 5: Availability of Toilet		
Response	Respondents	Percentage
Yes	44	28.35821
No	111	71.64179
Total	155	100.00
Source: Field Survey Data		

The majority of the surveyed households do not have access to toilet facilities, indicating a major sanitation gap and public health concern in the study area. Only a minority of respondents reported having access to a toilet, highlighting an urgent need for infrastructure development in household sanitation.

5. Electricity and Cooking Fuel:

Table 6: Electricity Connection		
Response	Respondents	Percentage
Yes	155	100
No	0	0
Total	155	100.00
Source: Field Survey Data		

All surveyed households have access to an electricity connection, indicating complete and successful rural electrification in the study area. No households reported a lack of electricity, highlighting robust power infrastructure provision.

Table 7: Primary Cooking Fuel		
Fuel Type	Respondents	Percentage
Firewood and chips	104	67.10
LPG	23	14.84
Firewood & LPG	28	18.06
Firewood & Kerosene	00	00.00
Electricity & LPG	00	00.00
Total	155	100
Source: Field Survey Data		

The majority of households rely heavily on firewood and chips as their primary cooking fuel, reflecting significant dependence on traditional biomass energy. Only a smaller group of respondents exclusively uses LPG or a combination of firewood and LPG for cooking, indicating restricted clean energy penetration. Other fuel combinations, such as firewood with kerosene or electricity with LPG, are completely absent among the surveyed population.

6. Education and Health Accessibility:

Table 8: Distance to Primary School		
Distance	Respondents	Percentage
Below 1 km	155	100
1 to 3 km	00	00
Above 3 km	00	00
Total	155	100.00
Source: Field Survey Data		

All surveyed households have a primary school located within a very close distance, indicating optimal educational infrastructure access in the study area. No respondents reported travelling a long distance to reach a primary school, highlighting favorable conditions for student enrollment and attendance.

Table 9: Distance to Health Centre		
Distance	Respondents	Percentage
Below 2 km	00	00
2 to 5 km	35	22.58
Above 5 km	120	77.42
Total	155	100.00
Source: Field Survey Data		

A significant majority of the surveyed population resides at a distance of more than five kilometers from a health centre, highlighting major accessibility barriers for timely medical treatment. A smaller portion of the respondents lives within a distance range of two to five kilometers from health facilities. None of the

surveyed households have a health centre located within a distance of less than two kilometers, indicating a critical shortage of localized healthcare infrastructure.

7. Connectivity and Communication:

Table 10: Road Connectivity		
Type	Respondents	Percentage
All-weather Road	109	70.32
Seasonal Road	46	29.68
No Motorable Road	00	00
Total	155	100.00
Source: Field Survey Data		

The majority of households have access to all-weather roads, reflecting favorable transportation and mobility conditions throughout the year. A notable portion of the respondents depends on seasonal roads, indicating some limitations in transport infrastructure during specific periods. None of the surveyed households suffer from a total lack of motorable roads, showing that basic connectivity infrastructure is present across the study area.

Table 11: Mobile Network Availability		
Response	Respondents	Percentage
Available	62	40.00
Partially Available	46	29.68
Not Available	47	30.32
Total	155	100.00
Source: Field Survey Data		

Only a portion of the surveyed households has full access to mobile networks, indicating restricted digital communication infrastructure in the study area. A notable group of respondents experiences only partial network availability, reflecting unstable connectivity conditions. A significant segment of the population reports no mobile network availability at all, highlighting a major digital divide and communication barrier.

8. Composite Basic Amenities Index:

Table 12: Selected Indicators and Normalization Values for CBAI				
Sr. No.	Indicator Category	Specific Indicator / Response	Observed Value (%)	Normalized Score (X_{norm})
1	Drinking Water	Year-round Availability	100.00	1.0000
2	Housing Condition	Quality of Structure (Pucca House)	54.84	0.5484
3	Sanitation	Availability of Latrine/Toilet (Yes)	28.36	0.2836
4	Electrification	Household Electricity Connection (Yes)	100.00	1.0000
5	Clean Cooking Fuel	Adoption of LPG Fuel (Exclusive & Combined)	32.90	0.3290
6	Road Connectivity	Accessibility (All-weather Road)	70.32	0.7032
7	Telecommunication	Digital Access (Mobile Network Available)	40.00	0.4000

Table 2: Composite Basic Amenities Index (CBAI) Calculation Matrix				
Sr. No	Component / Indicator	Normalized Value (X_{norm})	Weight (W_i)	Weighted Index Value ($W_i \times X_{norm}$)
1	Water Availability	1.0000	0.142857	0.142857
2	Housing Quality (Pucca)	0.5484	0.142857	0.078343
3	Toilet Facility	0.2836	0.142857	0.040514
4	Electricity Access	1.0000	0.142857	0.142857
5	Clean Fuel Adoption	0.3290	0.142857	0.047000
6	All-weather Road Connectivity	0.7032	0.142857	0.100457
7	Mobile Network Availability	0.4000	0.142857	0.057143
Total	Composite Basic Amenities Index (CBAI)	-	1.0000	0.6092

The empirical findings from the field study present a nuanced picture of rural infrastructure and amenity distribution. The overall **Composite Basic Amenities Index (CBAI)** score for the study area was calculated to be **0.6092 (60.92%)**, indicating a moderate level of basic infrastructural development.

Based on the empirical findings, the following policy measures may be considered:

1. Strengthen the implementation of rural drinking water programmes in tribal villages.
2. Improve the quality and sustainability of household sanitation facilities.
3. Expand all-weather road connectivity to remote tribal settlements.
4. Ensure uninterrupted electricity supply and promote clean cooking energy.
5. Improve accessibility to primary healthcare centres and educational institutions.
6. Promote digital connectivity and internet access in tribal villages.
7. Strengthen convergence among tribal welfare, rural development, health, and education departments.
8. Develop village-specific infrastructure plans based on household-level needs assessment.

Conclusion:

Both year-round drinking water availability and household electricity connection achieved a perfect index score (1.0000). This highlights effective public utility coverage and government scheme implementation at the village level. All-weather road connectivity scored 0.7032 (70.32%), enabling essential mobility and market access. Housing conditions showed moderate progress, with 54.84% of households residing in Pucca structures. Toilet availability recorded the lowest index contribution (0.2836), with 71.64% of households still lacking individual latrine facilities. This reflects a significant deficit in rural sanitation infrastructure and public health vulnerability. Only 32.90% of households utilize LPG (either exclusively or combined with firewood), while 67.10% continue to rely strictly on traditional firewood and chips. This demonstrates persistent energy poverty and associated indoor air quality risks. Mobile network availability registered a low score of

0.4000 (40.00%), with over 60% facing partial or complete lack of network coverage, hindering access to digital services and information.

While universal access to basic utilities like electricity and drinking water has been achieved, the **CBAI score of 0.6092** highlights intra-sectoral disparities. Targeted intervention is urgently needed in rural sanitation (Swachh Bharat Abhiyan coverage), clean energy adoption (Pradhan Mantri Ujjwala Yojana revival), and digital communication infrastructure to elevate the overall quality of life in the region.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Study of Dielectric Properties of *Acacia Nilotica* Tree Leaves in the C-Band Microwave Frequency Range

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DOI - 10.5281/zenodo.24334953

Abstract:

The present study investigates the dielectric properties of Acacia nilotica tree leaves in the C-band microwave frequency range. The dielectric constant and dielectric loss of the leaves are studied over a selected frequency range within the C-band, considering variations in moisture content. The measurements help to understand the interaction of microwave radiation with the leaf material and the influence of moisture on its electromagnetic response. The study may provide useful information for microwave remote sensing, vegetation monitoring, moisture estimation, and agricultural applications.

Keywords: Dielectric Constant, Dielectric Loss, Moisture Content, C-Band, Microwave, Tree Leaves.

Introduction:

Microwave techniques provide useful information about the physical and electromagnetic characteristics of natural materials. Vegetation is an important target in microwave remote sensing because its interaction with electromagnetic radiation depends strongly on its dielectric properties. The complex dielectric constant of vegetation consists of a real part, ε′, associated mainly with energy storage, and an imaginary part, ε″, associated with dielectric losses.

Several researchers have studied the dielectric properties of plants and vegetation [1-9]. The dielectric properties of leaves depend on several factors, including frequency, temperature, salinity, and particularly water content. Experimental studies on different plant leaves have shown that both ε′ and ε″ generally decrease when moisture content decreases. At higher moisture contents, frequency-dependent behaviour becomes more prominent [1].

C-band microwave measurements have previously been used to characterize vegetation such as corn and sugarcane. In such studies, laboratory measurements of complex dielectric properties were performed at C-band and related to moisture content for microwave remote-sensing applications [2].

However, experimental dielectric data specifically for its leaves can be useful for understanding its microwave response. Therefore, the present investigation aims to determine the dielectric properties of Acacia nilotica leaves over the selected C-band frequency range.

Materials and Methods:

1. Preparation of The Tree Leaves Samples

Samples of leaves of Acacia nilotica has been used in our experiments. This tree species selected lie within the small area covering about 1 km^2 in the Dhule city. Dhule district comes under tropical zone and located in the northern region of Maharashtra state (India). Height of these tree species ranged between 8 to 20 meters. Initially,

the newly plucked tree leaves are inserted into the solid dielectric cell and their dielectric constant is measured. Then the wet basis gravimetric moisture content (MC %) of the tree leaves sample was gradually reduced by drying it in a hot air oven at 45° to 50° C. Moistures of leaves are varied from its natural to oven dry value.

2. Complex Dielectric Constant Measurement:

The waveguide cell method is used to determine the dielectric properties of the tree leaves samples. An automated C-band microwave set-up in the TE10 mode with Gunn source operating at frequencies 4.1GHz and 5.1GHz PC-based slotted line control and data acquisition system is used for this purpose. It consists of Microcontroller (8051), ADC-12 Bit- MCP (3202) Visual based software. The solid dielectric cell with this sample is connected to the opposite end of the source. The signal generated from the microwave source is allowed to incident on the tree leaves sample. The sample reflects part of the incident signal from its front surface. The reflected wave combined with incident wave to give a standing wave pattern. These standing wave patterns are then used in determining the values of shift in minima resulted due to before and after inserting the sample.

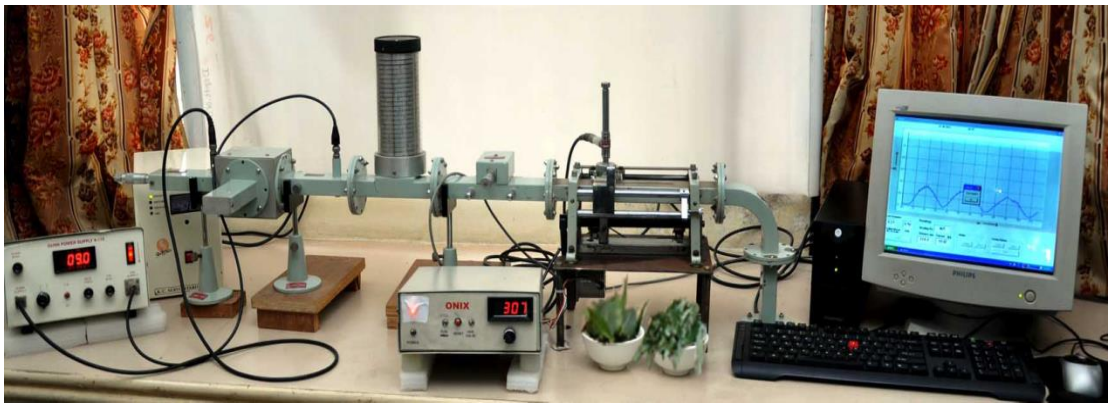

Figure 1 Photograph of automated C-band microwave bench setup for measurement of dielectric constant of tree leaves

The dielectric constant ε' and dielectric loss ε'' of the tree leaves are then determined from the following relations:

$$\varepsilon' = \frac{g_\varepsilon + (\lambda_{gs}/2a)^2}{1+(\lambda_{gs}/2a)^2} \quad \ldots. \quad (1)$$

$$\varepsilon'' = -\frac{\beta_\varepsilon}{1+\left(\lambda_{gs}/2a\right)^2} \quad \ldots. \quad (2)$$

Where,

a = Inner width of rectangular waveguide.

λ_{gs} = Wavelength in the air-filled guide.

g_ε = real part of the admittance;

β_ε = imaginary part of the admittance

From these measured values of dielectric constants at C-band frequencies (4.1GHz and 5.1GHz) for the tree leaves samples having different MC (%).

Results and Discussion:

Our results on the variations of dielectric constant (ε') and dielectric loss (ε'') of leaves samples of Acacia nilotica tree species with different gravimetric moisture contents (wet basis) These experiments are performed at microwave frequencies 4.1 GHz and 5.1 GHz, for MC variations from moistures of freshly plucked natural leaves to their oven- dry values.

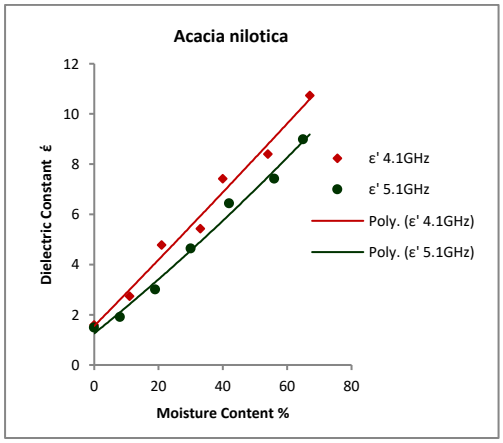

Figure 2(a)

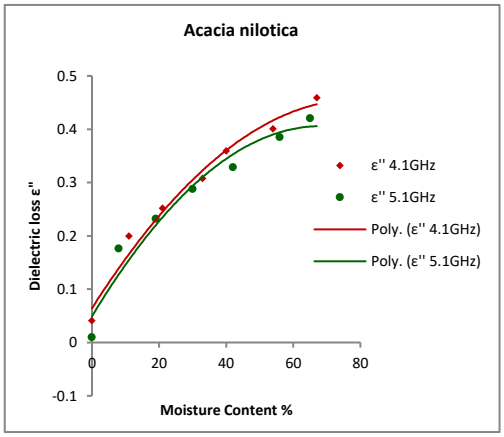

Figure 2(b)

Figure 2(a)-(b) shows how the dielectric constant and dielectric loss change with gravimetric moisture content (%) in Acacia nilotica leaf samples at microwave frequencies of 4.1 GHz and 5.1 GHz. Both the dielectric constant (ε') and dielectric loss (ε'') increase as the moisture content (%) rises across the entire range studied. The changes are more nonlinear for the dielectric constant (ε') than for the dielectric loss (ε''). The overall trends are similar at both frequencies, with only differences in their values. Additionally, there is a slight decrease in both dielectric constant and loss as the frequency increases.

Applications:

The dielectric characteristics obtained from this study may be useful in:

- Microwave remote sensing of vegetation
- Estimation of leaf moisture
- Vegetation monitoring
- Agricultural and environmental studies
- Interpretation of microwave scattering and emission from vegetation

Conclusion:

The study concludes that the dielectric properties of Acacia nilotica leaves show a significant dependence on frequency and moisture content in the C-band microwave frequency range. The dielectric constant and dielectric loss are influenced mainly by the water present in the leaves. As moisture content changes, the microwave response of the leaves also changes. These results indicate that dielectric measurements can be useful for estimating leaf moisture content and studying vegetation characteristics. The findings may have potential applications in microwave remote sensing, agricultural monitoring, and vegetation studies.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

A Review of Green Synthesis of Metal Nanoparticles Using *Ehretia laevis* Roxb and *Carissa carandas*

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DOI - 10.5281/zenodo.24334991

Abstract:

Green synthesis is gaining attention as an environmentally friendly and cost-effective alternative to conventional methods for producing metal nanoparticles. This review focuses on green synthesis approaches, with special emphasis on the use of Ehretia laevis *and* Carissa carandas *as plant-based sources for nanoparticle production. Plant extracts from these species contain bioactive compounds that act as natural reducing and stabilizing agents, leading to the formation of metal nanoparticles with desirable physicochemical properties. The review discusses different synthesis methods, commonly used characterization techniques, and the functional applications of these nanoparticles. In addition, the antimicrobial activity of metal nanoparticles synthesized using* Ehretia laevis Roxb *and* Carissa carandas *is examined, highlighting their potential role in combating microbial resistance. Overall, this review provides a clear overview of plant-mediated green synthesis of metal nanoparticles and encourages further research toward sustainable and eco-friendly nanotechnology.*

Keywords: Green synthesis; metal nanoparticles; Ehretia laevis Roxb; Carissa carandas; plant-mediated synthesis; bioactive compounds; antimicrobial activity; sustainable nanotechnology; characterization techniques; microbial resistance.

Introduction:

Nanotechnology focuses on the design, synthesis, and application of materials at the nanoscale, typically within the size range of 1 to 100 nanometers. At this scale, materials display physical and chemical properties that differ significantly from those of their bulk counterparts. These unique characteristics mainly arise from the increased surface-to-volume ratio and the influence of quantum effects, which strongly affect reactivity, optical behavior, and electrical properties.

Metal nanoparticles constitute an important class of nanomaterials in nanotechnology. They are defined as particles having at least one dimension within the nanoscale range of 1–100 nm [1,2]. These nanoparticles can be composed of various metals such as gold, silver, zinc, and copper, and are well known for their high surface area as well as distinctive optical, electrical, and magnetic properties [2,3]. Due to these features, metal nanoparticles have gained considerable attention for their potential use across a wide range of scientific and technological fields.

The unique physicochemical properties of metal nanoparticles, including high surface reactivity, enhanced catalytic efficiency, and tunable size and morphology, make them particularly valuable in biomedical applications. They are extensively explored in drug delivery systems, cancer therapy, and as antimicrobial agents, owing to their ability to interact effectively with biological membranes and

cellular structures[3,4]. In agriculture, metal nanoparticles have been reported to help alleviate abiotic stresses such as drought and salinity, thereby improving plant growth and productivity[1].

Overall, although metal nanoparticles offer remarkable benefits across multiple disciplines, addressing their potential environmental impact and promoting eco-friendly synthesis methods are essential for the responsible and sustainable advancement of nanotechnology.

Unique properties Nanotechnology and Metal Nanoparticles:

- **Size-Dependent Reactivity:**

The chemical reactivity of metal nanoparticles strongly depends on their size. Smaller nanoparticles exhibit higher reactivity due to their large surface area relative to volume. This property is particularly important in catalytic applications, where nanoparticles act as efficient catalysts with enhanced surface activity. In addition, changes in particle size influence the quantum mechanical behaviour of nanoparticles, leading to variations in their electronic, optical, and chemical properties, which are crucial for applications in electronics and photonics[12].

- **Implications and Applications:**

The unique size-dependent and surface-related properties of metal nanoparticles have enabled their application in diverse fields. In drug delivery systems, nanoparticles can be engineered for targeted and controlled delivery. In environmental applications, their high reactivity is utilized for pollutant degradation. However, challenges related to synthesis control, long-term stability, and potential environmental and health risks remain. Current research focuses on optimizing nanoparticle properties for specific applications while minimizing associated risks[13,14].

- **Limitations of Conventional Synthesis Methods**

Conventional synthesis methods for nanoparticles, such as physical and chemical methods, have various limitations that affects on their effectiveness and sustainability. These methods often involve high energy consumption, the use of toxic chemicals, and challenges in controlling particle size and shape, which can lead to environmental and health issues. Additionally, these methods may not be useful for industrial applications, limiting their commercial applicability.

Conventional chemical synthesis methods for nanoparticles often use hazardous solvents and stabilizing or coating agents, which can be dangerous to human health and the environment. In addition, these methods may generate toxic by-products, further increasing environmental and safety concerns[15].Many conventional nanoparticle synthesis methods are difficult to scale up, which limits their use in industrial applications[16]. However, a new focus on safety is pushing researchers toward 'green' methods. These new methods use plants and tiny germs instead of toxic chemicals, making them much safer for the environment [16,18].

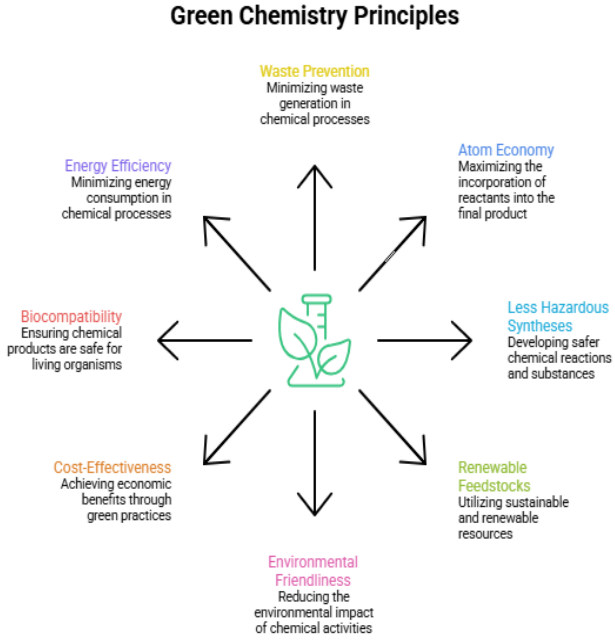

Figure No. 1: Green chemistry Principal

- **Role of Plant Extracts in Nanoparticle Synthesis:**

Making nanoparticles with plant extracts is a growing trend because it is sustainable and cost-effective. Plants are better than microbes for this because they contain a wider range of phytochemicals. These molecules act as reducing and capping agents, meaning they quickly build and stabilize the nanoparticles. This 'green synthesis' is safer than traditional chemical methods because it is non-toxic and eco-friendly.

Green synthesis, compared to microbial methods, plant-based synthesis is simpler and easier to scale up, as it does not require perfect growth conditions or long processing times[20]. In addition, plant extracts are readily available, cost-effective and eliminate the need for hazardous chemicals, making them a sustainable and eco-friendly option for nanoparticle production[21,22].

Botanical and Phytochemical Overview of Selected Plants:

- ***Ehretia laevis Roxb:***

Ehretia laevis is a fast-growing small deciduous tree with simple alternate leaves and tiny white flowers. It produces small, drupe- like fruits (fleshy fruit with a hard stone inside), which are commonly used in traditional medicinal practices[27,28]. This species grows in tropical areas across Asia, Africa, and Australia. In India, where it is often called 'Khandu Chakka' is widely found in regions such as Maharashtra[41]. It is widely used in traditional medicine for the treatment of respiratory, gastrointestinal, and reproductive disorders. It is commonly used to manage conditions such as jaundice, asthma, dysentery, ulcers, and diabetes. In Ayurvedic medicine, the plant is also recognized for its antidiabetic and antivenom properties[4142].The plant contains rich amounts of flavonoids and phenolic compounds, which contribute to its strong antioxidant and anti-inflammatory activities[31]. It contains alkaloids, though they are not fully studied yet. In addition, tannins present in the stem bark impart astringent (tissue-tightening) powers and antimicrobial (germ-killing) properties[33,42] .*Ehretia laevis* is widely valued for its traditional medicinal uses, but most of its uses are not yet proven by science. There is very little data on its safety and effectiveness. Further comprehensive research is required to understand how it works and to make sure it is safe for modern medical use.

- ***Carissa carandas:***

Carissa carandas is a thorny, evergreen shrub found in tropical parts of Asia and Africa. It grows small, berry-like fruits that are popular for adding flavor to food. *Carissa carandas* has been traditionally used to treat various ailments, including scabies, intestinal worm infections, pruritus (Severe itching), biliousness (Digestive issues or nausea), and snake bites. It is also employed in the management of diarrhea, stomach ache, rheumatism, and syphilitic pain. In addition, the plant is known for its cardiotonic (Heart strengthener), hepatoprotective (protects the liver), and anti-inflammatory properties[36].*Carissa carandas* contains several important bioactive compounds, including triterpenoids such as lupeol, β-sitosterol, and ursolic acid, which contribute to its antioxidant activities (reduce swelling and protect cells). The leaves are rich in saponins that kill harmful cells (cytotoxic). In addition, the presence of phenolic compounds enhances the plant's antioxidant potential[43]. Cardiac glycosides are also abundant and are responsible for their cardiotonic (Heart Health) properties, while other glycosides contribute to antimicrobial and antidiabetic activities[34,44].

Table No. 1: Phytochemical Overview of both plant

Plant Name	Phytochemical Class	Specific Compounds / Description	Reported Biological Activities
Ehretia laevis Roxb	Flavonoids	Leaf saponins	Antioxidant, anti-inflammatory
Ehretia laevis Roxb	Phenolic compounds	General phenolics	Antioxidant, anti-inflammatory
Ehretia laevis Roxb	Alkaloids	Presence reported	Pharmacological potential
Ehretia laevis Roxb	Tannins	Present mainly in stem bark	Astringent, antimicrobial
Carissa carandas	Triterpenoids	Lupeol, β-sitosterol, ursolic acid	Antioxidant, anti-inflammatory
Carissa carandas	Saponins	Leaf saponins	Cytotoxic activity
Carissa carandas	Phenolic compounds	General phenolics	Antioxidant
Carissa carandas	Cardiac glycosides	Leaf saponins	Cardiotonic activity
Carissa carandas	glycosides	Various glycosides	Antimicrobial, antidiabetic

Mechanism of Green Synthesis of Metal Nanoparticles:

The green synthesis of silver, copper, and zinc nanoparticles using plants is an eco-friendly and low-cost method. It is better than chemical and physical techniques due to its sustainability, cost-effectiveness, and lower environmental impact. In this process, phytochemicals present in plant extracts act as natural reducing and stabilizing agents, converting metal ions into nanoparticles. The synthesis typically proceeds through key stages, including ion reduction, nucleation, particle growth, and stabilization.

- **Silver Nanoparticles (AgNPs):**

Plant extracts contain various metabolites, including amino acids, organic acids, sugars, and phenolic compounds, which play an importanct role in reducing silver ions (Ag^{+}) to silver nanoparticles (AgNPs). Among these, reducing sugars such as cellobiose and fructose are particularly effective, as indicated by their reduced concentration after the reaction. The resulting AgNPs exhibit strong antibacterial activity, mainly due to their ability to they damage the bacteria's protective walls and generate reactive oxygen species (ROS)[45,46].

- **Copper Nanoparticles (CuNPs):**

Similar to silver nanoparticles, copper nanoparticles (CuNPs) can be synthesized using plant extracts rich in bioactive compounds such as flavonoids and terpenoids, which reduce copper ions (Cu^{2+}) to CuNPs. The synthesis process often involves the formation of copper oxide nanoparticles (CuO NPs) as intermediate species, which are subsequently reduced to CuNPs. Owing to their catalytic and antimicrobial properties, CuNPs are widely applied in environmental problem[47].

- **Zinc Nanoparticles (ZnNPs):**

Zinc nanoparticles (ZnNPs) are synthesized by reducing zinc ions (Zn^{2+}) using plant extracts rich in phytochemicals. ZnNPs exhibit important properties such as biocompatibility and selective cytotoxicity, which are mainly attributed to the release of zinc ions and the generation of reactive oxygen species (ROS), leading to oxidative stress in target cells. Due to their antibacterial and anticancer activities,

these nanoparticles have found wide applications in medicine and environmental science[48].

Characterization Techniques:

The characterization of metal nanoparticles synthesized through green methods is crucial for confirming their properties and potential applications. Green synthesis, which utilizes biological materials such as plant extracts, offers an eco-friendly and sustainable alternative to conventional methods. Characterization techniques are employed to determine the size, shape, composition, and other properties of the nanoparticles, ensuring their suitability for various applications.

Spectroscopic Techniques:

- **UV–Visible Spectrophotometry:** UV–Vis spectrophotometry is widely used to monitor the formation and stability of nanoparticles by analyzing their optical absorption behavior. The appearance and position of characteristic absorption peaks on the graph provide useful information about nanoparticle size, concentration, and stability[49].
- **Fourier Transform Infrared Spectroscopy (FT-IR):** FT-IR spectroscopy is employed to identify functional groups and to confirm the presence of biomolecules involved in nanoparticle synthesis. It helps us in understanding the role of plant-derived compounds acting as reducing and capping agents during the green synthesis process[50].

Microscopy Techniques:

- **Transmission Electron Microscopy (TEM):**TEM is a powerful technique for obtaining high-resolution images of nanoparticles, it gives accurate determination of their size, shape, and size distribution. It is particularly seful for check nanoparticle morphology and confirming monodispersity[51]..
- **Scanning Electron Microscopy (SEM):** SEM is employed to study the surface morphology and topographical features of nanoparticles. While TEM shows the inside or overall shape, SEM focuses on the outside details. Together, these two tools give a complete picture of how the particles are built[52].

Crystallographic and Elemental Analysis:

- **X-ray Diffraction (XRD):** XRD is used to determine the study of the internal structure and quality of nanoparticles. It confirms if the particles are solid crystals and checks if they are made of pure metal. This tool is essential to prove the exact type of material produced[52].
- **Energy-Dispersive X-ray Spectroscopy (EDX):** EDX, commonly coupled with SEM, is employed to analyze the elemental composition of nanoparticles and to confirm the presence of the desired metal elements[51].

Comparative Analysis of Both Plant:

Table No. 2: Comparative Analysis of Both Plant

Parameter	***Ehretia laevis* Roxb**	***Carissa carandas***
Plant type	Fast-growing, small deciduous tree	Thorny, evergreen shrub
Geographical distribution	Tropical regions of Asia, Africa, and Australia	Tropical regions of Asia and Africa
Common/local name	Khandu Chakka (India)	Commonly known as Karonda
Plant parts used	Fruits, stem bark, leaves (traditional use)	Fruits, leaves, roots (traditional use)
Traditional medicinal uses	Respiratory, gastrointestinal, and reproductive disorders; jaundice, asthma, dysentery, ulcers, diabetes	Scabies, intestinal worm infections, pruritus, biliousness, snake bites, diarrhea, stomachache, rheumatism
Ayurvedic importance	Antidiabetic and antivenom properties	Used for cardiotonic, hepatoprotective, and anti-inflammatory purposes
Major phytochemicals	Flavonoids, phenolic compounds, alkaloids, tannins	Triterpenoids (lupeol, β-sitosterol, ursolic acid), saponins, phenolics, cardiac glycosides
Biological activities	Antioxidant, anti-inflammatory, antimicrobial, astringent	Antioxidant, cytotoxic, cardiotonic, antimicrobial, antidiabetic
Mechanism of activity (reported)	Antioxidant and anti-inflammatory effects mainly due to flavonoids and phenolics	Antioxidant effects due to triterpenoids and phenolics; cardiotonic activity due to cardiac glycosides
Safety and toxicity data	Limited scientific validation available	Potent bioactive compounds; requires precise dosage
Research status	Traditional uses largely unverified scientifically	Needs further pharmacological and clinical validation
Scope for future research	Mechanism of action, toxicity, clinical efficacy	Dose optimization, safety evaluation, clinical studies

Applications of Green Synthesized Nanoparticles:

Green nanoparticles are synthesized using plants and microbes. This "green" method is better for the environment because it is safe, non-toxic, and often costs much less. In these methods, biological materials act as reducing and stabilizing agents, eliminating the need for hazardous chemicals. This environmentally safe approach produces nanoparticles with desirable properties such as high surface area and enhanced reactivity. As a result, green nanoparticles have found wide applications in fields including medicine, environmental science, and modern technology.

- **Drug Delivery and Therapeutic Applications**

Green-synthesized silver and gold nanoparticles are widely used in drug delivery systems due to their small size and ability to cross biological barriers to reach sick cells. These nanoparticles are very helpful in treating cancer. They can act as precise "carriers" for medicine, offering a safer alternative to regular chemotherapy[49].

- **Antimicrobial and Wound Healing:**

Green-synthesized silver and gold nanoparticles exhibit strong antimicrobial activity, including effectiveness against

antibiotic-resistant microorganisms. They work by damaging the germs' outer walls and DNA and they offering a promising alternative to conventional antibiotics. Similarly, green-synthesized zinc oxide and titanium dioxide nanoparticles show potent bactericidal (kill bacteria) properties, making them particularly useful in wound healing and infection control applications[49].

- **Antioxidant Activity:**

Green nanoparticles are great antioxidants because they neutralize harmful free radicals such as DPPH and ABTS•+, which are commonly used to evaluate antioxidant potential. This activity is attributed to the presence of surface functional groups, including –OH, C=O, and –C–O, which facilitate electron transfer and enable efficient neutralization of free radicals[54].

- **Catalytic and Photocatalytic Applications:**

Green-synthesized nanoparticles such as gold, silver, and iron are widely used as catalysts in various organic reactions. Because of their large surface area and abundance of active sites enhance reaction rates and selectivity, making them suitable for industrial applications. They also use light (photocatalytic) to break down pollution and harmful dyes, like Rhodamine B, making water cleaner. For example, Plant-made Titanium dioxide (TiO2) can break down industrial dyes like Rhodamine B when exposed to UV light.

Challenges, Limitations, and Research Gaps:

Despite the promising potential of green-synthesized nanoparticles, several challenges and research gaps remain. A major limitation is the lack of standardization in synthesis protocols, as differences in plant species, extraction procedure, and reaction conditions can lead to inconsistent nanoparticle properties. This variability also gives to reproducibility issues, making it difficult to compare results across different studies.

Another important research gap is the limited availability of in vivo studies. Most existing research is based on in vitro evaluations, while detailed animal and clinical studies are still lacking to adequately assess toxicity, biodistribution, and long-term safety. In addition, scaling up green synthesis methods for industrial production remains challenging due to difficulties in controlling particle size, shape, and yield on a large scale. Addressing these limitations through standardized protocols, systematic in vivo investigations, and scalable synthesis strategies is essential for the successful translation of green-synthesized nanoparticles into practical and commercial applications. Future research needs to focus on how exactly plants help build and protect nanoparticles.

Conclusion:

This review shows that plant-based nanoparticles are eco-friendly and cost-effective compared to chemical ones. Natural chemicals in plants act as tools to build these particles, giving them great features for medicine and environmental cleanup. Although we still face challenges in making them in large amounts, green synthesis is a promising and safe way to create advanced materials for the future.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Digital Literacy Programs and Curriculum

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DOI - 10.5281/zenodo.24335013

Abstract:

Digital literacy has moved from a niche educational objective to a foundational competence necessary for full participation in 21st-century life. This paper examines the concept of digital literacy, synthesizes global frameworks, reviews major programs and curricula, identifies implementation strategies and barriers, presents illustrative case studies, and offers recommendations for policy and practice. Drawing on international frameworks (UNESCO, Dig Comp), multilateral analyses (World Bank, OECD), and national initiatives (India, Finland, Singapore), this descriptive paper argues that effective digital literacy programming combines clear competency frameworks, curriculum integration across levels, sustained teacher development, equitable infrastructure, and continual evaluation.

Introduction:

The rapid diffusion of digital technologies into everyday social, educational, and economic activities has made digital literacy a core literacy alongside reading, writing, and numeracy. Digital literacy is not merely the ability to operate devices; it is a constellation of knowledge, skills, and dispositions that enable individuals to find, evaluate, create, communicate, and act responsibly in digital environments. The urgency to cultivate these competencies is driven by labour market transformations, civic information ecosystems shaped by online platforms, and the privacy and security concerns that accompany pervasive connectivity. International organizations, national governments, and private-sector actors have responded with frameworks, programs, and curricular reforms designed to bolster digital competencies across populations. This paper asks: What constitutes comprehensive digital literacy programming? How are curricula designed and implemented across contexts? What best practices and persistent challenges emerge from global experience?

Defining Digital Literacy: Evolution and Frameworks:

1. From Computer Literacy to Digital Competence:

Early definitions of "computer literacy" focused on basic operational skills: using word processors, spreadsheets, and email. Over the past two decades, thinkers and institutions have expanded the construct to include information literacy, media literacy, computational thinking, data literacy, online safety, and ethical/participatory dimensions (e.g., digital citizenship). The UNESCO Global Framework (2018) captured this breadth by mapping competencies across cognitive, socio-emotional, and technical domains—emphasizing that digital literacy is contextual and tied to meaningful participation in society.

2. Leading Competency Frameworks:

Several internationally recognized frameworks guide curricular design:

- **UNESCO Global Framework of Reference for Digital Literacy (2018):** Provides a taxonomy of competence areas and learning domains to harmonize disparate national frameworks.
- **Dig Comp (European Commission):** Articulates 5 competence areas and 21 competences for citizens (e.g., information and data literacy; communication and collaboration; digital content creation; safety; problem solving), with proficiency levels that support curriculum alignment and assessment. Dig Comp has evolved across versions and remains a reference point for policy and education design.
- **World Bank / OECD analyses:** Offer a policy lens, situating digital skills within economic development, workforce readiness, and education systems transformation. These reports emphasize planning, monitoring, and the interplay between supply (training) and demand (labour market).

These frameworks share common emphases: (a) multidimensional competencies beyond device operation; (b) levels of proficiency and progression; and (c) the need for contextualization to local curricula and labour markets.

Types of Digital Literacy Programs:

Digital literacy programs take varied forms depending on target populations, goals, and delivery modes. Key categories include:

1. Formal Education Programs (K–12 and Higher Education):

Formal curricula integrate digital competencies into subject learning (infusing digital tasks into language, math, science) or establish dedicated digital literacy courses. National curriculum reforms in many countries now include digital competence as a cross-curricular competence or a discrete subject area—Finland and Singapore being prominent examples.

2. National Campaigns and Mass-Training Initiatives:

Governments often launch large-scale initiatives to improve population-level digital literacy. India's **PMGDISHA** (Pradhan Mantri Gramin Digital Saksharta Abhiyan) and broader Digital India efforts aim to make households digitally literate through community centres, mobile labs, and accredited training programs. Such programs target adults and out-of-school populations and are delivered via public–private partnerships.

3. Workplace and Vocational Programs:

Employers, industry consortia, and technical institutions provide skills training focused on employability—coding bootcamps, data-analytics short courses, and ICT vocational streams. The World Bank advises aligning such programs with labour market demand and embedding higher-order digital skills (problem solving, collaboration) rather than narrow tool training.

4. Community-Based and Nonformal Initiatives:

Libraries, NGOs, and community centres deliver grassroots programs—often aimed at older adults, women, and marginalized groups. These programs prioritize access, basic navigation, e-services use, and online safety. Recent examples include mobile digital labs and library-cantered training initiatives in rural contexts.

5. Online and Blended Learning Platforms:

MOOCs, commercial platforms (Coursera, Microsoft Learn), and government portals provide self-paced modules spanning basic to advanced skills. Blended models that

combine online content with face-to-face mentoring are increasingly common to ensure practice and scaffolding.

Curriculum Design: Core Components and Pedagogical Principles:

A robust digital literacy curriculum is learner-cantered, progression-oriented, and grounded in authentic tasks. Key design elements include:

1. Core Competency Areas:

Most curricula map to similar domains (drawing on Dig Comp and UNESCO mappings):

- **Information and data literacy:** searching, evaluating, interpreting, and using digital information.
- **Communication and collaboration:** using digital tools for interaction, co-creation, and civic engagement.
- **Digital content creation:** producing media, coding basics, remixing content responsibly.
- **Safety and security:** privacy, digital rights, cyber hygiene, and mental well-being online.
- **Problem solving and critical thinking:** troubleshooting, computational thinking, and evaluating algorithmic outputs.

2. Curriculum Models and Progression:

Curricula may be framed as:

- **Cross-curricular integration:** embedding digital tasks within other subjects so that digital competence serves disciplinary learning goals.
- **Discrete subject or module:** a dedicated digital literacy course with clear progression across grade levels.
- **Learner pathways:** competency levels mapped to age/stage or proficiency levels (entry → intermediate → advanced) as in Dig Comp's proficiency descriptors.

3. Pedagogical Strategies:

Effective teaching strategies include:

- **Project-based learning (PBL):** authentic projects requiring digital research, collaboration, and content creation (e.g., digital storytelling, data projects).
- **Scaffolded skill development:** starting with guided tasks and moving toward open-ended creation and critique.
- **Critical media literacy exercises:** analysing misinformation, source evaluation, and argument mapping.
- **Simulation and problem-solving labs:** for cybersecurity basics and troubleshooting.
- **Blended instruction with formative assessment:** using digital tools for feedback and competency tracking. OECD evidence highlights the central role of teachers in mediating effective digital learning experiences.

4. Assessment and Certification:

Assessment must measure both procedural skills and critical application. Options include performance tasks, portfolios, and standardized competency assessments tied to proficiency frameworks. For population-level programs, credentialing (badges, certificates) supports employability and motivation.

Implementation: Systems, Teachers, and Infrastructure:

1. System-Level Planning and Governance:

Successful national programs integrate policy, funding, standards, and monitoring. The World Bank's guidance recommends country action plans that align education, labour, and digital infrastructure investments. Planning should include clear target populations, delivery channels, and evaluation metrics.

2. Teacher Professional Development:

Teachers are the linchpin of curricular change. Professional development must:

- Provide pedagogical training for integrating digital tasks into subject teaching.
- Offer hands-on practice with tools and formative assessment techniques.
- Include communities of practice and ongoing coaching. OECD analyses underline that investment in teacher capacity is more predictive of success than device provision alone.

3. Infrastructure and Access:

Reliable connectivity, devices, and technical support are prerequisites. Yet the mere presence of devices does not guarantee learning gains; usage quality and alignment with pedagogy matter. Equity strategies—device provision, subsidized connectivity, and localized content—are necessary to reduce the digital divide.

4. Public–Private Partnerships (PPPs):

Governments often partner with tech firms, telecom providers, and NGOs to scale programs (content, teacher training, infrastructure). Effective PPPs define shared goals, roles, and sustainability plans.

Challenges and Barriers:

1. The Digital Divide and Equity Gaps:

Disparities in access (rural vs. urban, gender, income) remain the dominant barrier to inclusive digital literacy. National programs that do not account for structural inequities risk widening rather than narrowing gaps.

2. Teacher Preparedness and Attitudes:

Many teachers lack confidence or time to incorporate digital literacy. Inadequate pre-service training and the absence of incentives for upskilling constrain classroom adoption.

3. Content Relevance and Language:

Digital content is often produced in dominant languages and fails to address local contexts, undermining relevance and uptake among diverse populations.

4. Misinformation, Privacy, and Safety Risks:

Teaching critical evaluation and online safety is complex: curricula must evolve rapidly to address new threats (deepfakes, targeted misinformation, algorithmic bias). This raises the need for continuous curricular updates and teacher expertise.

5. Sustainability and Evaluation Challenges:

Short-term pilot funding and weak monitoring limit program sustainability. Rigorous evaluation frameworks and data collection are often missing, making it difficult to measure long-term impacts on civic participation or employment outcomes.

Case Studies:

1. Finland: Integrative National Curriculum:

Finland integrated digital competence into its national core curriculum as a transversal competence, emphasizing critical thinking, media literacy, and creative application. The Finnish approach models cross-curricular integration, teacher autonomy, and systemic support for pedagogical innovation. This systemic integration ensures that digital literacy is not siloed but embedded across learning experiences.

2. India: PMGDISHA and Digital India Initiatives:

India's PMGDISHA aimed at household-level digital literacy via accredited training centres, community mobilization, and government e-service linkages. The program demonstrates how national campaigns can mobilize scale but also highlights challenges: heterogeneity of delivery quality, infrastructure gaps, and the need for robust monitoring to confirm outcomes.

3. Singapore: National Digital Literacy Programme (NDLP) and Smart Nation:

Singapore's Ministry of Education established the NDLP and broader Smart Nation initiatives to equip students with digital

competencies through structured curricula, device provisioning (PLDs), and "Find-Think-Apply-Create" pedagogical frameworks. Singapore's coordinated policy, strong infrastructure, and emphasis on teacher training provide a model for systemic rollout.

Emerging Trends and Future Directions:

1. AI and Algorithmic Literacy:

As AI-driven tools become ubiquitous, curricula must teach not only how to use AI but how to understand its limitations, biases, and ethical implications. Algorithmic literacy—interpreting outputs, questioning datasets, and recognizing automation's socio-economic impacts—will be central. OECD and national discussions increasingly emphasize this shift.

2. Data Literacy and Evidence-Informed Decision Making:

Data literacy—collecting, analysing, and responsibly using data78—supports civic and economic participation. Education systems are beginning to incorporate data projects into K–12 sequences and vocational training.

3. Lifelong and Modular Learning Pathways:

Digital literacy requires continual updating. Modular credentials, micro-credentials, and stackable badges allow learners to reskill over time. These pathways must be linked to labour market signals and recognized across institutions.

4. Inclusive Design and Localization:

Programs must be localized—linguistically and culturally—to reach marginalized groups. Inclusive content, assistive technologies, and flexible delivery (mobile labs, community spaces) are essential to broad uptake.

5. Measurement, Evidence, and Policy Learning:

Improved evaluation designs—randomized trials, longitudinal studies, and competency assessments aligned with frameworks—are needed to evidence what works across contexts. The OECD and World Bank frameworks encourage rigorous monitoring and national data systems to inform policy.

Recommendations:

Based on the synthesis above, the following recommendations are offered for policymakers, educators, and program designers:

1. **Adopt a competency framework as a foundation.** Use internationally recognized frameworks (e.g., Dig Comp, UNESCO) but adapt them to local contexts and languages to ensure relevance and comparability.
2. **Integrate digital literacy across curricula.** Prefer cross-curricular integration supported by discrete modules where appropriate; ensure progression across grade levels and clear proficiency descriptors.
3. **Invest in teacher capacity.** Prioritize sustained, practice-oriented professional development, coaching, and communities of practice. Teacher readiness is critical to turning infrastructure into learning gains.
4. **Address access and equity systematically.** Combine device/connectivity provision with subsidies, community outlets, and localized content to reach rural and marginalized groups. Monitor uptake with disaggregated indicators.
5. **Embed critical and safety competencies.** Ensure that curricula teach information verification, privacy practices, and resilience against misinformation—skills that preserve civic agency.
6. **Align programs to labour market needs.** For vocational and workforce programs, use labor market diagnostics to shape content and validate credentials.
7. **Measure, evaluate, and iterate.** Develop robust monitoring systems and evidence-

generation strategies to refine programs and scale proven approaches.

Conclusion:

Digital literacy is a complex, dynamic, and essential set of competencies that requires intentional policy, curriculum design, teacher support, infrastructure, and evaluation. International frameworks provide useful blueprints, but local adaptation and a focus on equity determine whether programs produce meaningful participation and opportunity. The future of digital literacy lies in integrating AI and data literacies, designing lifelong modular pathways, and scaling inclusive delivery models. Policymakers and educators who prioritize teacher development, learner-cantered pedagogy, and rigorous evaluation will be best positioned to equip citizens for the technological and civic demands of the coming decades.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

How Emerging Technologies Can Help Sustainable Agriculture and Rural Development in India

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Abstract:

Agriculture plays an important role in economic growth, food security, and rural development in India. However, climate change, population growth, water scarcity, and rising farming costs have created serious challenges for farmers, especially smallholder farmers. Emerging technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), precision agriculture, remote sensing, blockchain, and digital financial services can help address these challenges. This paper reviews the role of these technologies in improving agricultural productivity, reducing resource wastage, supporting better farming decisions, and increasing farmers' income. It also discusses how digital technologies can improve access to markets, financial services, and agricultural information. The study is based on a review of existing research papers, government reports, policy documents, and other secondary sources. The review highlights that technology can support sustainable farming, improve resource management, and strengthen agricultural supply chains. However, challenges such as poor internet connectivity, high technology costs, limited digital knowledge, data privacy, and unequal access to digital services remain important concerns. The paper suggests that better rural infrastructure, farmer training, government support, and affordable digital solutions are necessary for the successful adoption of these technologies. It concludes that the responsible and inclusive use of emerging technologies can help build a more productive, sustainable, and resilient agricultural sector and improve the livelihoods of rural communities in India.

Keywords: Smart Farming, Artificial Intelligence, Internet of Things, Precision Agriculture, Digital Agriculture, Smallholder Farmers, Sustainable Agriculture, Farmers' Income.

Introduction:

Agriculture plays an important role in food security, economic growth, and rural development. However, the agricultural sector faces several challenges, including population growth, climate change, water scarcity, rising production costs, and limited natural resources. The growing global population is increasing the demand for food, while the availability of agricultural land and water remains limited. Therefore, there is a need to adopt modern and sustainable farming practices that can increase food production while protecting the environment.

Climate change has made agriculture more challenging by affecting rainfall patterns, increasing temperatures, and causing extreme weather events. These changes can reduce crop yields, increase the risk of pest attacks, and create financial difficulties for farmers. Traditional farming practices may also contribute to soil erosion, deforestation, excessive water use, and environmental degradation. Sustainable agriculture is therefore necessary to improve productivity, protect natural resources, and ensure long-term food security.

India is one of the world's major agricultural countries, and agriculture provides livelihoods for

a large section of its population. However, Indian agriculture faces several challenges, such as small landholdings, limited access to modern technology, uncertain weather conditions, and increasing input costs. Small and marginal farmers are particularly vulnerable because they often have limited financial resources and face difficulties in accessing reliable agricultural information, credit, and modern equipment. These challenges highlight the need for affordable and practical technological solutions.

Emerging technologies offer new opportunities to improve agricultural practices. Precision agriculture uses technologies such as the Global Positioning System (GPS), Geographic Information Systems (GIS), soil sensors, and remote sensing to collect and analyze information about field conditions. This information helps farmers apply water, fertilizers, pesticides, and seeds according to the specific needs of their crops. As a result, precision agriculture can reduce unnecessary input use, improve crop management, and support better farm productivity.

Similarly, the Internet of Things (IoT) enables connected sensors and devices to monitor soil moisture, temperature, humidity, and other environmental conditions. Artificial Intelligence (AI) can analyze agricultural data to support crop disease detection, weather forecasting, yield prediction, and farm management decisions. Other technologies, such as blockchain, can improve transparency and traceability in agricultural supply chains. Digital platforms and financial services can also help farmers access market information, financial resources, and agricultural advisory services.

Despite these benefits, the adoption of emerging technologies in India remains challenging for many farmers. High initial costs, limited digital literacy, poor internet connectivity, inadequate infrastructure, and a lack of technical support can restrict their use. Farmers may also hesitate to invest in new technologies when the financial benefits are uncertain. Therefore, successful technology adoption depends not only on the availability of advanced tools but also on farmer awareness, access to credit, government support, agricultural research, and effective extension services.

The COVID-19 pandemic further highlighted the importance of resilient agricultural systems and reliable food supply chains. Disruptions in production, transportation, and market access demonstrated the need for better planning, digital connectivity, and efficient resource management. In this context, digital agriculture can help improve farm-level decision-making, reduce avoidable losses, strengthen supply chains, and create opportunities to improve farmers' incomes.

Against this background, the present study reviews the role of emerging technologies in promoting sustainable agriculture and rural development, with particular attention to India and smallholder farmers. It examines how technologies such as AI, IoT, precision agriculture, remote sensing, blockchain, and digital financial services can improve agricultural productivity, resource efficiency, market access, and farmers' livelihoods. It also considers the economic, social, infrastructural, and ethical challenges that may affect technology adoption. The study aims to highlight the importance of affordable, accessible, and inclusive technological solutions for building a productive, resilient, and sustainable agricultural sector.

Problem Statement:

Farmers need to produce food despite changing weather, limited water, high costs, and uncertain market prices. Modern technologies may help, but not every farmer can use them. Some farmers do not have reliable internet,

suitable devices, enough money, or the skills needed to use digital tools. Technology may also fail to help if its advice does not match local crops and conditions. This paper therefore looks at how technology can help Indian farmers and what support is needed to make it useful for small farmers.

Aim and Objectives:

The main aim of this paper is to explain how modern technologies can support sustainable agriculture and rural development in India.

1. To explain the main technologies used in agriculture.
2. To describe how technology may help farmers make better decisions and use resources carefully.
3. To discuss how digital tools may improve market access and access to financial services.
4. To identify the main problems that stop farmers from using new technologies.
5. To suggest ways to make these technologies affordable and accessible to small farmers.

Main Technologies Used in Agriculture:

Modern technologies are playing an important role in changing agricultural practices. Farmers have traditionally depended on their experience, local knowledge, rainfall, and seasonal conditions to grow crops. However, changes in climate, rising input costs, water shortages, and increasing food demand have created new challenges for agriculture. Emerging technologies can help farmers make better decisions, use resources carefully, reduce unnecessary expenses, and improve agricultural production.

Technologies such as precision farming, the Internet of Things (IoT), satellite images, drones, Artificial Intelligence (AI), blockchain, online platforms, and digital financial services offer new opportunities for farmers. These technologies can improve farming practices and support sustainable agriculture. However, their success depends on affordability, internet connectivity, technical knowledge, and the availability of suitable services, especially in rural areas.

1. Precision Farming:

Precision farming is a modern farming method in which farmers provide crops with the resources they need in different parts of a field. In traditional farming, farmers often apply the same amount of water, fertilizer, and pesticides across the entire field. However, soil quality, moisture, nutrient levels, and crop growth may differ from one area to another. Precision farming helps farmers understand these differences and take appropriate action.

GPS technology and digital maps can help identify the exact location of different areas within a field. Soil testing, sensors, satellite images, and other digital tools can provide information about soil conditions and crop health. Farmers can use this information to decide where more water or fertilizer is required and where fewer inputs may be sufficient.

For example, if one part of a field has enough moisture while another part is dry, a farmer can provide water mainly to the dry area. Similarly, fertiliser can be applied according to the nutrient requirements of the soil. This approach may reduce the unnecessary use of agricultural inputs, lower production costs, and reduce environmental damage caused by excessive chemicals.

Precision farming can also support better crop management and improve the use of land and water resources. However, the initial cost of equipment, software, sensors, and technical services may be high. Small farmers may find it difficult to purchase these tools individually.

Shared equipment, government support, farmer groups, and affordable agricultural services can help make precision farming more accessible.

2. Internet of Things (IoT):

The Internet of Things (IoT) refers to connected devices and sensors that collect and share information through digital systems. In agriculture, IoT can help farmers monitor soil, crops, weather conditions, water supply, and farm equipment. These devices collect information that can help farmers understand what is happening in their fields.

For example, a soil moisture sensor can measure the amount of water present in the soil. When the moisture level becomes low, the system can alert the farmer that irrigation may be required. In some systems, irrigation can also be controlled automatically. Other sensors can measure temperature, humidity, rainfall, and water flow.

IoT technology can help farmers save water, reduce unnecessary field visits, and manage agricultural activities more efficiently. It may also support greenhouse farming, livestock monitoring, and the management of water pumps. Timely information can help farmers respond more quickly to changing conditions.

However, IoT systems require reliable equipment, electricity or battery power, and, in many cases, internet connectivity. Devices may also need regular maintenance and replacement. Farmers must understand how to interpret the information provided by sensors. Affordable devices, local technical support, and training can help small farmers benefit from this technology.

3. Satellite Images and Drones:

Satellite images and drones are useful tools for observing agricultural land from above. Satellites collect images of large areas, while drones can capture detailed pictures of specific fields. These images can provide information about crop growth, vegetation conditions, water availability, and possible damage caused by pests, diseases, floods, or droughts.

Farmers and agricultural experts can use satellite images to identify areas where crops are growing well and areas where plants may be under stress. Repeated images can help monitor changes in crop conditions over time. Drones can provide more detailed information about particular sections of a field and may help identify problems that are difficult to observe from the ground.

For example, after heavy rainfall or flooding, drone images may help identify damaged areas of a field. Such information can support crop assessment and may also assist in documenting damage for crop insurance claims, depending on the requirements of the insurance provider.

These technologies can save time and improve the monitoring of large agricultural areas. However, good-quality images do not always provide a complete explanation of the problem. Farmers may need expert advice to determine whether poor crop growth is caused by water shortages, nutrient deficiencies, pests, or other factors. The cost of drones, image analysis, and technical services can also be a challenge. Affordable shared services and support from agricultural institutions can improve access to these tools.

4. Artificial Intelligence (AI):

Artificial Intelligence (AI) is a technology that uses computer systems to analyze information, identify patterns, and support decision-making. In agriculture, AI can study information about soil, weather, crop growth, pests, diseases, and past production to provide useful suggestions to farmers.

AI-based applications may help identify crop diseases from photographs of leaves. They can also support weather forecasting, pest-risk assessment, irrigation planning, and crop-yield

estimation. By combining weather information with crop and soil data, these systems may help farmers decide when to irrigate, apply fertilizer, or take action against a possible pest problem.

For example, if an AI-based system identifies signs of a crop disease from an image, it may alert the farmer to investigate the problem at an early stage. Early identification can help reduce crop damage, although the farmer may still need confirmation from an agricultural expert before using pesticides or other treatments.

AI can also support agricultural extension services by providing information in local languages and helping farmers access advice more quickly. However, the quality of AI recommendations depends on the accuracy of the data used to develop and operate the system. Advice developed for one region may not always be suitable for another region with different crops, soil, and weather conditions.

Some farmers may also face difficulties because of limited digital literacy, language barriers, or a lack of internet access. Therefore, AI should support farmers' knowledge and expert guidance rather than replace them completely. Local information, farmer training, and reliable agricultural advice are essential for its effective use.

5. Blockchain Technology:

Blockchain is a digital system used to maintain records of transactions and other information across a network. In agriculture, blockchain may be used to record information about the origin of agricultural products, their movement through the supply chain, and transactions between farmers, traders, processors, and retailers.

For example, information about a batch of vegetables may be recorded when it leaves a farm and updated as it moves through storage, transport, and retail. Buyers may then be able to check the recorded information about the product's origin and journey, where the system provides access to those records.

This technology may improve transparency, support product traceability, and help build trust between farmers and buyers. It may be useful for agricultural products that require information about their source, quality standards, or handling conditions.

However, blockchain cannot automatically guarantee that all recorded information is correct. If incorrect information is entered at the beginning, the system may preserve that incorrect information. The technology also requires suitable digital infrastructure, cooperation among supply-chain participants, and clear rules about who can enter or access information.

For small farmers, the cost and complexity of blockchain systems may be significant. Therefore, its use should depend on practical needs, affordability, and the benefits it provides. Simpler digital record systems may be sufficient for some agricultural activities.

6. Online Platforms and E-commerce:

Online platforms and e-commerce services are creating new ways for farmers to obtain agricultural information and connect with markets. Through mobile applications, websites, and digital platforms, farmers may access weather updates, crop advice, market prices, information about seeds and fertilizers, and details about government agricultural schemes.

Some platforms also connect farmers directly with buyers, wholesalers, retailers, food-processing companies, and other market participants. This may give farmers access to a wider range of customers and help them compare prices in different markets. Digital platforms can also support the purchase of agricultural inputs and provide information about available services.

For example, a farmer may use a mobile application to compare market prices before

deciding where to sell a crop. A digital marketplace may also help a group of farmers find buyers for their produce. Such services may improve access to market information and create additional selling opportunities.

However, using an online platform does not guarantee a higher selling price or greater profit. Transport expenses, storage facilities, product quality, packaging, platform charges, and market demand continue to influence farmers' earnings. Farmers may also face difficulties with digital payments, online fraud, and understanding platform rules.

To improve the benefits of online platforms, farmers need digital literacy, reliable market information, transparent charges, and access to transport and storage services. Local-language applications and assistance through farmer organizations can make these services easier to use.

7. Digital Financial Services:

Digital financial services include online payments, electronic bank transfers, mobile banking, digital credit services, and certain services related to agricultural insurance. These services can help farmers receive payments, transfer money, manage financial transactions, and access information about available financial products.

For example, a farmer may receive payment for agricultural produce directly into a bank account instead of relying entirely on cash transactions. Digital systems may also help eligible farmers receive government benefits through direct bank transfers. Depending on availability and eligibility, farmers may use digital channels to access credit or insurance-related services.

Digital financial services can reduce the time and effort required for some transactions. They may improve financial access for farmers living far from bank branches and help maintain records of payments. These records can support better household budgeting and farm financial management.

However, digital financial services also involve risks and challenges. Farmers may face poor network connectivity, failed transactions, limited digital knowledge, or difficulties in resolving payment problems. Fraudulent messages, fake applications, and requests for confidential banking information can also lead to financial losses.

Therefore, farmers need clear instructions, secure digital systems, accessible customer support, and awareness of safe banking practices. Financial institutions and government agencies should provide suitable assistance, especially to farmers who have limited experience with digital services.

How Technology May Help Farmers:

1. Better Decisions:

Farmers can make better decisions when they receive timely information about weather, soil, crops, pests, and market prices. Advice can be shared through mobile phones, text messages, voice calls, and other services. It is most useful when it is easy to understand, available in local languages, and suited to local farming conditions.

2. Saving water and other inputs:

Sensors and precision farming tools may help farmers use water, fertilisers, pesticides, and seeds more carefully. Using only what is needed can reduce waste and may lower costs. The results depend on whether the information and advice are accurate.

3. Crop production and income:

Better crop monitoring and early warnings may help farmers reduce some crop losses. Online market information may help them compare prices and contact buyers. However, technology does not always increase income.

Costs, crop yields, market prices, weather, and the type of service all affect the final result.

4. Food storage and supply chains:

Digital records and better coordination can help connect farmers with transport, storage, processors, and markets. The India-focused paper describes a banana supply-chain example in which better infrastructure, traceability, and packaging were linked with longer shelf life and lower wastage. This example suggests that technology works better when it is supported by good storage and transport.

5. Access to markets and financial services:

Digital platforms may help farmers find buyers and access payments, loans, insurance, or government support. These services can reduce some difficulties caused by distance and paperwork. However, they must be easy to use and provide help to farmers who have limited digital skills or weak internet access.

6. Preparing for climate risks:

Weather updates and crop alerts can help farmers prepare for droughts, heavy rain, pests, and other risks. Digital tools can support planning, but they cannot remove all risks. Farmers may also need suitable seeds, irrigation, insurance, credit, and advice from agricultural experts.

Main Challenges:

- **High cost:** Devices, sensors, software, and repairs can be too expensive for many small farmers.
- **Poor internet and electricity:** Some rural areas do not have reliable internet, mobile coverage, or electricity.
- **Lack of training:** Farmers may need simple demonstrations and ongoing help to use digital tools.
- **Lack of trust:** Farmers may not follow advice if they do not understand it or if it does not fit local conditions.
- **Data privacy:** Farmers should know what information is collected, who can use it, and how it is protected.
- **Unequal access:** Women farmers, remote communities, and people with limited literacy may face extra barriers.
- **Wrong information:** Poor data or faulty equipment can lead to incorrect advice and farming losses.
- **Other basic needs:** Technology cannot replace good roads, storage, transport, credit, markets, and agricultural extension services.

Discussion:

This paper suggest that different technologies can help with different farming needs. Sensors and AI can help farmers understand crop conditions. Satellite images and drones can help monitor fields. Online platforms may improve access to information and markets. Digital financial services may support payments, credit, and insurance. These tools can work together, but their success depends on farmers' needs and local conditions.

Technology is not enough by itself. Farmers need affordable services, training, reliable internet, and advice they can trust. Shared equipment, cooperatives, farmer organisations, and local service providers may help reduce costs. Support should be available in local languages and should match the crops and conditions of each area.

It is also important to check whether technology creates real benefits. For example, saving water or receiving weather information may improve farming decisions, but the effect on income depends on costs, crop production, and selling prices. Future studies should measure changes in income, input costs, crop losses, water use, and access for different groups of farmers.

Recommendations:

1. Improve internet, electricity, roads, and storage facilities in rural areas.
2. Provide practical training through agricultural universities, Krishi Vigyan Kendras, extension workers, and farmer groups.
3. Make digital tools affordable and easy to use, and provide shared services where possible.
4. Offer farming advice in local languages and match it to local crops and weather.
5. Improve cooperation between farmers, researchers, government departments, technology companies, banks, and buyers.
6. Protect farmers' data and explain clearly how it will be collected, stored, and used.
7. Make sure women farmers, small farmers, tenant farmers, and remote communities can also use digital services.
8. Check whether programmes improve income, reduce costs, save water, reduce crop losses, and satisfy farmers.
9. Keep offline support available for farmers who cannot use mobile or online services.
10. Use technology together with good agricultural advice, infrastructure, and fair market access.

Conclusion:

Emerging technologies offer several opportunities to improve agricultural practices and support sustainable rural development. Precision farming can help farmers use inputs more carefully, IoT can provide timely information about field conditions, and satellite images and drones can support crop monitoring. AI may improve agricultural decision-making, while blockchain can support traceability and transparency. Online platforms can improve access to market information, and digital financial services can make certain financial transactions easier.

However, the benefits of these technologies are not automatic. High costs, limited internet access, lack of technical knowledge, and inadequate support services may prevent small farmers from using them effectively. To address these challenges, affordable technology, farmer training, local-language services, reliable rural infrastructure, and suitable government support are important. When these conditions are met, emerging technologies can contribute to more efficient farming, better resource management, and improved opportunities for rural communities.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

अभिलेखांचे डिजिटल जतन: आधुनिक तंत्रज्ञान, आव्हाने आणि भविष्यातील दिशा

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DOI - 10.5281/zenodo.24335067

प्रस्तावना:

भारत हा प्राचीन संस्कृती, समृद्ध ऐतिहासिक वारसा आणि विविधांगी ज्ञानपरंपरेने संपन्न असलेला देश आहे. भारतीय संस्कृतीचा इतिहास हजारो वर्षांचा असून या दीर्घ परंपरेतून समाजजीवन, धर्म, तत्त्वज्ञान, साहित्य, कला, स्थापत्य, संगीत, नृत्य, लोकपरंपरा, भाषा, हस्तकला आणि वैज्ञानिक विचारांचा विकास झाला आहे. वेद, उपनिषदे, पुराणे, बौद्ध व जैन साहित्य, प्राचीन हस्तलिखिते, शिलालेख, ताम्रपट, नाणी, ऐतिहासिक वास्तू, मंदिरे, लेणी, लोककथा, लोकगीते, सण-उत्सव आणि पारंपरिक ज्ञानपद्धती हे भारतीय सांस्कृतिक वारशाचे महत्त्वपूर्ण घटक आहेत. भारतीय ज्ञान परंपरा ही केवळ प्राचीन ग्रंथांपुरती मर्यादित नसून त्यामध्ये आयुर्वेद, योग, गणित, खगोलशास्त्र, कृषिज्ञान, जलव्यवस्थापन, पर्यावरण संवर्धन, शिक्षणपद्धती आणि लोकजीवनातून विकसित झालेल्या अनुभवाधारित ज्ञानाचाही समावेश होतो. या वारशाचे जतन करणे, त्याचा अभ्यास करणे आणि पुढील पिढ्यांपर्यंत त्याचे हस्तांतरण करणे ही वर्तमान काळातील महत्त्वपूर्ण जबाबदारी आहे.

आधुनिक काळात जागतिकीकरण, नागरीकरण, औद्योगिकीकरण, पर्यावरणीय बदल आणि जीवनशैलीतील परिवर्तन यांमुळे अनेक पारंपरिक ज्ञानपद्धती, लोककला, बोलीभाषा, मौखिक परंपरा आणि ऐतिहासिक साधने लोप पावण्याच्या स्थितीत आहेत. प्राचीन हस्तलिखितांची जीर्ण अवस्था, ऐतिहासिक वास्तूंचे नुकसान, दुर्मीळ दस्तऐवजांची अनुपलब्धता, पारंपरिक ज्ञानाचे अपुरे दस्तऐवजीकरण आणि सांस्कृतिक साधनांच्या संवर्धनासाठी आवश्यक असलेल्या संसाधनांची कमतरता ही प्रमुख आव्हाने आहेत. त्यामुळे सांस्कृतिक वारसा आणि भारतीय ज्ञान परंपरेचे संरक्षण करण्यासाठी पारंपरिक जतन पद्धतींबरोबरच आधुनिक डिजिटल तंत्रज्ञानाचा प्रभावी वापर करणे आवश्यक झाले आहे.

डिजिटल तंत्रज्ञानामुळे सांस्कृतिक वारशाचे संकलन, दस्तऐवजीकरण, वर्गीकरण, संवर्धन आणि प्रसारण अधिक सुलभ झाले आहे. डिजिटल छायाचित्रण, उच्च गुणवत्तेचे स्कॅनिंग, कृत्रिम बुद्धिमत्ता (Artificial Intelligence), मशीन लर्निंग, त्रिमितीय प्रतिकृती (3D Modelling), आभासी वास्तव (Virtual Reality), संवर्धित वास्तव (Augmented Reality), भौगोलिक माहिती प्रणाली (GIS), डिजिटल संग्रहालये आणि ऑनलाइन अभिलेखागारे यांसारख्या तंत्रज्ञानाच्या साहाय्याने ऐतिहासिक वास्तू, पुरातत्त्वीय अवशेष, हस्तलिखिते, शिलालेख आणि मौखिक परंपरांचे डिजिटल स्वरूपात जतन करता येते. या माध्यमांमुळे संशोधक, विद्यार्थी, शिक्षक आणि सामान्य नागरिकांना भौगोलिक

अंतराची मर्यादा ओलांडून सांस्कृतिक साधनांचा अभ्यास करता येतो. तसेच डिजिटल माध्यमांद्वारे भारतीय ज्ञान परंपरेतील विविध संकल्पना, ग्रंथ आणि परंपरा जागतिक स्तरावर पोहोचविण्याची संधी उपलब्ध झाली आहे.

डिजिटल जतनाची प्रक्रिया अनेक आव्हानांनी युक्त आहे. डिजिटल साधनांची निर्मिती व देखभाल करण्यासाठी लागणारा खर्च, तांत्रिक कौशल्यांचा अभाव, डिजिटल माहितीची दीर्घकालीन सुरक्षितता, तंत्रज्ञानातील वेगवान बदल, कॉपीराइट आणि बौद्धिक संपदा हक्क, माहितीची सत्यता, सांस्कृतिक संदर्भांचे योग्य प्रतिनिधित्व आणि स्थानिक समुदायांच्या पारंपरिक ज्ञानावरील अधिकार हे महत्त्वाचे प्रश्न आहेत. विशेषतः आदिवासी, ग्रामीण आणि स्थानिक समुदायांकडे पिढ्यान्पिढ्या जतन झालेले ज्ञान डिजिटल स्वरूपात नोंदविताना त्यांच्या संमतीचा, सांस्कृतिक संवेदनशीलतेचा आणि ज्ञानावरील अधिकारांचा आदर करणे आवश्यक आहे. केवळ माहितीचे डिजिटल रूपांतर करणे म्हणजे सांस्कृतिक जतन नव्हे, तर त्या माहितीचा ऐतिहासिक संदर्भ, सामाजिक महत्त्व आणि सांस्कृतिक अर्थ सुरक्षित ठेवणेही तितकेच महत्त्वाचे आहे.

या पार्श्वभूमीवर, 'सांस्कृतिक वारसा आणि भारतीय ज्ञान परंपरा यांचे डिजिटल जतन: आधुनिक तंत्रज्ञान, आव्हाने आणि भविष्यातील दिशा' हा विषय विशेष महत्त्व प्राप्त करतो. या विषयाच्या माध्यमातून सांस्कृतिक वारसा आणि भारतीय ज्ञान परंपरेच्या जतनासाठी वापरण्यात येणाऱ्या आधुनिक डिजिटल तंत्रज्ञानाचा अभ्यास करता येतो. त्याचबरोबर विविध डिजिटल उपक्रमांची उपयुक्तता, त्यांच्या अंमलबजावणीतील मर्यादा, शैक्षणिक व संशोधन क्षेत्रातील योगदान आणि भविष्यातील संभाव्य दिशा यांचे विश्लेषण करता येते. शासकीय संस्था, विद्यापीठे, ग्रंथालये, संग्रहालये, अभिलेखागारे, संशोधन संस्था आणि स्थानिक समुदाय यांच्या समन्वयातून डिजिटल वारसा संवर्धन अधिक प्रभावी करण्याच्या उपाययोजनांचाही विचार करता येतो.

एकंदरीत, सांस्कृतिक वारसा आणि भारतीय ज्ञान परंपरेचे डिजिटल जतन हे केवळ भूतकाळातील ज्ञानाचे संरक्षण करण्याचे साधन नसून वर्तमानातील संशोधन, शिक्षण, सांस्कृतिक अस्मिता आणि भविष्यातील ज्ञाननिर्मिती यांना दिशा देणारी प्रक्रिया आहे. आधुनिक तंत्रज्ञान आणि पारंपरिक ज्ञान यांचा समन्वय साधून भारताचा समृद्ध सांस्कृतिक वारसा अधिक सुरक्षित, सुलभ, सर्वसमावेशक आणि शाश्वत स्वरूपात पुढील पिढ्यांपर्यंत पोहोचविणे ही काळाची गरज आहे. त्यामुळे डिजिटल जतनाच्या संधींचा योग्य उपयोग करणे, त्यासमोरील आव्हानांवर मात करणे आणि भविष्यासाठी प्रभावी धोरणे विकसित करणे हे या विषयाच्या अभ्यासाचे प्रमुख उद्दिष्ट ठरते.

भारत हा विविध कला, भाषा, तत्त्वज्ञान, आयुर्वेद, खगोलशास्त्र आणि गणिताचा उगम देश आहे. हा अमूल्य वारसा शतकानुशतके ताडपत्रे, भोजपत्रे, जुनी हस्तलिखिते आणि मौखिक परंपरेच्या (उदा. वेदांचे पाठांतर) माध्यमातून टिकून राहिला. परंतु, नैसर्गिक आपत्ती, हवामानातील बदल, कागदाचे आयुष्य आणि मानवी दुर्लक्ष यांमुळे हा वारसा नष्ट होण्याचा धोका निर्माण झाला आहे.

आधुनिक २१ व्या शतकात 'डिजिटल जतन' हे या समस्येवरील सर्वात प्रभावी माध्यम म्हणून समोर आले आहे. माहिती तंत्रज्ञानाचा (IT) वापर करून या प्राचीन ज्ञानाला डिजिटल स्वरूपात (High-Resolution Images, Cloud Platforms, 3D Models) रूपांतरित करणे, म्हणजेच डिजिटल जतन होय. हे केवळ जुन्या गोष्टी साठवणे नव्हे, तर राष्ट्रीय शैक्षणिक धोरण २०२० (NEP

2020) च्या उद्दिष्टांनुसार हे ज्ञान नव्या पिढीला सोप्या भाषेत उपलब्ध करून देणे आहे.

संशोधनाचे उद्देश (Objectives of the Research):

1. भारतीय ज्ञान परंपरा आणि सांस्कृतिक वारशाच्या जतनामध्ये डिजिटल तंत्रज्ञानाची भूमिका स्पष्ट करणे.
2. सध्या भारतात सुरू असलेल्या प्रमुख डिजिटल उपक्रमांचा (उदा. सी-डॅकचे प्रयत्न) अभ्यास करणे.
3. प्राचीन हस्तलिखिते आणि प्रादेशिक भाषांच्या (उदा. मराठी, मोडी) जतनासमोरील मुख्य आव्हाने शोधणे.
4. डिजिटल डेटा दीर्घकाळ सुरक्षित ठेवण्यासाठी योग्य उपाययोजना सुचवणे.

परिकल्पना :

- आधुनिक डिजिटल तंत्रज्ञानाचा (AI आणि 3D स्कॅनिंग) प्रभावी वापर केल्यास भारताचा लुप्त होत चाललेला अमूल्य सांस्कृतिक वारसा कायमस्वरूपी आणि सुरक्षितपणे जतन करता येऊ शकतो.
- डिजिटल जतनामुळे जागतिक स्तरावर भारतीय ज्ञान परंपरेची (IKS) उपलब्धता आणि संशोधनाचा वेग वाढेल.

संशोधन पूर्व साहित्य (Literature Review):

- **शर्मा आणि जोशी (२०२१)** यांच्या मते, भारतातील संग्रहालयांचे डिजिटायझेशन केल्यामुळे जागतिक संशोधकांना भारताच्या प्राचीन कलाकृतींचा अभ्यास करणे सोपे झाले आहे. 'जतन' सॉफ्टवेअरने यामध्ये मोठी क्रांती घडवली आहे.
- **कुलकर्णी (२०२३)** यांनी मोडी आणि प्राचीन मराठी हस्तलिखितांच्या डिजिटल जतनावरील अभ्यासात असे नमूद केले आहे की, ऑप्टिकल कॅरेक्टर रेकग्निशन (OCR) तंत्रज्ञान भारतीय भाषांसाठी अजूनही पूर्णपणे विकसित होणे बाकी आहे, ज्यामुळे हस्तलिखितांचे मजकुरात रूपांतर करण्यात अडचणी येत आहेत.
- **सांस्कृतिक मंत्रालय अहवाल (२०२४)** भारत सरकारच्या अहवालानुसार, 'ज्ञान भारतम मिशन' अंतर्गत लाखो हस्तलिखितांचे यशस्वी डिजिटायझेशन करण्यात आले असून, यामुळे भारतीय ज्ञान परंपरा (IKS) शाळा-कॉलेजांपर्यंत पोहोचवण्यास गती मिळाली आहे.

संशोधन पद्धती:

प्रस्तुत संशोधनासाठी वर्णनात्मक आणि विश्लेषणात्मक संशोधन पद्धतीचा वापर करण्यात आला आहे. हा लेख प्रामुख्याने दुय्यम माहिती स्रोतांवर आधारित आहे. यामध्ये भारत सरकारच्या सांस्कृतिक मंत्रालयाचे अहवाल, राष्ट्रीय हस्तलिखित मिशनची (National Mission for Manuscripts) आकडेवारी आणि विविध आंतरराष्ट्रीय डिजिटल आर्काइव्ह्जच्या संकेतस्थळांचा अभ्यास करून निष्कर्ष काढण्यात आले आहेत.

चर्चा व विश्लेषण

अ) भारतीय ज्ञान परंपरा (IKS) आणि महाराष्ट्राचा सांस्कृतिक वारसा

भारतीय ज्ञान परंपरेचा आवाका केवळ संस्कृत ग्रंथांपुरता मर्यादित नाही, तर त्यात प्रादेशिक भाषा आणि लोकपरंपरांचा मोलाचा वाटा आहे. महाराष्ट्राचा विचार केल्यास, संत ज्ञानेश्वर (ज्ञानेश्वरी), संत तुकाराम (गाथा) आणि संत एकनाथ (एकनाथी भागवत) यांचे साहित्य हे केवळ धार्मिक नसून त्यात तत्कालीन समाजशास्त्र, तत्त्वज्ञान आणि भाषाविज्ञानाचा अमूल्य ठेवा आहे. तसेच, शिवकाळ

आणि पेशवेकाळातील प्रशासकीय, राजकीय आणि सामाजिक व्यवहारांची नोंद 'मोडी लिपीत' आहे. पुणे येथील 'पेशवे दप्तर' आणि तंजावरच्या 'सरस्वती महाल ग्रंथालयात' लाखो मोडी दस्तऐवज आहेत. हवामान, कीड आणि कागदाच्या खराब गुणवत्तेमुळे हा इतिहास नष्ट होण्याच्या मार्गावर होता. या अमूल्य ऐतिहासिक ठेव्याला पुनरुज्जीवित करण्यासाठी आधुनिक डिजिटल जतन तंत्रज्ञान वरदान ठरत आहे.

ब) डिजिटल जतनासाठी वापरले जाणारे प्रगत तंत्रज्ञान

प्राचीन ज्ञान साठवण्यासाठी आणि त्याचा अभ्यास करण्यासाठी प्रामुख्याने खालील चार प्रगत तंत्रज्ञानांचा वापर केला जात आहे. संशोधनाच्या सुलभतेसाठी हे तंत्रज्ञान खालील तक्त्यामध्ये वर्गीकृत केले आहे

क्र.	तंत्रज्ञान (Technology)	मुख्य कार्यपद्धती (Working Mechanism)	सांस्कृतिक जतनामधील उपयोग (Application in Heritage)
१	**AI आणि प्रगत OCR / HTR**	कॉम्प्युटर व्हिजन आणि डीप लर्निंग मॉडेल्सद्वारे हस्तलिखितांच्या वळणांचे संगणकीय विश्लेषण करणे.	मोडी, ब्राह्मी किंवा जुन्या देवनागरी हस्तलिखितांचे स्वयंचलित आधुनिक मराठीत रूपांतर करणे.
२	**३डी लेझर स्कॅनिंग व LiDAR**	ऐतिहासिक वास्तूवर लाखो लेझर किरण सोडून १ मिमीच्या अचूकतेसह गुणक डेटा गोळा करणे.	अजिंठा-वेरूळ लेण्या किंवा रायगड किल्ल्याचा 'डिजिटल ट्विन' (Digital Twin) तयार करणे.
३	**मल्टिस्पेक्ट्रल इमेजिंग (MSI)**	वेगवेगळ्या वेव्हलेंथच्या (UV आणि Infrared) प्रकाशाचा वापर करून छायाचित्रे घेणे.	काळ्या पडलेल्या किंवा पुसट झालेली शाई असलेल्या ताडपत्रांवरील मूळ अक्षरे स्पष्ट करणे.
४	**मेटाडेटा आणि क्लाउड आर्काइव्ह**	साहित्याचा काळ, लेखक आणि विषयांनुसार (उदा. आयुर्वेद, गणित) डिजिटल टॅगिंग करणे.	जगभरातील संशोधकांसाठी ऑनलाइन शोधण्यायोग्य (Searchable) डेटाबेस तयार करणे.

१. कृत्रिम बुद्धिमत्ता (AI) आणि प्रगत OCR (Optical Character Recognition):

पारंपारिक OCR सॉफ्टवेअर हे केवळ इंग्रजी किंवा छापील देवनागरी भाषा वाचू शकतात. परंतु, हस्तलिखित मोडी लिपी किंवा ताडपत्रांवरील जुनी अक्षरे वाचणे त्यांना शक्य नसते. यासाठी आता AI-driven Handwriting Recognition (HTR) आणि Deep Learning मॉडेल्स वापरले जात आहेत. संगणक जुनी हस्तलिखिते स्वतः वाचून त्यांचे आधुनिक देवनागरी (मराठी) किंवा इंग्रजी भाषेत स्वयंचलित रूपांतर (Transliteration) करू शकतो.

२. ३डी लेझर स्कॅनिंग आणि LiDAR (Light Detection and Ranging):

महाराष्ट्रातील अजिंठा-वेरूळच्या लेण्या, रायगड, राजगड यांसारखे ऐतिहासिक किल्ले आणि प्राचीन मंदिरे यांच्या जतनासाठी हे तंत्रज्ञान वापरले जाते. याद्वारे वास्तूचा एक-एक मिलीमीटरचा अचूक डेटा मिळतो आणि संगणकावर तिचा हुबेहूब ३डी प्रतिकृती तयार होते. भविष्यात एखाद्या नैसर्गिक आपत्तीमुळे वास्तूचे नुकसान

झाले, तरी या ३डी डेटाच्या साहाय्याने ती पुन्हा तशीच उभी करता येऊ शकते. तसेच, जगभरातील लोक आभासी सफर (Virtual Reality) करू शकतात.

क) भारतातील यशस्वी प्रायोगिक प्रकल्प :

१) सी-डॅक (C-DAC), पुणे आणि 'जतन' सॉफ्टवेअर:

सी-डॅकने विकसित केलेले 'जतन' हे म्युझियम क्युरेशन सॉफ्टवेअर आहे. महाराष्ट्रातील छत्रपती शिवाजी महाराज वस्तू संग्रहालय (मुंबई) आणि राजा दिनकर केळकर संग्रहालय (पुणे) यांसह देशातील सर्व प्रमुख संग्रहालयातील प्राचीन नाणी, शस्त्रे, चित्रे आणि वस्त्रांचे डिजिटल कॅटलॉगिंग या सॉफ्टवेअरद्वारे यशस्वीरित्या पूर्ण झाले आहे.

२) मोडी लिपी डिजिटायझेशन प्रकल्प:

पुणे विद्यापीठ, इतिहास अभ्यासक आणि काही खाजगी संस्थांच्या तंत्रज्ञांनी मिळून 'पेशवे दप्तरा'तील लाखो मोडी कागदपत्रांचे स्कॅनिंग पूर्ण केले आहे. आता हे दस्तऐवज जगभरातील इतिहास संशोधकांसाठी ऑनलाइन अभ्यासाकरिता उपलब्ध करून दिले जात आहेत.

३) नॅशनल डिजिटल लायब्ररी ऑफ इंडिया

आयआयटी खडगपूरच्या माध्यमातून लाखो प्राचीन पुस्तके आणि ग्रंथ मोफत ऑनलाइन उपलब्ध करून दिले आहेत.

ड) आव्हाने आणि तांत्रिक मर्यादा

जरी तंत्रज्ञान प्रगत असले, तरी भारतीय संदर्भात काही मोठ्या अडचणी आहेत:

१) डेटा साठवणुकीचे आयुष्य

- आज आपण डेटा ज्या पेनड्राइव्ह, हार्डडिस्क किंवा क्लाउडवर ठेवतो, ते तंत्रज्ञान २०-३० वर्षांनंतर बदलेल. जुन्या फाईल्स नवीन सॉफ्टवेअरमध्ये उघडतील की नाही, हा मोठा प्रश्न असतो. डिजिटल डेटा साठवण्यासाठी वापरल्या जाणाऱ्या हार्डडिस्क किंवा सर्व्हर्सचे आयुष्य १५-२० वर्षांपेक्षा जास्त नसते. सॉफ्टवेअर सतत अपडेट होत असल्यामुळे जुन्या फाईल्स कालबाह्य होण्याचा धोका असतो. याला 'डिजिटल ऑब्सोलेसन्स' म्हणतात.

२) तज्ज्ञांची कमतरता:

- संगणक तंत्रज्ञान समजणारे आणि त्याच वेळी मोडी किंवा प्राचीन संस्कृत-प्राकृत भाषा जाणणारे तज्ज्ञ (Cross-disciplinary Experts) भारतात खूप कमी आहेत. जुनी हस्तलिखिते वाचू शकणारे आणि सोबतीने संगणकाचे ज्ञान असणारे तज्ज्ञ खूप कमी आहेत.

३) सायबर सुरक्षा आणि सत्यता:

- डिजिटल डेटा हॅक होण्याचा किंवा मूळ ज्ञानात फेरबदल (Data Manipulation) होण्याचा धोका असतो.

निष्कर्ष (Conclusion):

- सांस्कृतिक वारसा आणि भारतीय ज्ञान परंपरा यांचे डिजिटल जतन करणे ही केवळ एक तांत्रिक प्रक्रिया नसून भारताची बौद्धिक संपदा वाचवण्याचे राष्ट्र उभारणीचे कार्य आहे.
- संशोधनातून असे सिद्ध होते की, डिजिटल तंत्रज्ञानामुळे प्राचीन ज्ञानाचे आयुष्य वाढले आहे तसेच, जगभरातील संशोधकांसाठी हा डेटा सहज उपलब्ध होत आहे
- तांत्रिक बदल आणि लिपींच्या अडचणींवर मात करण्यासाठी आयआयटी (IITs) आणि सी-

डॅकसारख्या संस्थांनी प्रादेशिक भाषांसाठीचे विशेष AI टूल्स विकसित करणे गरजेचे आहे.

- भारताला जागतिक स्तरावर 'ज्ञान केंद्र' (Knowledge Hub) बनवण्यासाठी हे डिजिटल जतन अत्यंत महत्त्वपूर्ण पाऊल ठरेल.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

कृत्रिम बुद्धिमत्ता व रोजगारातील बदल

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DOI - 10.5281/zenodo.24335088

जागतिक स्तरावर मानवी इतिहास बघितला असता अनेक क्रांती घडून आलेल्या आहेत. उदा. औद्योगिक क्रांती, संगणक क्रांती, इंटरनेट क्रांती इ. यामुळे जागतिक अर्थव्यवस्थेमध्ये उत्पादन पद्धती, व्यवसाय पद्धती व रोजगाराच्या स्वरूपात मूलभूत बदल घडून आलेले आहेत. प्रत्येक तांत्रिक क्रांतीने सुरुवातीला भीती निर्माण केली, पण शेवटी प्रत्येक क्रांती नवीन संधी घेऊन आली. 1980 च्या दशकात भारतामध्ये संगणक क्रांती आली तेव्हा सुरुवातीला रोजगार कमी होण्याची भीती व्यक्त करण्यात आली होती परंतु कालांतराने संगणक क्रांतीतून अनेक नवीन व्यवसाय व रोजगार क्षेत्र भारतामध्ये निर्माण झाली. यातून पुढे सॉफ्टवेअर, संगणक दुरुस्ती, माहिती तंत्रज्ञान, डिजिटल मार्केटिंग, इंटरनेट क्रांती त्यानंतर ई-कॉमर्स यासारखे नवीन क्षेत्रे भारतामध्ये विकसित झाले. या साखळीतील पुढची पायरी म्हणजेच वर्तमानकालीन एआयक्रांती किवा कृत्रिम बुद्धीमत्ता होय.

कृत्रिम बुद्धिमत्ता आधुनिक काळात आर्थिक सामाजिक तांत्रिक परिवर्तन घडविणारी एक महत्त्वपूर्ण शक्ति म्हणून 21 व्या शतकात उदयास आलेली आहे. अर्थव्यवस्थेतील विविध क्षेत्रात उदाहरणार्थ कृषी, उद्योग, सेवा क्षेत्र, आरोग्य, शिक्षण, बँकिंग, माहिती तंत्रज्ञान, ई-कॉमर्स इत्यादी विविध क्षेत्रांमध्ये याचा वापर झपाट्याने आज होत आहे. कृत्रिम बुद्धिमत्तेमुळे कामाची गती वाढलेली आहे, त्याचबरोबर आपण केलेल्या कामात अचूकता व त्या कामाची उत्पादकता वाढण्यास त्यामुळे मदत होत आहे, परंतु पारंपरिक रोजगाराच्या स्वरूपात यामुळे बदल होण्याची शक्यता निर्माण झाली आहे यामुळे संगणकाद्वारे करण्यात येणारी कामे ही स्वयंचलित होण्याचा धोका जगापुढे निर्माण झाला आहे. रोजगार संधीचा जर विचार केला तर यामुळे डेटा विश्लेषक, एआय प्रशिक्षक, डिजिटल उद्योजक, सायबर सुरक्षा तज्ञ यासारख्या नवीन रोजगार संधी निर्माण होत आहेत, यामुळे विविध क्षेत्रातील रोजगारामध्ये निर्माण होणाऱ्या बदलांचा अभ्यास करणे व त्याचा पारंपारिक नोकऱ्यांवरील होणारा परिणाम स्पष्ट करणे आणि एआयएमधून निर्माण होणाऱ्या नवीन रोजगाराच्या संधी यांचे विश्लेषण करणे महत्त्वाचे ठरते

भारतातील अर्थव्यवस्थेचा विचार करता रोजगार व्यवस्था, शिक्षण व्यवस्था, प्रशिक्षण व्यवस्था, कौशल्य विकास या संदर्भात ए आय चे महत्त्व विशेष आहे यामुळे केवळ रोजगार जाणार नाहीत त्याचबरोबर तंत्रज्ञानाची क्रांती होऊन रोजगाराचे स्वरूप बदलणार आहे. नवीन आर्थिक संधी निर्माण होण्यास मदत मिळणार आहे. या संधीचा लाभ

मिळविण्यासाठी भारतामध्ये योग्य धोरणांची आवश्यकता आहे. योग्य प्रशिक्षण केंद्र उभारणे, डिजिटल कौशल्य विकसित करणे, मानवी सृजनशीलता यासारख्या धोरणांची अंमलबजावणी करणे आवश्यक आहे.

आज इंटरनेट आणि संगणकांशिवाय जगाची कल्पनाही करणे कठीण झाले आहे. एआय ही त्याच प्रकारची पुढची मोठी क्रांती आहे. यामुळे नवीन संधी निर्माण होणार आहेत, तसेच काही पारंपरिक व्यवसायांवर परिणामही होणार आहे.

संशोधनाची उद्दिष्टे:

प्रस्तुत शोधनिबंधाची प्रमुख उद्दिष्टे पुढीलप्रमाणे आहेत.

1. एआयमुळे पारंपरिक नोकऱ्यांवर होणाऱ्या संभाव्य परिणामांचा अभ्यास करणे.
2. एआयमुळे निर्माण होणाऱ्या नवीन करिअर आणि उद्योजकीय संधींचे विश्लेषण करणे.
3. एआयचा भारतीय अर्थव्यवस्थेवर होणाऱ्या संभाव्य परिणामांचा अभ्यास करणे.

कृत्रिम बुद्धिमत्ता (एआय) संकल्पना :

कृत्रिम बुद्धिमत्ता (एआय) ही आजच्या काळातील सर्वांत प्रभावशाली आणि परिवर्तन घडवणारी तंत्रज्ञानक्रांती मानली जाते. "एआय म्हणजे अशा संगणक प्रणाली आणि यंत्रणा, ज्या मानवी बुद्धिमत्तेसारखे विचार करू शकतात, शिकू शकतात, निर्णय घेऊ शकतात आणि समस्यांचे निराकरण करू शकतात अशाप्रकारचे तंत्रज्ञान होय".

गेल्या काही वर्षांमध्ये एआयचा वापर आरोग्यसेवा, शिक्षण, बँकिंग, उत्पादन, ई-कॉमर्स आणि माहिती तंत्रज्ञान अशा अनेक क्षेत्रांमध्ये मोठ्या प्रमाणावर वाढला आहे. एआय मुळे मजकूर चित्रे संगणकीय कोड डिजिटल सामग्री तयार करणे शक्य होते आज एआयच्या मदतीने वैद्यकीय निदान अधिक अचूक केले जाते, ग्राहक सेवा चॅटबॉट्सद्वारे स्वयंचलित झाली आहे आणि व्यवसायांमध्ये डेटा विश्लेषण अधिक वेगाने आणि प्रभावीपणे केले जात आहे.

एआयमुळे नोकऱ्यांमध्ये होणारे बदल:

आजच्या आधुनिक युगात इंटरनेट आणि संगणकांशिवाय जगाची कल्पनाही करणे कठीण झाले आहे. एआय ही त्याच प्रकारची पुढची मोठी क्रांती आहे. यामुळे नवीन संधी निर्माण होणार आहेत, तसेच काही पारंपरिक व्यवसायांवर परिणामही होणार आहे.

एआयमुळे काम करण्याच्या पद्धती अधिक कार्यक्षम, वेगवान आणि अचूक बनल्या आहेत. त्यामुळे एक महत्त्वाचा प्रश्न सर्वांच्या मनात निर्माण झाला आहे की, एआयमुळे नवीन नोकऱ्या आणि व्यवसाय निर्माण होतील की लोकांच्या नोकऱ्या जाणार आहेत? या प्रश्नाचे उत्तर एका बाजूने देता येणार नाही. एआयमुळे काही पारंपरिक नोकऱ्यांवर परिणाम होणार आहे, पण त्याच वेळी अनेक नवीन संधी आणि व्यवसाय निर्माण होणार आहेत.

नवीन करिअरच्या संधी:

एआयमुळे निर्माण होणाऱ्या नवीन संधी अधिक मोठ्या आणि प्रभावी आहेत. आज अनेक कंपन्या एआय-आधारित उत्पादने आणि सेवा तयार करत आहेत. त्यामुळे एआय डेव्हलपर, एआय प्रॉडक्ट डिझायनर, एआय ट्रेनर, डेटा सायंटिस्ट आणि एआय कन्सल्टंट यांसारख्या नवीन रोजगार संधी निर्माण होत आहेत.

यूएक्स डिझायनर क्षेत्रासाठीही एआयमुळे नवीन संधी निर्माण झाल्या आहेत. एआय-आधारित ॲप्स, चॅटबॉट्स आणि ऑटोमेशन सिस्टीमसाठी उत्तम युजर एक्सपीरियन्स तयार करणे ही एक महत्त्वाची गरज बनली

आहे. त्यामुळे यूएक्स डिझायनर्सना एआय समजून घेऊन काम करण्याची संधी मिळते.

व्यवसाय आणि उद्योजकतेतील संधी:

एआयमुळे व्यवसायाच्या संधीदेखील मोठ्या प्रमाणात वाढल्या आहेत. पूर्वी एखादा व्यवसाय सुरू करण्यासाठी मोठी टीम, वेळ आणि पैसा लागायचा. पण आता एआयच्या मदतीने एक व्यक्तीदेखील मोठा व्यवसाय सुरू करू शकते.

उदा. एआय वापरून कंटेंट तयार करणे, डिझाइन तयार करणे, वेबसाइट बनवणे आणि मार्केटिंग करणे ही सर्व कामे जलद आणि कमी खर्चात करता येतात. त्यामुळे स्टार्टअप्स आणि सोलोप्रेन्युअर्ससाठी एआय एक मोठी संधी आहे. अनेक लोक एआय ऑटोमेशन, एआय सल्लागार आणि एआय-आधारित उत्पादने तयार करून यशस्वी व्यवसाय उभारत आहेत.

एआयमुळे आणखी एक महत्त्वाचा फायदा म्हणजे उत्पादकतेमध्ये वाढ. एआय पुनरावृत्तीची कामे स्वयंचलित करते, त्यामुळे माणसाला महत्त्वाच्या आणि सर्जनशील कामांसाठी वेळ मिळतो.

त्यामुळे त्याचे काम अधिक वेगाने आणि प्रभावीपणे पूर्ण होते.

एआय आणि मानवी कौशल्ये:

एआय माणसाची जागा पूर्णपणे घेत नाही, तर त्याला अधिक सक्षम बनवते. एआयला एक साधन किंवा सहाय्यक म्हणून पाहिले पाहिजे, जे माणसाची क्षमता वाढवते. तथापि, एआयमुळे काही आव्हानेदेखील निर्माण होतील. ज्यांना नवीन तंत्रज्ञान शिकण्याची तयारी नाही, त्यांना अडचणी येऊ शकतात. त्यामुळे सतत शिकणे आणि कौशल्य विकास खूप महत्त्वाचा आहे. एआयच्या युगात टिकून राहण्यासाठी आणि प्रगती करण्यासाठी लोकांनी नवीन कौशल्ये शिकणे आवश्यक आहे. उदाहरणार्थ, एआय साधने कशी वापरायची, ऑटोमेशन कसे करायचे आणि एआयसोबत काम कसे करायचे हे शिकणे गरजेचे आहे.

जे लोक एआयला स्वीकारतील आणि त्याचा योग्य वापर करतील, त्यांना अधिक संधी मिळतील. एआयमुळे शिक्षणाच्या क्षेत्रातही मोठे बदल होत आहेत. विद्यार्थी एआयच्या मदतीने अधिक चांगल्या प्रकारे शिकू शकतात. वैयक्तिकृत शिक्षण, तत्काळ अभिप्राय आणि कौशल्य विकास यांमुळे शिक्षण अधिक प्रभावी झाले आहे. जागतिक आर्थिक मंचाच्या २०२५ च्या अहवालानुसार, २०३० पर्यंत सध्याच्या कामांसाठी आवश्यक असलेल्या कौशल्यांपैकी सुमारे ३९ टक्के कौशल्यांमध्ये बदल होण्याची किंवा ती कालबाह्य होण्याची अपेक्षा आहे. त्यामुळे पुनर्प्रशिक्षण आणि कौशल्यवृद्धी यांना विशेष महत्त्व प्राप्त होते.

भारतीय अर्थव्यवस्था आणि एआय:

भारतासारख्या मोठी अर्थव्यवस्था असलेल्या देशात तसेच मोठी रोजगारव्यवस्था असलेल्या देशासाठी एआयमध्ये संधी आणि आव्हाने दोन्ही आहेत. भारतात माहिती तंत्रज्ञान, बँकिंग, दूरसंचार, शिक्षण, आरोग्यसेवा, कृषी आणि उत्पादन क्षेत्रांमध्ये एआयचा उपयोग वाढविता येऊ शकतो.

जागतिक स्तरावर सर्वात जास्त लोकसंख्या असलेल्या देश म्हणजे भारताकरिता तरुण लोकसंख्या आणि डिजिटल सेवांचा विस्तार हे महत्त्वाचे फायदे आहेत. मात्र, सर्व तरुणांना समान प्रमाणात इंटरनेट, आधुनिक उपकरणे आणि गुणवत्तापूर्ण प्रशिक्षण उपलब्ध करणे आवश्यक आहे. त्यामुळे एआयच्या संधींचा लाभ

घेण्यासाठी डिजिटल दरी कमी करून सर्वाना या संधीचा लाभ मिळवून देणे आवश्यक आहे.

नीती आयोगाच्या Roadmap for Job Creation in the AI Economy या अहवालात भारताच्या तंत्रज्ञान क्षेत्रातील रोजगाराचे भविष्य, एआयमुळे होणारे बदल आणि नवीन संधी निर्माण करण्यासाठी कौशल्यविकास व समन्वित प्रयत्नांची गरजेचे आहे. असे नमूद केले आहे. भारतात एआयचा परिणाम सर्व क्षेत्रांमध्ये सारखा होणार नाही. संगणकावर आधारित नियमित कामांमध्ये एआयचा प्रभाव तुलनेने अधिक असू शकतो, तर प्रत्यक्ष शारीरिक श्रम, स्थानिक परिस्थितीचे ज्ञान, मानवी संबंध आणि प्रत्यक्ष निरीक्षण आवश्यक असलेल्या अनेक कामांमध्ये मानवी सहभाग महत्त्वाचा राहील.

शिक्षण आणि भविष्यातील रोजगार:

एआयमुळे शिक्षणाची प्रक्रिया सोपी आणि प्रभावी बनत आहे. भविष्यात एआय आणि माणूस एकत्र काम करतील. एआय माणसाची जागा पूर्णपणे घेणार नाही, पण जो माणूस एआय वापरू शकतो तो निश्चितच अधिक यशस्वी होईल.

एआयमुळे काम करण्याची पद्धत बदलेल, पण काम करण्याची गरज संपणार नाही. उलट, एआयमुळे नवीन प्रकारच्या नोकऱ्या आणि व्यवसाय निर्माण होतील, ज्यांची आपण आज कल्पनाही करू शकत नाही.

कृषी क्षेत्रातील संधी:

भारतीय अर्थव्यवस्थेत कृषी क्षेत्राचे महत्त्व लक्षात घेता एआयचा वापर शेतीमध्येही उपयुक्त ठरू शकतो. हवामानाचा अंदाज, पिकांवरील रोगांची प्राथमिक ओळख, सिंचनाचे नियोजन, मातीविषयक माहितीचे विश्लेषण आणि बाजारभावांचा अभ्यास यासाठी एआय-आधारित साधने वापरता येतात.

यामुळे शेतकऱ्यांना निर्णय घेण्यास मदत होऊ शकते. तसेच कृषी तंत्रज्ञान सल्लागार, ड्रोन सेवा पुरवठादार, कृषी डेटा विश्लेषक आणि डिजिटल कृषी सेवा उद्योजक यांसारख्या संधी निर्माण होऊ शकतात. मात्र, या सुविधांचा लाभ मिळण्यासाठी स्थानिक भाषेतील सेवा, परवडणारी साधने, इंटरनेट सुविधा आणि तांत्रिक मार्गदर्शन आवश्यक आहे.

निष्कर्ष :

कृत्रिम बुद्धिमत्ता ही आधुनिक अर्थव्यवस्थेतील परिवर्तनाची महत्त्वपूर्ण शक्ती आहे. एआयमुळे काही पारंपरिक कामांचे स्वयंचलन होऊ शकते, काही रोजगारांमध्ये घट होऊ शकते आणि अनेक कर्मचाऱ्यांना नवीन कौशल्ये आत्मसात करावी लागू शकतात. मात्र, त्याच वेळी एआय विकास, डेटा विश्लेषण, सायबर सुरक्षा, डिजिटल सेवा, कृषी तंत्रज्ञान आणि एआय-आधारित उद्योजकता यांसारख्या क्षेत्रांत नवीन संधी निर्माण होण्याची शक्यता आहे.

आंतरराष्ट्रीय कामगार संघटनेच्या अभ्यासातून बहुतांश व्यवसाय पूर्णपणे नाहीसे होण्यापेक्षा त्यांच्यातील कामांचे स्वरूप बदलण्याची शक्यता अधिक असल्याचे दिसून येते.

एआयमुळे सर्व नोकऱ्या संपतील किंवा सर्वांसाठी मोठ्या प्रमाणात नवीन रोजगार निर्माण होतील, असा एकांगी निष्कर्ष काढणे योग्य ठरणार नाही. एआयचा रोजगारावरील अंतिम परिणाम हा तंत्रज्ञानाचा वापर कसा केला जातो, त्यातून निर्माण होणाऱ्या आर्थिक लाभांचे वितरण कसे होते आणि कामगारांना प्रशिक्षण व संरक्षण कितपत मिळते यावर अवलंबून असेल. सरकारने योग्य

धोरणे आखणे, शैक्षणिक संस्थांनी रोजगाराभिमुख कौशल्ये विकसित करणे आणि उद्योगांनी कर्मचाऱ्यांच्या प्रशिक्षणात गुंतवणूक करणे आवश्यक आहे.

शेवटी, एआय ही मानवी बुद्धिमत्तेची जागा घेणारी शक्ती म्हणून पाहण्याऐवजी मानवी क्षमता वाढविणारे साधन म्हणून वापरणे अधिक योग्य ठरेल. त्यामुळे एआय क्रांती ही केवळ नोकऱ्यांच्या अंत होणार नसून, योग्य नियोजन आणि कौशल्यविकासाच्या माध्यमातून नवीन करिअर घडविण्याची संधीही ठरू शकते.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

नंदुरबार शहरातील उद्योजकांच्या व्यावसायिक संस्कृतीवर आणि कार्यक्षमतेवर सोशल मीडियाच्या अतिवापराचा प्रभाव

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DOI - 10.5281/zenodo.24335115

सारांश (ABSTRACT):

प्रस्तुत संशोधन निबंधात नंदुरबार शहरातील स्थानिक उद्योजक व व्यापाऱ्यांच्या दैनंदिन व्यावसायिक कामकाजावर सोशल मीडियाच्या अतिवापरामुळे होणाऱ्या परिणामांचे संख्यात्मक विश्लेषण करण्यात आले आहे. डिजिटल साधने (उदा. WhatsApp Business, Facebook, Instagram) व्यवसाय वाढीसाठी अत्यंत प्रभावी मानली जात असली, तरी कामाच्या वेळेत त्यांचा होणारा अनियंत्रित व अतिवापर (दररोज ३ तासांपेक्षा जास्त) उद्योजकांमध्ये मुख्य व्यावसायिक कामांबद्दल 'कार्यात्मक अनास्था' (Operational Disinterest) निर्माण करतो. नंदुरबार शहरातील ११२ उद्योजकांकडून (N=112) उद्दिष्टपूर्ण व स्तरित नमुना पद्धतीने माहिती गोळा करण्यात आली. काय-वर्ग विश्लेषणाद्वारे (χ^2 Test of Independence) हे सिद्ध झाले आहे की, व्यावसायिक वेळेतील अति-स्क्रीन टाइम आणि कार्यात्मक अनास्था यांच्यात थेट सांख्यिकी संबंध आहे ($\chi^2 = 28.42$, $p < 0.001$). तसेच, या अतिवापरामुळे ग्राहकांकडे दुर्लक्ष होणे, साठा व्यवस्थापनात चुका होणे आणि ऑर्डर वितरणास विलंब होणे यांमुळे ५९.४% व्यापाऱ्यांच्या निव्वळ महसुलात (Net Revenue) लक्षणीय घट झाली आहे. हा संशोधन निबंध स्थानिक व्यापाऱ्यांसाठी डिजिटल स्वच्छता व व्यावसायिक शिस्तीचे धोरणात्मक मार्गदर्शक तत्त्वे मांडतो.

महत्त्वाचे शब्द (Keywords): सोशल मीडिया अतिवापर, कार्यात्मक अनास्था, नंदुरबार शहर, व्यापारी संस्कृती, महसूल घट, काय-वर्ग चाचणी (χ^2 Test), डिजिटल शिस्त.

प्रस्तावना आणि संशोधनाची पार्श्वभूमी:

आधुनिक डिजिटल युगात लहान व मध्यम स्वरूपाच्या उद्योगांसाठी सोशल मीडिया ही विपणन आणि ग्राहक संपर्काची एक अत्यंत गतिमान यंत्रणा बनली आहे. महाराष्ट्र राज्यातील नंदुरबार शहरात गेल्या काही वर्षांत डिजिटल पायाभूत सुविधांचा विस्तार वेगाने झाला आहे. स्थानिक किराणा व्यापारी, कपड्यांचे विक्रेते, घाऊक व्यापारी आणि सेवा क्षेत्रातील उद्योजक ग्राहक संवर्धन आणि उत्पादनांच्या जाहिरातीसाठी WhatsApp Business, Facebook Pages आणि Instagram यांचा मोठ्या प्रमाणावर वापर करत आहेत.

मात्र, व्यावसायिक उपयोगाच्या सीमारेषा पुसट होऊन कामाच्या वेळेत वैयक्तिक व मनोरंजनपर सोशल मीडिया वापराचे प्रमाण वाढले आहे. सकाळी दुकाने

उघडल्यापासून ते रात्री दुकान बंद करेपर्यंतच्या मुख्य व्यावसायिक तासांमध्ये (Active Business Hours) स्मार्टफोनचा वारंवार होणारा वापर उद्योजकांचे लक्ष मूळ व्यावसायिक कर्तव्यांवरून विचलित करत आहे. प्रस्तुत शोधनिबंध या समस्येचा शास्त्रीय व संख्यात्मक दृष्टिकोनातून सखोल अभ्यास करतो.

समस्येचे स्वरूप आणि संशोधनाची उद्दिष्टे:

सोशल मीडियाचे सुरुवातीचे वापर-फायदे (उदा. त्वरित संदेशवहन व जाहिरात) अनियंत्रित वापरात रूपांतरित झाल्यानंतर व्यापाऱ्यांच्या मानसिकतेत बदल घडवून आणतात. व्यावसायिक तासांमध्ये रील पाहणे, सोशल नेटवर्किंग ग्रुप्सवरील चर्चांमध्ये गुंतणे किंवा वैयक्तिक गप्पा मारणे यांमुळे उद्योजकांमध्ये 'कार्यात्मक अनास्था' (Operational Disinterest) निर्माण होते. या अनास्थेचा थेट परिणाम दैनंदिन दुकान व्यवस्थापन, स्टॉक नोंदी, ग्राहकांशी होणारा संवाद आणि वेळेवर सेवा देण्यावर होतो. परिणामी, दुकानात येणारा ग्राहक दुरावतो आणि व्यवसायाचा महसूल घटतो.

संशोधनाची मुख्य उद्दिष्टे (Research Objectives):

१. नंदुरबार शहरातील उद्योजकांच्या व्यावसायिक तासांतील सोशल मीडिया वापराचे प्रमाण व स्वरूप अभ्यासणे.

२. कामाच्या वेळेतील अतिवापरामुळे उद्योजकांमध्ये निर्माण होणाऱ्या कार्यात्मक अनास्थेचे (Operational Disinterest) मापन करणे.

३. सोशल मीडियाच्या अतिवापराचा व्यवसायाच्या निव्वळ महसुलावर (Net Revenue) होणारा परिणाम सांख्यिकी पद्धतींद्वारे तपासणे.

४. नंदुरबार शहरातील व्यापाऱ्यांसाठी व्यावसायिक कार्यक्षमता टिकवून ठेवण्यासाठी धोरणात्मक व व्यावहारिक शिफारसी मांडणे.

संशोधन गृहितके आणि कार्यपद्धती (Hypotheses & Research Methodology):

प्रस्तुत शोधनिबंधात आकडेवारीच्या विश्लेषणासाठी पुढील २ मुख्य संशोधन गृहितके मांडण्यात आली आहेत व त्यांची काय-वर्ग चाचणी (Chi-Square Test) द्वारे पडताळणी करण्यात आली आहे:

संशोधन गृहितके (Research Hypotheses):

१. **गृहितक १ (H_{01}):** व्यावसायिक वेळेतील सोशल मीडियाचा दैनंदिन वापर आणि उद्योजकांमधील कार्यात्मक अनास्था यांच्यात कोणताही लक्षणीय संबंध नाही.

२. **पर्याय गृहितक १ (H_{11}):** व्यावसायिक वेळेतील सोशल मीडियाचा अतिवापर उद्योजकांमध्ये कार्यात्मक अनास्था निर्माण करण्यास कारणीभूत ठरतो.

३. **गृहितक २ (H_{02}):** कामाच्या तासांतील स्क्रीन टाइमचा व्यवसायाच्या निव्वळ महसुलावर कोणताही नकारात्मक प्रभाव पडत नाही.

४. **पर्याय गृहितक २ (H_{12}):** कामाच्या तासांतील ३ तासांपेक्षा जास्त स्क्रीन टाइम व्यवसायाच्या निव्वळ महसुलात थेट घट घडवून आणतो.

संशोधन कार्यपद्धती (Methodology):

अभ्यास क्षेत्र: नंदुरबार शहर (Nandurbar City urban market limits).

नमुना आकार (Sample Size): ११२ नोंदणीकृत व अनोंदणीकृत स्थानिक उद्योजक व सूक्ष्म व्यापारी (N=112).

नमुना निवड पद्धती: स्तरित यादृच्छिक नमुना पद्धती (Stratified Random Sampling - रिटेल, होलसेल, सर्व्हिस व उत्पादन क्षेत्र).

माहिती संकलन: प्राथमिक माहिती संरचित प्रश्नावलीद्वारे (Structured Questionnaire) संकलित केली गेली.

सांख्यिकी चाचणी: Chi-Square Test of Independence (χ^2 चाचणी) व प्रमाण पृथक्करण (Percentage Analysis).

आकडेवारी विश्लेषण आणि गृहितक चाचणी (Data Analysis & Hypothesis Testing):

नंदुरबार शहरातील ११२ उत्तरदात्यांकडून प्राप्त झालेल्या प्राथमिक आकडेवारीचे वर्गीकरण आणि सांख्यिकी पृथक्करण खालील कोष्टकांमध्ये दर्शविले आहे.

सारणी १: उत्तरदात्यांचे लोकसंख्याशास्त्रीय व व्यावसायिक वर्गीकरण (N=112)

अ.क्र.	लोकसंख्याशास्त्रीय घटक	वर्ग/श्रेणी (Category)	उत्तरदाते संख्या (N)	टक्केवारी (%)
1	**वयोगट (Age Group)**	३५ वर्षांपेक्षा कमी	४८	४२.९%
		३५ ते ५० वर्षे	४२	३७.५%
		५० वर्षांपेक्षा जास्त	२२	१९.६%
2	**लिंग (Gender)**	पुरुष	८४	७५.०%
		महिला	२८	२५.०%
3	**व्यावसायिक क्षेत्र (Sector)**	किराणा व रिटेल	३८	३३.९%
		कापड व इलेक्ट्रॉनिक्स	३२	२८.६%
		सेवा क्षेत्र	२५	२२.३%
		इतर	१७	१५.२%
4	**दैनंदिन स्क्रीन टाइम (Screen Time)**	१ तासापेक्षा कमी	२४	२१.४%
		१ ते ३ तास	४५	४०.२%
		३ तासांपेक्षा जास्त	४३	३८.४%
5	**व्यावसायिक अनुभव (Experience)**	५ वर्षांपेक्षा कमी	३६	३२.१%
		५ ते १५ वर्षे	५२	४६.४%
		१५ वर्षांपेक्षा जास्त	२४	२१.४%

गृहितक १ ची चाचणी: व्यावसायिक वेळेतील अतिवापर वि. कार्यात्मक अनास्था:

कामाच्या वेळेत दररोज ३ तासांपेक्षा जास्त सोशल मीडिया वापरणारे व्यापारी आणि त्यांच्यातील कार्यात्मक अनास्था (उदा. ग्राहकांकडे दुर्लक्ष, साठ्याची नोंद न ठेवणे) यांच्यातील संबंध तपासण्यासाठी काय-वर्ग चाचणी (Chi-Square Test of Independence) करण्यात आली. ११२ व्यापाऱ्यांचे निरीक्षण खालीलप्रमाणे आहे:

सारणी २

स्क्रीन टाइम (Screen Time)	**उच्च अनास्था (High Disinterest)**	**कमी/अल्प अनास्था (Low Disinterest)**	**एकूण (Total)**
अतिवापर (> ३ तास/दिवस)	३५ (८१.४%)	८ (१८.६%)	४३ (१००%)
मध्यम वापर (१ - ३ तास)	१८ (४०.०%)	२७ (६०.०%)	४५ (१००%)
नियंत्रित वापर (< १ तास)	३ (१२.५%)	२१ (८७.५%)	२४ (१००%)
एकूण (Total N)	**५६ (५०.०%)**	**५६ (५०.०%)**	**११२ (१००%)**

सांख्यिकी निष्कर्ष (Hypothesis 1 Result):

- गणना केलेले काय-वर्ग मूल्य (Calculated χ^2): २८.४२
- स्वातंत्र्य श्रेणी (Degrees of Freedom, df): (३-१) × (२-१) = २
- सारणीबद्ध मूल्य (Critical χ^2 at $\alpha = 0.05$): ५.९९१ (p-value < 0.001)
- निर्णय: गणना केलेले χ^2 मूल्य (२८.४२) हे सारणीबद्ध मूल्यापेक्षा (५.९९१) खूप जास्त असल्यामुळे शून्य गृहितक (H_{01}) नाकारण्यात आले असून पर्याय गृहितक (H_{11}) स्वीकारण्यात आले आहे. यावरून हे सिद्ध होते की, कामाच्या वेळेतील ३ तासांपेक्षा जास्त सोशल मीडियाचा वापर उद्योजकांमध्ये कार्यात्मक अनास्था निर्माण करतो.

गृहितक २ ची चाचणी: स्क्रीन टाइम वि. निव्वळ महसूल प्रभाव (Revenue Impact):

कामाच्या तासांतील स्क्रीन टाइमचा व्यवसायाच्या निव्वळ महसुलावर होणारा परिणाम तपासण्यासाठी दुसऱ्या काय-वर्ग चाचणीचे विश्लेषण करण्यात आले.

सारणी ३.

स्क्रीन टाइम वर्ग	**महसुलात घट (Revenue Decline)**	**महसूल स्थिर/वाढ (Revenue Stable/Growth)**	**एकूण (Total)**
अतिवापर (> ३ तास/दिवस)	३६ (८३.७%)	७ (१६.३%)	४३ (१००%)
मध्यम/नियंत्रित (≤ ३ तास)	२१ (३०.४%)	४८ (६९.६%)	६९ (१००%)
एकूण (Total N)	**५७ (५०.९%)**	**५५ (४९.१%)**	**११२ (१००%)**

सांख्यिकी निष्कर्ष (Hypothesis 2 Result):

- गणना केलेले काय-वर्ग मूल्य (Calculated χ^2): ३६.७५
- स्वातंत्र्य श्रेणी (df): (२-१) × (२-१) = १
- सारणीबद्ध मूल्य (Critical χ^2 at $\alpha = 0.05$): ३.८४१ (p-value < 0.001)
- निर्णय: गणना केलेले χ^2 मूल्य (३६.७५) हे सारणीबद्ध मूल्यापेक्षा (३.८४१) अत्यंत जास्त असल्याने शून्य गृहितक (H_{02}) नाकारण्यात आले आणि पर्याय गृहितक (H_{12}) स्वीकारले गेले. यावरून हे सिद्ध होते की, कामाच्या वेळेतील सोशल मीडियाचा अतिवापर व्यवसायाच्या निव्वळ महसुलावर थेट प्रतिकूल परिणाम घडवून आणतो.

सारणी ४: कार्यात्मक अनास्थेमुळे निर्माण होणाऱ्या व्यावसायिक दोषांचे प्रमाण (N=112)

कार्यात्मक दोष / समस्या (Operational Disruption)	प्रभावित व्यापारी संख्या	टक्केवारी (%)
ऑर्डर वितरण आणि सेवेत विलंब (Order Delay)	८३	७४.१%
साठा व्यवस्थापन व नोंदींकडे दुर्लक्ष (Stock Neglect)	७७	६८.८%
ग्राहकांशी संवादातील अनास्था (Customer Inattention)	७०	६२.५%
बिलिंग व हिशोबातील चुका (Billing Errors)	६०	५३.६%

निष्कर्ष आणि सविस्तर चर्चा (Discussion & Main Findings):

प्राथमिक आकडेवारी आणि काय-वर्ग चाचण्यांच्या निष्कर्षांवरून असे दिसून येते की, नंदुरबार शहरातील व्यापारी वर्गात सोशल मीडियाचा वापर दोन परस्परविरोधी टप्प्यांमध्ये विभागला गेला आहे:

१. **उलटा-U वक्र प्रभाव (Inverted-U Curve Effect):**

दररोज १ ते १.५ तासांपर्यंतचा मर्यादित व नियोजित सोशल मीडिया वापर (उदा. सकाळी व संध्याकाळी उत्पादनांचे फोटो पाठवणे) व्यवसायाला +१८.६% ग्राहक वाढ मिळवून देतो. मात्र, वापर ३ तासांच्या पुढे गेल्यावर हा फायदा नकारात्मक रूपात बदलून निव्वळ महसुलात -१४.८% घट घडवून आणतो.

२. **वयोमानानुसार विचलनाचे प्रमाण:**

३५ वर्षांपेक्षा कमी वय असलेल्या तरुण उद्योजकांमध्ये कामाच्या वेळेत स्क्रीन टाइम ३ तासांपेक्षा जास्त असण्याचे प्रमाण ५४.२% आहे, तर ५० वर्षांपेक्षा जास्त वय असलेल्या अनुभवी व्यापाऱ्यांमध्ये हे प्रमाण केवळ १८.२% आहे.

३. **कार्यात्मक दुर्लक्षाची साखळी:**

काउंटरवर बसलेला व्यापारी मोबाईलवर शॉर्ट व्हिडिओ किंवा चॅटिंगमध्ये व्यस्त असताना दुकानात येणाऱ्या ग्राहकाकडे तात्काळ लक्ष दिले जात नाही. या दुर्लक्षामुळे ग्राहक इतर दुकानांमध्ये निघून जातात, ज्यामुळे प्रत्यक्ष विक्रीची संधी (Walk-in Conversion) हुकते.

शिफारसी आणि रणनीतिक मार्गदर्शक तत्त्वे (Recommendations & Operational Guidelines):

नंदुरबार शहरातील स्थानिक उद्योजकांनी डिजिटल तंत्रज्ञानाचा लाभ घेताना व्यावसायिक कार्यक्षमता टिकवून ठेवण्यासाठी खालील धोरणात्मक उपायांची अंमलबजावणी करणे आवश्यक आहे:

- **निश्चित पोस्टिंग विंडो (Fixed Posting Window):** सोशल मीडिया विपणनासाठी कामाच्या तासांऐवजी सकाळी दुकान उघडण्यापूर्वी ३० मिनिटे व रात्री बंद केल्यानंतर ३० मिनिटे अशी विशिष्ट वेळ निश्चित करावी.
- **काउंटर उपकरणांचे अलगीकरण (Device Separation):** मुख्य बिलिंग आणि काउंटर टेबलवर केवळ व्यावसायिक कामांसाठीचा साधा मोबाईल किंवा सिस्टीम ठेवावी. मनोरंजनपर ॲप्स असलेला वैयक्तिक मोबाईल काउंटरवर वापरणे टाळावे.
- **दैनिक कार्य प्राधान्य यादी (Daily Checklist First):** दिवसभरातील साठा नोंदी, हिशोब आणि ग्राहक सेवा पूर्ण झाल्याशिवाय वैयक्तिक स्क्रीन टाइमला अनुमती देऊ नये.
- **व्यापारी संघटनांद्वारे डिजिटल स्वच्छता कार्यशाळा:** नंदुरबार व्यापारी मंडळाने तरुण उद्योजकांसाठी 'डिजिटल स्वच्छता व वेळ व्यवस्थापन' (Digital Hygiene & Time Management) या विषयावर जनजागृती सत्रे आयोजित करावीत.

निष्कर्ष (Conclusion):

सोशल मीडिया हे स्वतःहून व्यवसायासाठी हानिकारक नसून त्याचा कामाच्या वेळेतील अनियंत्रित व अतिवापर हा मूळ धोक्याचा मार्ग ठरतो. नंदुरबार शहरातील उद्योजकांनी डिजिटल साधनांचा वापर केवळ पूर्व-नियोजित विपणनापुरता मर्यादित ठेवून काउंटरवरील प्रत्यक्ष ग्राहक सेवा व व्यवसाय व्यवस्थापनाला सर्वोच्च प्राधान्य दिले, तरच डिजिटल तंत्रज्ञानाचा खरा आर्थिक फायदा मिळवणे शक्य होईल.

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Acknowledgments:

This work is supported by Kavayitri Bahinabai Chaudhari North Maharashtra University Jalgaon under V.C.R.M.S, Grant No. (KBCNMU/11A/VCRMS-C.&M.-2025-26/39/2026), through the project titled**"नंदुरबार जिल्ह्यातील व्यावसायिकांच्या कार्य संस्कृतीवर समाज माध्यमांमुळे होणाऱ्या परिणामांचा अभ्यास" (सन २०२५-२०२७)**. The views and conclusions expressed in this paper are those of the author and do not necessarily reflect the official policies of the funding agency. The author sincerely thanks the funding agency for their support.

International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

महाराष्ट्रातील उत्सवाधारित सूक्ष्म उद्योजकता आणि व्यावसायिक नवोन्मेष : आर्थिक सक्षमीकरणाचा अभ्यास

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DOI - 10.5281/zenodo.24335142

सारांश:

महाराष्ट्राची सांस्कृतिक परंपरा विविध सण, यात्रा, जत्रा, धार्मिक उत्सव, लोककला महोत्सव आणि पारंपरिक बाजारपेठांनी समृद्ध आहे. हे उत्सव केवळ धार्मिक व सांस्कृतिक अभिव्यक्तीचे माध्यम नसून स्थानिक अर्थव्यवस्थेला चालना देणारे महत्त्वाचे आर्थिक व्यासपीठही आहेत. उत्सवांच्या काळात फुले, पूजासाहित्य, खाद्यपदार्थ, हस्तकला, पारंपरिक वस्तू, कपडे, खेळणी, वाहतूक, निवास, पर्यटन आणि इतर सेवा क्षेत्रांमध्ये मागणी वाढते. त्यामुळे सूक्ष्म उद्योजक, महिला बचतगट, पारंपरिक कारागीर, युवक आणि स्थानिक सेवा पुरवठादारांना उत्पन्न व रोजगाराच्या संधी उपलब्ध होऊ शकतात.

या संशोधन लेखाचा मुख्य उद्देश महाराष्ट्रातील उत्सवाधारित सूक्ष्म उद्योजकतेचे स्वरूप, त्यामध्ये व्यावसायिक नवोन्मेषाची भूमिका आणि त्यातून साध्य होणाऱ्या आर्थिक सक्षमीकरणाच्या संधींचा अभ्यास करणे हा आहे. डिजिटल पेमेंट, समाजमाध्यमांद्वारे विपणन, ऑनलाइन उत्पादन सूची, स्थानिक उत्पादनांचे ब्रँडिंग, सामूहिक विक्री व्यवस्था आणि पर्यावरणपूरक व्यवसाय प्रारूप यांचा उत्सवाधारित उद्योगांच्या विकासासाठी कसा उपयोग होऊ शकतो, याची चर्चा या लेखात केली आहे.

हा लेख संकल्पनात्मक व वर्णनात्मक स्वरूपाचा असून त्यामध्ये उत्सवाधारित अर्थचक्र, सूक्ष्म उद्योजकतेच्या संधी, नवोन्मेषी व्यवसाय प्रारूप, महिला व युवकांचे सक्षमीकरण, अंमलबजावणीतील आव्हाने आणि धोरणात्मक उपाय यांचा आढावा घेतला आहे. प्रत्यक्ष क्षेत्रीय सर्वेक्षणातील आकडेवारी उपलब्ध नसल्यामुळे कोणतेही विशिष्ट आर्थिक निष्कर्ष किंवा रोजगारवाढीचे प्रमाण सिद्ध झाल्याचा दावा केलेला नाही. लेखाच्या निष्कर्षानुसार, उत्सवांचे नियोजन स्थानिक उद्योजकतेशी जोडून डिजिटल तंत्रज्ञान, कौशल्यविकास, बाजारपेठ जोडणी आणि आर्थिक साक्षरता यांचा समन्वय साधल्यास महाराष्ट्रातील उत्सवाधारित अर्थव्यवस्थेला अधिक समावेशक व शाश्वत स्वरूप देता येऊ शकते.

बीजशब्द : उत्सवाधारित अर्थव्यवस्था, सूक्ष्म उद्योजकता, व्यावसायिक नवोन्मेष, आर्थिक सक्षमीकरण, महिला बचतगट, डिजिटल विपणन, स्थानिक रोजगार, महाराष्ट्र.

प्रस्तावना:

भारतामध्ये सण, उत्सव, यात्रा आणि जत्रांना सामाजिक, सांस्कृतिक, धार्मिक तसेच आर्थिक महत्त्व आहे. महाराष्ट्रातील गणेशोत्सव, नवरात्रोत्सव, आषाढी वारी, पंढरपूरची यात्रा, कोल्हापूरची धार्मिक परंपरा, ग्रामीण भागातील ग्रामदैवतांच्या यात्रा, विविध लोककला महोत्सव आणि पारंपरिक जत्रा या समाजजीवनाचा अविभाज्य भाग आहेत. या उत्सवांमधून श्रद्धा, परंपरा, लोककला, सामाजिक एकात्मता आणि सांस्कृतिक वारसा यांचे जतन होते. त्याचबरोबर स्थानिक उत्पादनांना ग्राहक मिळतात,

तात्पुरत्या बाजारपेठा निर्माण होतात आणि विविध प्रकारच्या सेवांना मागणी प्राप्त होते.

उत्सवांच्या काळात लहान दुकानदार, फेरीवाले, फुलविक्रेते, मिठाई व खाद्यपदार्थ विक्रेते, कुंभार, मूर्तिकार, विणकर, हस्तकलाकार, खेळणी विक्रेते, वाहतूक व्यावसायिक आणि इतर सेवा पुरवठादार आर्थिक व्यवहारात सहभागी होतात. या व्यवसायांपैकी अनेक व्यवसाय कमी भांडवलावर सुरू होऊ शकतात. त्यामुळे उत्सव हे नवउद्योजकतेसाठी प्रवेशद्वार ठरू शकतात.

तथापि, उत्सवांमध्ये निर्माण होणाऱ्या व्यावसायिक संधींचा लाभ सर्व उद्योजकांना समान प्रमाणात मिळतोच असे नाही. विक्रीसाठी योग्य जागा न मिळणे, भांडवलाची कमतरता, बाजारपेठेची अपुरी माहिती, अनिश्चित ग्राहकसंख्या, डिजिटल कौशल्यांचा अभाव, साठवणुकीच्या अडचणी आणि उत्सवानंतर मागणी कमी होणे अशा समस्यांना सूक्ष्म उद्योजकांना सामोरे जावे लागू शकते.

या पार्श्वभूमीवर उत्सवांकडे केवळ सांस्कृतिक कार्यक्रम म्हणून न पाहता स्थानिक उत्पादन, सेवा, रोजगार, नवकल्पना आणि उद्योजकता यांना जोडणारी आर्थिक परिसंस्था म्हणून पाहणे आवश्यक आहे. प्रस्तुत संशोधन लेख याच दृष्टिकोनातून महाराष्ट्रातील उत्सवाधारित सूक्ष्म उद्योजकता आणि व्यावसायिक नवोन्मेष यांचा आर्थिक सक्षमीकरणाशी असलेला संबंध स्पष्ट करण्याचा प्रयत्न करतो.

संशोधन समस्येचे स्वरूप:

महाराष्ट्रातील उत्सवांमध्ये मोठ्या प्रमाणावर ग्राहकांची गर्दी, वस्तू व सेवांची मागणी आणि तात्पुरत्या व्यावसायिक व्यवहारांची संधी निर्माण होऊ शकते. मात्र, या संधींचे नियमित उत्पन्न, टिकाऊ व्यवसाय आणि दीर्घकालीन उद्योजकतेमध्ये रूपांतर करण्यासाठी नियोजनबद्ध व्यवस्था आवश्यक आहे.

अनेक सूक्ष्म व्यावसायिक उत्सवकाळापुरते व्यवसाय करतात. त्यांच्याकडे ग्राहकांची माहिती, डिजिटल विपणनाची साधने, उत्पादनांचे ब्रँडिंग, खर्च-उत्पन्न नोंदी, वित्तपुरवठा आणि उत्सवानंतर विक्री सुरू ठेवण्यासाठी आवश्यक संपर्कव्यवस्था नसण्याची शक्यता असते. परिणामी, उत्सवातील तात्पुरती मागणी कायमस्वरूपी व्यवसायविकासात रूपांतरित होण्यात अडथळे निर्माण होऊ शकतात.

म्हणूनच या संशोधनातील प्रमुख समस्या अशी आहे की, महाराष्ट्रातील उत्सवांमधून निर्माण होणाऱ्या आर्थिक संधींचा उपयोग सूक्ष्म उद्योजकांच्या आर्थिक सक्षमीकरणासाठी कशा प्रकारे करता येईल आणि त्यामध्ये व्यावसायिक नवोन्मेष, डिजिटल तंत्रज्ञान व संस्थात्मक सहकार्याची भूमिका काय असू शकते?

संशोधनाची उद्दिष्टे:

या संशोधनाची प्रमुख उद्दिष्टे पुढीलप्रमाणे आहेत.

1. महाराष्ट्रातील उत्सवाधारित सूक्ष्म उद्योजकतेचे स्वरूप आणि प्रमुख व्यवसायप्रकारांचा अभ्यास करणे.
2. उत्सवांमुळे स्थानिक बाजारपेठ, रोजगार आणि उत्पन्ननिर्मितीस मिळू शकणाऱ्या चालनेचे विश्लेषण करणे.
3. उत्सवाधारित व्यवसायांमध्ये डिजिटल तंत्रज्ञान, विपणन आणि उत्पादनविकास यांसारख्या नवोन्मेषी पद्धतींची भूमिका स्पष्ट करणे.
4. महिला बचतगट, युवक, पारंपरिक कारागीर आणि ग्रामीण सूक्ष्म उद्योजकांसाठी उपलब्ध असलेल्या संधींचा अभ्यास करणे.

5. उत्सवाधारित व्यवसायांच्या विकासातील आर्थिक, तांत्रिक, व्यवस्थापकीय आणि बाजारपेठविषयक अडचणी ओळखणे.
6. उत्सवाधारित सूक्ष्म उद्योगांना प्रोत्साहन देण्यासाठी व्यवहार्य व्यवसाय प्रारूप आणि धोरणात्मक उपाय सुचविणे.
7. उत्सवांच्या आर्थिक क्षमतेचा स्थानिक व शाश्वत विकासासाठी उपयोग करण्याच्या शक्यता तपासणे.

संशोधन गृहीतके:

प्रत्यक्ष क्षेत्रीय अभ्यासात तपासण्यासाठी पुढील गृहीतके मांडता येतील.

गृहीतक १ : उत्सवाधारित सूक्ष्म उद्योगांमध्ये डिजिटल तंत्रज्ञानाचा वापर आणि व्यावसायिक कामगिरी यांच्यात सकारात्मक संबंध असण्याची शक्यता आहे.

गृहीतक २ : उद्योजकांना कौशल्यविकास व व्यवसाय प्रशिक्षण मिळाल्यास त्यांची बाजारपेठेतील स्पर्धात्मकता वाढू शकते.

गृहीतक ३ : महिला बचतगटांचा उत्सवाधारित बाजारपेठांमध्ये सहभाग त्यांच्या उत्पन्ननिर्मितीच्या संधींशी सकारात्मकरीत्या संबंधित असू शकतो.

गृहीतक ४ : उत्सव आयोजक मंडळे आणि स्थानिक प्रशासनाकडून विक्रीची जागा, माहिती व मूलभूत सुविधा उपलब्ध झाल्यास सूक्ष्म उद्योजकांचा सहभाग वाढू शकतो.

गृहीतक ५ : उत्सवकाळातील व्यवसायाचे ऑनलाइन विक्री, ग्राहक संपर्क आणि वर्षभरातील बाजारपेठेशी एकत्रीकरण केल्यास व्यवसायाच्या सातत्याला मदत होऊ शकते.

संशोधन पद्धती:

प्रस्तुत लेख संकल्पनात्मक व वर्णनात्मक स्वरूपाचा आहे. यामध्ये उत्सवाधारित व्यवसायांचे संभाव्य स्वरूप, नवोन्मेषाच्या संधी आणि आर्थिक सक्षमीकरणाच्या प्रक्रियेचे विश्लेषण केले आहे. या विषयावर प्रत्यक्ष प्रबंध किंवा परिषदेसाठी संशोधन अधिक मजबूत करण्यासाठी पुढील पद्धती वापरता येतील.

संशोधनाचे स्वरूप:

वर्णनात्मक, विश्लेषणात्मक आणि आवश्यकतेनुसार मिश्र संशोधन पद्धतीचा वापर केला आहे. गुणात्मक माहितीमधून उद्योजकांचे अनुभव व अडचणी समजून घेतल्या आहेत.; तर परिमाणात्मक माहितीमधून विक्री, खर्च, नफा, रोजगार आणि डिजिटल व्यवहारांचे विश्लेषण केले आहे.

अभ्यासाचे क्षेत्र:

महाराष्ट्रातील शहरी आणि ग्रामीण उत्सवांचा समावेश करून जिल्हा, तालुका व उत्सवाच्या स्वरूपानुसार नमुना निवडला आहे. धार्मिक यात्रा, ग्रामीण जत्रा, सार्वजनिक उत्सव आणि सांस्कृतिक महोत्सव यांचा तुलनात्मक अभ्यास केला आहे.

अभ्यासाचे नमुना घटक:

नमुना घटक	संकलित करावयाची प्रमुख माहिती
सूक्ष्म उद्योजक व विक्रेते	विक्री, खर्च, नफा, भांडवल, ग्राहकसंख्या
महिला बचतगट	उत्पादनप्रकार, सामूहिक विक्री, उत्पन्न, प्रशिक्षण

पारंपरिक कारागीर	उत्पादनखर्च, मागणी, कौशल्य, बाजारपेठ
युवक व नवउद्योजक	व्यवसाय कल्पना, डिजिटल कौशल्य, स्टार्टअप संधी
उत्सव आयोजक मंडळे	विक्री जागा, शुल्क, सुविधा, विक्रेत्यांची संख्या
स्थानिक प्रशासन व सेवा पुरवठादार	परवानग्या, स्वच्छता, वाहतूक, पायाभूत सुविधा

माहिती संकलनाची साधने:

- संरचित प्रश्नावली व मुलाखती
- उद्योजक आणि उत्सव आयोजकांशी चर्चा
- निवडक उत्सवस्थळांचे निरीक्षण
- उपलब्ध शासकीय अहवाल, आर्थिक पाहणी आणि जिल्हा सामाजिक व आर्थिक समालोचन
- सूक्ष्म, लघु व मध्यम उद्योग, पर्यटन आणि ग्रामीण उपजीविकेशी संबंधित अधिकृत अहवाल
- संबंधित संशोधन लेख, पुस्तके, प्रबंध आणि परिषद साहित्य

माहितीचे विश्लेषण:

संकलित माहितीच्या स्वरूपानुसार टक्केवारी, सरासरी, विक्रीतील बदल, खर्च-उत्पन्न विश्लेषण, रोजगारनिर्मिती, गटांमधील तुलना आणि सहसंबंध यांचा वापर केला आहे. पुरेसा नमुना आणि योग्य माहिती उपलब्ध असल्यास काई-स्क्वेअर चाचणी, सहसंबंध विश्लेषण किंवा प्रतिगमन विश्लेषण वापरण्याचा विचार केला आहे.

महाराष्ट्रातील उत्सवाधारित सूक्ष्म उद्योजकतेचे स्वरूप:

उत्सवाधारित सूक्ष्म उद्योजकता म्हणजे उत्सव, यात्रा, जत्रा किंवा सांस्कृतिक कार्यक्रमांशी संबंधित मागणीचा उपयोग करून वस्तूंचे उत्पादन, विक्री किंवा सेवा पुरविण्याच्या उद्देशाने चालविलेले लहान व्यवसाय. हे व्यवसाय कायमस्वरूपी, हंगामी किंवा उत्सवाच्या विशिष्ट कालावधीपुरते असतात.

धार्मिक व पूजासाहित्याशी संबंधित व्यवसाय:

धार्मिक उत्सव आणि यात्रांमध्ये फुले, हार, नारळ, अगरबत्ती, दिवे, पूजासाहित्य, धार्मिक प्रतिमा आणि प्रसादाशी संबंधित वस्तूंना मागणी निर्माण होते. या व्यवसायांमधून स्थानिक उत्पादक, शेतकरी, महिला बचतगट आणि लहान विक्रेत्यांना संधी मिळते.

खाद्यपदार्थ व स्थानिक पाककृती:

उत्सवस्थळांवरील खाद्यपदार्थांचे स्टॉल, पारंपरिक मिठाई, स्थानिक खाद्यपदार्थ, पेये आणि पॅकबंद स्थानिक उत्पादने हे व्यवसायाचे महत्त्वाचे प्रकार आहेत. स्वच्छता, अन्नसुरक्षा, आकर्षक पॅकेजिंग आणि उत्पादनाच्या गुणवत्तेवर भर दिल्यास या व्यवसायांना अधिक विश्वासार्ह स्वरूप देता येते.

हस्तकला आणि पारंपरिक उत्पादन:

मातीच्या वस्तू, पारंपरिक खेळणी, हातमाग उत्पादने, बांबूच्या वस्तू, लोककलेशी संबंधित साहित्य, सजावटीच्या वस्तू आणि स्थानिक कलावस्तू यांना उत्सवांमध्ये ग्राहक मिळतात. योग्य ब्रँडिंग आणि बाजारपेठ जोडणीमुळे पारंपरिक कारागिरीला आधुनिक व्यावसायिक संधी मिळतात.

सेवा क्षेत्रातील व्यवसाय:

वाहतूक, तात्पुरती निवासव्यवस्था, ध्वनी व प्रकाशयोजना, छायाचित्रण, स्वच्छता, तंबू, सजावट, कार्यक्रम व्यवस्थापन आणि डिजिटल जाहिरात या सेवा

उत्सवाच्या अर्थचक्राचा भाग आहेत. युवकांसाठी या क्षेत्रात कौशल्याधारित रोजगार आणि स्वयंरोजगाराच्या संधी निर्माण होतात.

महिला बचतगटांचे योगदान:

महिला बचतगट स्थानिक खाद्यपदार्थ, मसाले, वस्त्रनिर्मिती, हस्तकला, पूजासाहित्य आणि पर्यावरणपूरक वस्तूंचे उत्पादन व विक्री करतात. सामूहिक उत्पादन, संयुक्त पॅकेजिंग, सामायिक विक्री केंद्र आणि डिजिटल कॅटलॉग यांमुळे बाजारपेठेत प्रवेश सुलभ होण्याची शक्यता आहे.

उत्सवाधारित व्यवसायातील व्यावसायिक नवोन्मेष:

व्यावसायिक नवोन्मेष म्हणजे ग्राहकांच्या गरजा, उत्पादनाची गुणवत्ता, विपणन, वितरण, खर्च व्यवस्थापन किंवा व्यवसायाचे प्रारूप यामध्ये नवीन किंवा लक्षणीयरीत्या सुधारित पद्धतींचा वापर करणे. उत्सवाधारित सूक्ष्म उद्योगांसाठी नवोन्मेष नेहमीच महागड्या तंत्रज्ञानावर अवलंबून नसतो. साधे डिजिटल उपाय, सामूहिक विक्री आणि ग्राहकाभिमुख नियोजनही उपयुक्त ठरते.

डिजिटल पेमेंट आणि व्यवहार व्यवस्थापन:

UPI आणि इतर डिजिटल पेमेंट साधनांमुळे ग्राहकांना पैसे देणे सोपे होते. डिजिटल व्यवहारांच्या नोंदींमुळे विक्रीचे निरीक्षण आणि आर्थिक नियोजनास मदत होते. तथापि, नेटवर्कची उपलब्धता, व्यवहारांची सुरक्षितता आणि डिजिटल साक्षरता यांची काळजी घेणे आवश्यक आहे.

समाजमाध्यमांद्वारे विपणन:

WhatsApp Business, Instagram आणि इतर डिजिटल माध्यमांचा वापर करून उत्पादनांची छायाचित्रे, किंमत, उपलब्धता आणि संपर्क माहिती ग्राहकांपर्यंत पोहोचवता येते. उत्सव सुरू होण्यापूर्वीच उत्पादनांची माहिती प्रसारित केल्यास विक्रीची पूर्वतयारी करणे शक्य होते.

स्थानिक उत्पादनांचे ब्रँडिंग:

स्थानिक उत्पादनांना विशिष्ट ओळख देण्यासाठी नाव, पॅकेजिंग, उत्पादनाची माहिती आणि गुणवत्तेचे निकष निश्चित करता येतात. उदाहरणार्थ, एखाद्या परिसरातील पारंपरिक खाद्यपदार्थ किंवा हस्तकला उत्पादनांचे उत्सवाशी संबंधित ब्रँडिंग करता येईल. यामुळे ग्राहकांना उत्पादनाची ओळख निर्माण होण्यास मदत होते.

सामूहिक विपणन आणि सामायिक सुविधा:

अनेक लहान विक्रेत्यांनी एकत्र येऊन सामूहिक विक्री केंद्र, संयुक्त जाहिरात, पॅकेजिंग किंवा वाहतूक व्यवस्था वापरल्यास खर्च कमी करण्याची शक्यता असते. उत्सव आयोजक मंडळे आणि स्थानिक स्वराज्य संस्था यांच्याशी समन्वय साधून विक्रीसाठी नियोजित जागा उपलब्ध करता येऊ शकतात.

ऑनलाइन बाजारपेठ आणि वर्षभरातील विक्री:

उत्सव संपल्यानंतरही व्यवसाय सुरू राहावा यासाठी ऑनलाइन ऑर्डर, ग्राहक संपर्क सूची, स्थानिक वितरण आणि डिजिटल उत्पादन सूची तयार करता येतील. अशा प्रकारे हंगामी विक्रीला नियमित व्यवसायामध्ये रूपांतरित करण्याचा प्रयत्न करता येऊ शकतो.

पर्यावरणपूरक व्यावसायिक प्रारूप:

पुनर्वापरयोग्य साहित्य, कमी प्लास्टिक वापर, कचरा वर्गीकरण, पर्यावरणपूरक सजावट आणि स्थानिकरीत्या उपलब्ध कच्च्या मालाचा वापर यांमुळे हरित उद्योजकतेच्या संधी निर्माण होतात. अशा उपक्रमांसाठी खर्च, गुणवत्ता आणि ग्राहकांची मागणी यांचा विचार करून व्यवहार्य नियोजन करणे आवश्यक आहे.

उत्सवाधारित उद्योजकता आणि आर्थिक सक्षमीकरण:

आर्थिक सक्षमीकरण म्हणजे व्यक्ती किंवा समूहाला उत्पन्ननिर्मिती, आर्थिक निर्णयक्षमता, संसाधनांवरील प्रवेश आणि आर्थिक स्वावलंबन वाढविण्याच्या संधी उपलब्ध होणे. उत्सवाधारित सूक्ष्म उद्योजकता या प्रक्रियेत विविध प्रकारे योगदान देऊ शकते.

उत्पन्ननिर्मिती आणि स्वयंरोजगार:

उत्सवांमधील तात्पुरत्या बाजारपेठांमुळे लहान व्यावसायिकांना त्यांच्या वस्तू आणि सेवांची विक्री करण्याची संधी मिळते. यासाठी आवश्यक भांडवल, उत्पादनक्षमता आणि बाजारपेठेची मागणी यांचा विचार करणे महत्त्वाचे आहे. व्यवसायाच्या उत्पन्नातून खर्च वजा केल्यानंतर मिळणारा निव्वळ नफा हा आर्थिक लाभाचा अधिक योग्य निर्देशक ठरतो.

महिलांचे आर्थिक सक्षमीकरण:

महिला बचतगटांना उत्सवांमध्ये स्वतंत्र विक्री केंद्रे, सामूहिक उत्पादन, पॅकेजिंग, डिजिटल व्यवहार आणि ग्राहक संपर्क यांसारख्या सुविधा उपलब्ध झाल्यास त्यांच्या व्यवसायविकासाला मदत होते. महिलांचा सहभाग केवळ विक्रीपुरता मर्यादित न ठेवता किंमत निश्चिती, खर्च व्यवस्थापन, नफा वितरण आणि व्यवसायविस्ताराच्या निर्णयांमध्येही असणे आवश्यक आहे.

युवकांसाठी स्टार्टअप संधी:

उत्सवाधारित अर्थव्यवस्थेत युवकांना अनेक नावीन्यपूर्ण व्यवसाय सुरू करता येतात. उदाहरणार्थ:

- उत्सवांसाठी डिजिटल प्रचार व जाहिरात सेवा.
- स्थानिक उत्पादनांची ऑनलाइन विक्री.
- कार्यक्रम व्यवस्थापन व तिकीट किंवा नोंदणी सेवा.
- पर्यावरणपूरक सजावट आणि कचरा व्यवस्थापन.
- पर्यटकांसाठी स्थानिक सांस्कृतिक अनुभव व मार्गदर्शन.
- उत्सवातील विक्रेते आणि ग्राहकांना जोडणारे डिजिटल व्यासपीठ.

यापैकी कोणताही उपक्रम स्टार्टअप ठरेलच असे नाही; त्यासाठी नावीन्य, व्यवहार्य व्यवसाय प्रारूप, ग्राहकांची मागणी आणि विस्ताराची क्षमता यांचा विचार करावा लागेल.

पारंपरिक कारागिरांचे सक्षमीकरण:

पारंपरिक कारागीर अनेकदा कौशल्यसंपन्न असले तरी त्यांना विपणन, उत्पादनांचे आधुनिकीकरण, पॅकेजिंग आणि नियमित ग्राहक मिळविण्यात अडचणी येतात. उत्सवांशी जोडलेल्या विक्री केंद्रांद्वारे आणि डिजिटल माध्यमांद्वारे त्यांच्या उत्पादनांना अधिक ग्राहकांपर्यंत पोहोचविण्याची संधी उपलब्ध होते.

स्थानिक अर्थव्यवस्थेचे बळकटीकरण:

उत्सवांमध्ये स्थानिक उत्पादनांना प्राधान्य दिल्यास कच्चा माल पुरवठादार, उत्पादक, विक्रेते आणि सेवा पुरवठादार यांच्यात आर्थिक व्यवहार वाढण्याची शक्यता असते. यामुळे स्थानिक आर्थिक मूल्यसाखळी विकसित होते. मात्र, स्थानिक पातळीवरील प्रत्यक्ष आर्थिक लाभ मोजण्यासाठी विक्री, खर्च, रोजगार, बाहेरून येणारा माल आणि स्थानिक खरेदी यांची माहिती संकलित करणे आवश्यक आहे.

उत्सवाधारित उद्योजकतेचे नवोन्मेषी व्यवसाय प्रारूप:

या संशोधनाच्या अनुषंगाने महाराष्ट्रातील उत्सवाधारित सूक्ष्म उद्योजकतेसाठी पुढील व्यवसाय प्रारूप सुचविता येतात.

एक उत्सव – एक स्थानिक उत्पादन:

प्रत्येक निवडक उत्सवात परिसरातील वैशिष्ट्यपूर्ण उत्पादनांना प्राधान्य देणे. स्थानिक खाद्यपदार्थ, हस्तकला, पारंपरिक वस्तू किंवा शेतीमाल यांना ब्रँडिंग आणि विक्रीची संधी उपलब्ध करून देणे.

महिला बचतगट उत्सव बाजार:

महिला बचतगटांसाठी स्वतंत्र विक्री क्षेत्र, सामूहिक उत्पादन सूची, डिजिटल पेमेंट आणि व्यवसाय मार्गदर्शन उपलब्ध करून देणे.

डिजिटल उत्सव बाजारपेठ:

विक्रेत्यांची नोंदणी, उत्पादनांची डिजिटल सूची, ग्राहक संपर्क आणि ऑनलाइन ऑर्डर यांसाठी साधे डिजिटल व्यासपीठ विकसित करणे.

पारंपरिक कला ते आधुनिक बाजारपेठ:

कारागिरांना उत्पादन सुधारणा, पॅकेजिंग, किंमत निर्धारण, ग्राहक अभिप्राय आणि ऑनलाइन विक्रीचे प्रशिक्षण देणे.

हरित उत्सव उद्योजकता:

पर्यावरणपूरक सजावट, पुनर्वापरयोग्य साहित्य, कचरा वर्गीकरण आणि शाश्वत सेवा यांशी संबंधित लघुउद्योगांना प्रोत्साहन देणे.

उत्सवाधारित अर्थचक्राचे विश्लेषण:

उत्सवाधारित आर्थिक व्यवहार समजून घेण्यासाठी खालील मूल्यसाखळी उपयुक्त ठरू शकते.

- उत्पादक आणि कच्चा माल पुरवठादार
- शेतकरी, कारागीर, स्थानिक उत्पादक
- सूक्ष्म उद्योजक आणि महिला बचतगट
- उत्पादन, पॅकेजिंग, किंमत निर्धारण
- उत्सव बाजारपेठ आणि डिजिटल विपणन
- विक्री केंद्रे, डिजिटल पेमेंट, जाहिरात
- ग्राहक, भाविक आणि पर्यटक
- खरेदी, सेवा वापर आणि ग्राहक अभिप्राय
- आर्थिक परिणाम आणि व्यवसायविस्तार
- उत्पन्न, रोजगार, पुनर्गुंतवणूक आणि नियमित बाजारपेठ

या मूल्यसाखळीमध्ये वित्तीय संस्था, प्रशिक्षण संस्था, स्थानिक प्रशासन, उत्सव आयोजक मंडळे आणि डिजिटल सेवा पुरवठादार यांची सहाय्यक भूमिका महत्त्वाची ठरते. पुरवठा, विक्री आणि ग्राहक यांना जोडणारी व्यवस्था कार्यक्षम असेल, तर सूक्ष्म उद्योजकांना अधिक नियोजनबद्ध पद्धतीने व्यवसाय करता येऊ शकतो.

उत्सवाधारित व्यवसायांच्या विकासातील प्रमुख आव्हाने:

उत्सवाधारित सूक्ष्म उद्योजकतेचा विकास करताना पुढील अडचणींचा विचार करणे आवश्यक आहे.

1. भांडवलाची कमतरता : माल खरेदी, वाहतूक, स्टॉल भाडे आणि पॅकेजिंगसाठी सुरुवातीला निधी आवश्यक असतो.
2. हंगामी मागणी : उत्सव संपल्यानंतर ग्राहकांची संख्या कमी झाल्यामुळे उत्पन्नात अनिश्चितता निर्माण होऊ शकते.
3. विक्रीच्या जागेची समस्या : नियोजित व परवडणाऱ्या जागा नसल्यास विक्रेत्यांना अडचणी येऊ शकतात.
4. स्पर्धा आणि किंमत निर्धारण : अनेक विक्रेते समान वस्तू विकत असल्यास नफा कमी होण्याची शक्यता असते.

5. डिजिटल कौशल्यांचा अभाव : डिजिटल पेमेंट, ऑनलाइन प्रचार आणि नोंदवही व्यवस्थापनासाठी प्रशिक्षणाची गरज असते.
6. मूलभूत सुविधांची कमतरता : पिण्याचे पाणी, स्वच्छता, वीज, साठवणूक आणि वाहतूक यांचा व्यवसायावर परिणाम होऊ शकतो.
7. औपचारिक व्यवसाय व्यवस्थापनाचा अभाव : खर्च, विक्री, नफा आणि साठ्याच्या नोंदी नसल्यास व्यवसायाची वास्तविक आर्थिक स्थिती समजणे कठीण जाते.
8. पर्यावरणीय समस्या : प्लास्टिक कचरा, अन्नाचा अपव्यय आणि गर्दी व्यवस्थापन या बाबींकडे दुर्लक्ष केल्यास उत्सवाचा पर्यावरणावर विपरीत परिणाम होऊ शकतो.

धोरणात्मक उपाय आणि शिफारसी:

महाराष्ट्रातील उत्सवाधारित सूक्ष्म उद्योजकतेला चालना देण्यासाठी पुढील उपाय विचारात घेता येतील.

उत्सवाधारित उद्योजक नोंदणी:

निवडक उत्सवांमधील विक्रेते, महिला बचतगट, कारागीर, सेवा पुरवठादार आणि युवक उद्योजक यांची स्वेच्छाधारित नोंदणी करून व्यवसायप्रकार, उत्पादन, प्रशिक्षणाची गरज आणि बाजारपेठेची माहिती संकलित करता येईल. माहितीचा वापर पारदर्शक पद्धतीने आणि गोपनीयतेचे संरक्षण करून करावा.

उत्सव उद्योजकता सहाय्य कक्ष:

उत्सव आयोजक मंडळे, स्थानिक प्रशासन आणि उद्योजकता प्रशिक्षण संस्थांच्या सहकार्याने माहिती व मार्गदर्शन केंद्र सुरू करता येईल. या केंद्रामधून विक्री जागा, परवाने, डिजिटल पेमेंट, आर्थिक साक्षरता, प्रशिक्षण आणि बाजारपेठ जोडणी याविषयी माहिती देता येईल.

कौशल्यविकास व आर्थिक साक्षरता:

उद्योजकांना किंमत निश्चिती, खर्च-नफा विश्लेषण, ग्राहक सेवा, डिजिटल व्यवहार, उत्पादन गुणवत्ता आणि व्यवसाय नियोजन यांचे प्रशिक्षण देणे आवश्यक आहे. प्रशिक्षण हे स्थानिक उद्योजकांच्या गरजांनुसार व व्यवहार्य उदाहरणांवर आधारित असावे.

वित्तपुरवठा आणि संस्थात्मक जोडणी:

पात्र उद्योजकांना बँका, सूक्ष्म वित्त संस्था, बचतगट आणि संबंधित शासकीय योजनांची माहिती उपलब्ध करून देता येईल. कोणत्याही कर्ज किंवा अनुदानाची उपलब्धता संबंधित पात्रता आणि अधिकृत नियमांवर अवलंबून असेल.

स्थानिक उत्पादनांना प्राधान्य:

उत्सवांमध्ये स्थानिक उत्पादकांना बाजारपेठ उपलब्ध करून देण्यासाठी नियोजित विक्री क्षेत्र, उत्पादन प्रदर्शन, सामूहिक विपणन आणि स्थानिक उत्पादनांचा प्रचार यांचा विचार करता येईल.

उत्सव आर्थिक नकाशांकन:

निवडक उत्सवांमध्ये विक्रेत्यांची संख्या, व्यवसायप्रकार, अंदाजित किंवा नोंदवलेली विक्री, रोजगार, खर्च आणि ग्राहकांचा सहभाग यांची पद्धतशीर नोंद करावी. वेगवेगळ्या उत्सवांची तुलना करताना एकसमान व्याख्या व माहिती संकलन पद्धती वापरणे महत्त्वाचे आहे.

उत्सवानंतर व्यवसाय सातत्य:

उत्सव संपल्यानंतर विक्री बंद होऊ नये यासाठी स्थानिक दुकाने, प्रदर्शन, डिजिटल कॅटलॉग, ऑनलाइन ऑर्डर आणि नियमित ग्राहक संपर्क यांना प्रोत्साहन देता येईल.

अपेक्षित परिणाम आणि मूल्यमापनाचे निर्देशक:

प्रस्तावित उपाययोजनांचा परिणाम तपासण्यासाठी पुढील निर्देशक वापरता येतील.

परिणामाचे क्षेत्र	**मोजमापाचे निर्देशक**
आर्थिक सक्षमीकरण	व्यवसायाचे उत्पन्न, खर्च व निव्वळ नफा
रोजगार	पूर्णवेळ, अर्धवेळ व हंगामी रोजगार
महिला सहभाग	सहभागी महिला उद्योजक व बचतगटांची संख्या
डिजिटल नवोन्मेष	डिजिटल पेमेंट व ऑनलाइन विक्रीचा वापर
बाजारपेठ विस्तार	नवीन ग्राहक, पुनर्खरेदी व उत्सवानंतरची विक्री
उद्योजकता विकास	नवीन व्यवसाय, व्यवसायविस्तार व पुनर्गुंतवणूक
स्थानिक अर्थव्यवस्था	स्थानिक खरेदी व स्थानिक पुरवठादारांचा सहभाग
शाश्वतता	कचरा कमी करणे, पुनर्वापर व पर्यावरणपूरक उत्पादनांचा वापर

या निर्देशकांचे मूल्यमापन करण्यासाठी उत्सवापूर्वी आणि उत्सवानंतरची माहिती गोळा करणे उपयुक्त ठरेल. शक्य असल्यास मागील वर्षातील तुलनात्मक माहिती आणि तत्सम व्यवसायांचा संदर्भ घेऊन परिणामांचा अधिक विश्वसनीय अंदाज बांधता येईल.

निष्कर्ष:

महाराष्ट्रातील उत्सवपरंपरा ही सूक्ष्म उद्योजकता, स्वयंरोजगार, पारंपरिक कारागिरी, महिला आर्थिक सहभाग आणि स्थानिक बाजारपेठांच्या विकासासाठी संभाव्य व्यासपीठ आहे. उत्सवांशी संबंधित वस्तू आणि सेवांच्या मागणीचा उपयोग नियोजनबद्ध पद्धतीने केल्यास स्थानिक उद्योजकांना नवीन ग्राहक मिळविणे, व्यवसायाची ओळख निर्माण करणे आणि उत्पन्ननिर्मितीच्या संधी विकसित करणे शक्य होऊ शकते.

डिजिटल पेमेंट, समाजमाध्यमांद्वारे विपणन, उत्पादनांचे ब्रँडिंग, सामूहिक विक्री, ऑनलाइन बाजारपेठ आणि पर्यावरणपूरक व्यवसाय प्रारूप ही या प्रक्रियेला मदत करणारी महत्त्वाची साधने ठरू शकतात. महिला बचतगट, युवक, ग्रामीण उद्योजक आणि पारंपरिक कारागीर यांना प्रशिक्षण व संस्थात्मक सहकार्य उपलब्ध झाल्यास या संधी अधिक समावेशक होऊ शकतात.

त्याचवेळी उत्सवाधारित व्यवसायांची हंगामी प्रकृती, भांडवलाची कमतरता, विक्रीतील अनिश्चितता, पायाभूत सुविधांचा अभाव आणि डिजिटल कौशल्यांची गरज या समस्यांकडे लक्ष देणे आवश्यक आहे. उत्सवकाळातील विक्रीचे वर्षभरातील व्यवसायात रूपांतर करण्यासाठी नियमित बाजारपेठ, ग्राहक संपर्क आणि व्यवसाय नियोजन महत्त्वाचे आहे.

त्यामुळे 'उत्सव ते उद्यम', 'एक उत्सव – एक स्थानिक उत्पादन' आणि 'डिजिटल उत्सव बाजारपेठ' यांसारखे उपक्रम प्रायोगिक स्वरूपात राबवून त्यांचे मूल्यमापन करता येईल. उत्सवांच्या आर्थिक परिणामांचे विश्वसनीय मोजमाप, पारदर्शक नियोजन आणि स्थानिक संस्थांचा सहभाग यांच्या मदतीने महाराष्ट्रातील उत्सवाधारित अर्थचक्र अधिक शाश्वत, समावेशक आणि नवोन्मेषाभिमुख बनविण्याची दिशा विकसित होऊ शकते.

अंततः, उत्सव हे केवळ परंपरा जपण्याचे माध्यम नसून स्थानिक कौशल्य, उद्योजकता आणि सांस्कृतिक वारसा यांना आधुनिक बाजारपेठेशी जोडण्याची संधीही आहेत. या संधींचा प्रभावी उपयोग करण्यासाठी सांस्कृतिक संवेदनशीलता, आर्थिक व्यवहार्यता आणि व्यावसायिक नवोन्मेष यांचा समन्वय आवश्यक आहे.

संदर्भसूची व पुढील संदर्भांसाठी स्रोत:

1. महाराष्ट्र शासन. महाराष्ट्राची आर्थिक पाहणी — संबंधित उपलब्ध वर्षांचे अहवाल.
2. महाराष्ट्र शासन, अर्थ व सांख्यिकी संचालनालय. जिल्हा सामाजिक व आर्थिक समालोचन — निवडलेल्या जिल्ह्यांचे अहवाल.
3. भारत सरकार, सूक्ष्म, लघु आणि मध्यम उद्योग मंत्रालय (MSME). वार्षिक अहवाल व सूक्ष्म उद्योजकतेशी संबंधित धोरणात्मक दस्तऐवज.
4. भारत सरकार, सांख्यिकी व कार्यक्रम अंमलबजावणी मंत्रालय (MoSPI). असंघटित क्षेत्र आणि उद्योगांशी संबंधित उपलब्ध सर्वेक्षण अहवाल.
5. भारतीय रिझर्व्ह बँक (RBI). वित्तीय समावेशन आणि डिजिटल पेमेंटशी संबंधित अधिकृत अहवाल.
6. राष्ट्रीय ग्रामीण आजीविका अभियान (DAY-NRLM) व महाराष्ट्र राज्य ग्रामीण जीवनोन्नती अभियान (उमेद). महिला बचतगट व ग्रामीण उपजीविकेशी संबंधित उपलब्ध दस्तऐवज.
7. पर्यटन संचालनालय, महाराष्ट्र शासन. पर्यटन आणि सांस्कृतिक पर्यटनाशी संबंधित उपलब्ध अहवाल.
8. सूक्ष्म उद्योजकता, सामाजिक उद्योजकता, नवोन्मेष आणि स्थानिक आर्थिक विकास यांवरील समकक्ष-समीक्षित संशोधन लेख, पुस्तके आणि विद्यापीठीय प्रबंध.

International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

डिजिटल गव्हर्नन्स आणि नागरिक सक्षमीकरण: भारतीय संदर्भातील एक विश्लेषणात्मक अभ्यास

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DOI - 10.5281/zenodo.24335168

गोषवारा (Abstract):

सध्याच्या काळात मोठ्या प्रमाणात डिजिटल गव्हर्नन्स अर्थात इ गव्हर्नन्स चा वापर होताना दिसत आहे.या इ गव्हर्नन्सच्या माध्यमातून नागरिकांना सक्षम करण्याचा प्रयत्न केला जात आहे. तसेच त्यांच्यासाठी वेगवेगळ्या प्रकारच्या सोयी सुविधा उपलब्ध करण्याचा प्रयत्न देखील होताना दिसत आहे.सदर संशोधन पत्रात डिजिटल गव्हर्नन्स आणि त्याच्या माध्यमातून नागरिकांचे सक्षमीकरण यांमधील संबंधाचा चिकित्सकपणे अभ्यास केला आहे. 21 वे शतक हे माहिती तंत्रज्ञानाचे आहे .या माहिती तंत्रज्ञानाच्या प्रसारामुळे मोठ्या प्रमाणात प्रशासकीय कामात पारदर्शकता, गतिशीलता आलेली आहे. त्याचबरोबर उत्तरदायित्वाची भावना सुद्धा वाढीस लागलेली दिसून येते. भारतासारख्या विकसनशील देशांमध्ये डिजिटल इंडिया मोहिमेच्या माध्यमातून शासकीय सेवा थेट नागरिकांपर्यंत पोहोचवण्यात या डिजिटल इंडियाने मोठे मोलाची भूमिका निभावलेली आहे. या संशोधन पेपर मध्ये दुय्यम सामग्रीच्या आधाराने भारतातील प्रमुख डिजिटल उपक्रमांचे त्यांचे नागरिकांच्या सक्षमीकरणावरील परिणाम आणि त्यासमोरील आव्हानांचे विश्लेषण केले आहे. त्यानंतर मिळालेल्या निष्कर्षातून असे दिसून येते की ,डिजिटल गव्हर्नन्समुळे भ्रष्टाचाराला आळा बसला आहे. नागरिकांच्या लोकशाही व्यवस्थेवरील विश्वास मोठ्या प्रमाणात वाढलेला आहे. हे जरी खरं असलं तरी आदिवासी पाडे, खेडेगाव आणि शहरी भागातील डिजिटल दरी मात्र पूर्णपणे मिटलेले नाही.अजूनही अनेक भागात या डिजिटल गव्हर्नरचा प्रचार आणि प्रसार पूर्णपणे झालेला नसल्याने ती दरी भरून काढण्यासाठी ठोस प्रयत्नांची गरज आहे.

महत्त्वाचे शब्द (Keywords): डिजिटल गव्हर्नन्स, नागरिक सक्षमीकरण, डिजिटल इंडिया, पारदर्शकता, सुशासन.

प्रस्तावना (Introduction):

पारंपारिक प्रशासनामध्ये मोठ्या प्रमाणात लालफीतशाहीचा प्रभाव दिसून येतो.त्याचबरोबर दप्तर दिरंगाई आणि मानवी हस्तक्षेप यांच्यामुळे भ्रष्टाचार वाढलेला होता. या समस्यांवर उपाय म्हणून डिजिटल तंत्रज्ञान महत्वाची भूमिका निभाऊ शकत. सुशासनाची संकल्पना जर प्रत्यक्षात आणायची असेल तर त्यासाठी डिजिटल गव्हर्मेंट हे आजच्या काळातील सर्वात प्रभावी माध्यम ठरू शकत. नागरिकांच्या सक्षमीकरणासाठी त्यांना सर्वप्रथम आपल्या हक्कांची जाणीव करून देणे, त्यांना निर्णय प्रक्रियेमध्ये सहभागी करून घेणे सोबतच विविध शासकीय सेवा विना विलंब त्यांना उपलब्ध करून देणे आवश्यक आहे.तसेच भ्रष्टाचार विरहितपणे मिळणे आवश्यक आहे. भारत सरकारने 2015 मध्ये डिजिटल इंडिया मोहीम सुरू केली. त्या आधारे आधार, यूपीआय आणि थेट लाभ हस्तांतरण योजना यांसारख्या गोष्टी सुरू

केल्यात. त्यामुळे नागरिकांचे जीवन अधिक सुकर व्हायला मदत झाली. आज आधार लिंकिंग च्या माध्यमातून थेट लाभ हस्तांतरणाच्या योजना यशस्वीपणे राबवल्या जात आहेत. त्यामुळे या योजनांमधला भ्रष्टाचार कमी झाला आहे. प्रत्यक्ष लाभार्थ्याला कोणत्याही प्रकारचा हस्तक्षेप न करता योजनेचा लाभ मिळत आहे .त्यामुळे ई गव्हर्नन्समुळे नागरिकांचे सक्षमीकरण होण्यास मदत झाली आहे. म्हणूनच डिजिटल गव्हर्नन्स हे केवळ तांत्रिक परिवर्तनाचे साधन नसून ते सामाजिक आणि आर्थिक सक्षमीकरणाचे एक महत्त्वाचे साधन बनले आहे, याचा अभ्यास या संशोधन पत्रात केला आहे .

संशोधनाची उद्दिष्टे (Objectives of the Research):

- डिजिटल गव्हर्नन्स संकल्पना समजून घेणे
- नागरिक सक्षमीकरणात डिजिटल गव्हर्नन्सचे महत्त्व स्पष्ट करणे.
- भारतातील प्रमुख ई-गव्हर्नन्स योजनांच्या प्रभावाचे मूल्यमापन करणे.
- डिजिटल प्रशासनामुळे नागरिकांच्या जीवनात झालेल्या सामाजिक-आर्थिक बदलांचे विश्लेषण करणे.
- डिजिटल गव्हर्नन्सच्या अंमलबजावणीतील आव्हाने शोधून त्यावर व्यावहारिक उपाय व शिफारशी सुचवणे.

अभ्यास पद्धती (Research Methodology):

प्रस्तुत संशोधन प्रामुख्याने वर्णनात्मक आणि विश्लेषणात्मक स्वरूपाचे आहे. यात प्रामुख्याने अभ्यासासाठी द्वितियक अभ्यास सामग्रीचा वापर करण्यात आला आहे.त्यात भारत सरकारच्या इलेक्ट्रॉनिक्स आणि माहिती तंत्रज्ञान मंत्रालयाचा वार्षिक अहवाल, जागतिक बँकेचे डिजिटल निर्देशांक, राष्ट्रीय व आंतरराष्ट्रीय स्तरावरील नामांकित जर्नल्स, संशोधन लेख, पुस्तके तसेच अधिकृत सरकारी संकेतस्थळांवरून माहिती संकलित करण्यात आली आहे.

मुख्य विश्लेषण आणि चर्चा:

डिजिटल गव्हर्नन्समुळे नागरिकांचे सक्षमीकरण प्रामुख्याने प्रशासकीय सुलभता, आर्थिक पारदर्शकता आणि लोकशाहीतील सहभाग या तीन स्तरांवर झालेले आहे.

अ) आर्थिक पारदर्शकता आणि थेट लाभ :

पूर्वीच्या काळी सरकारी योजनांचा लाभ सर्वसामान्य नागरिकांपर्यंत पोहोचताना मोठ्या प्रमाणावर मध्यस्थांची साखळी असायची.एकदा भारताचे माजी पंतप्रधान राजीव गांधी म्हणाले होते की," सरकार वरून एक रुपया पाठवत पण प्रत्यक्षात मात्र लाभार्थ्यापर्यंत 15 पैसेच पोहचतात ." मात्र डिजिटल गव्हर्नन्समुळे हि गळती थांबून पूर्ण एक रुपया लाभार्थ्यापर्यंत पोहचतो.या 'थेट लाभ हस्तांतरण' (DBT) आणि जन धन-आधार-मोबाईल सारख्या योजनांमुळे आज शेतकरी, विद्यार्थी आणि महिलांच्या खात्यात अनुदानाची रक्कम थेट जमा होते. यामुळे भ्रष्टाचाराला मोठा आळा बसला आहे.

ब) प्रशासकीय सुलभता आणि सेवांचे विकेंद्रीकरण :

सरकारी काम आणि सहा महिने थांब या उक्तीप्रमाणे पूर्वी नागरिकांना विविध दाखले, परवाने किंवा कागदपत्रांसाठी सरकारी कार्यालयांचे उंबरठे झिजवावे लागत असत .पण काम मात्र रेंगाळत राहायचे .लवकर पूर्ण व्हायचे नाहीत.परंतु सध्या मात्र हे चित्र बदललेलं आहे.आता महाराष्ट्र शासनाचे 'आपले सरकार' पोर्टल किंवा केंद्र सरकारचे 'उमंग' ॲप यांमुळे शेकडो सेवा 24 तास उपलब्ध आहेत.काम लवकर झाले नाही तर घरी बसून ऑनलाईन तक्रार दाखल करता येते.तिचा पाठपुरावा करता

येतो.त्यामुळे नागरिकांचा पैसा आणि वेळ वाचायला मदत झाली आहे.विविध शासकीय सेवांचे विकेंद्रीकरण व्हायला त्यामुळे मदत झाली आहे.

क) भारतातील प्रमुख डिजिटल साधनांचा प्रभाव खालील तक्त्याच्या माध्यमातून स्पष्ट करून सांगता येईल .

डिजिटल प्रणाली	**सुरुवात**	**मुख्य कार्य / वैशिष्ट्य**	**नागरिक सक्षमीकरणावरील प्रभाव**
आधार (Aadhaar)	2009	युनिक डिजिटल ओळख	देशातील प्रत्येक नागरिकाला कायदेशीर व डिजिटल ओळख मिळून बोगस लाभार्थी संपले.
मायगव्ह(MyGov.in)	2014	नागरिकांचा थेट सहभाग	सरकारी धोरणांवर नागरिक आपल्या सूचना आणि मते मांडू शकतात.सरकारी उपक्रमात सहभागी होऊ शकतात.
डिजिलॉकर (DigiLocker)	2015	कागदपत्रांचे डिजिटल संचयन	ऑनलाईन कागदपत्रे सुरक्षितपणे हाताळली जातात.कागदपत्रे हरवण्याची भीती नाही. कुठेही पडताळणी करणे सोपे झाले.
(युपीआय) UPI	2016	सोपे आणि विनामूल्य डिजिटल पेमेंट	आज देशाच्या कानाकोपऱ्यात वापरले जाते. ग्रामीण भागातील सामान्य व्यापाऱ्यांचे व नागरिकांचे आर्थिक सक्षमीकरण झाले.

ड) अंमलबजावणीतील प्रमुख आव्हाने :

विश्लेषणावरून असे दिसून येते की,

1. तंत्रज्ञानाचा विकास वेगाने होत असला तरी 'डिजिटल दरी' हे मोठे आव्हान आहे.
2. आदिवासी आणि ग्रामीण भागातील महिला तसेच आर्थिकदृष्ट्या दुर्बल घटकांमध्ये अजूनही डिजिटल साक्षरतेचा अभाव आहे.
3. सायबर गुन्हेगारी, डिजिटल अरेस्ट यांसारख्या घटनांमध्ये वाढ होत आहे.
4. डेटा सुरक्षेचा प्रश्न गंभीर बनला आहे.केव्हाही सायबर हल्ले होतात.
5. ग्रामीण आणि आदिवासी भागात इंटरनेट कनेक्टिव्हिटीच्या संदर्भात मोठ्या प्रमाणात अडचणी आहेत.दुर्गम पाडे अजूनही इंटरनेट कनेक्टिव्हिटीपासून कोसो दूर आहेत.

यांमुळे डिजिटल गव्हर्नन्सच्या पूर्ण क्षमतेचा वापर करण्यात अडथड्यांची मोठी शर्यत पार करून जिंकावी लागणार आहे.

निष्कर्ष:

संशोधनाच्या आधारे असा निष्कर्ष निघतो की,

1) डिजिटल गव्हर्नन्सने भारतातील नागरिक सक्षमीकरणात मोठा हातभार लावला आहे.
2) शासकीय यंत्रणेत पारदर्शकता आली असून सर्वसामान्य नागरिकांचा आवाज दिल्लीपासून गल्लीपर्यंत पोहोचू लागला आहे.
3) तंत्रज्ञानाने नागरिकांना त्यांचे हक्क मिळवून देण्याचे काम केले आहे.
4) परंतु, जोपर्यंत देशातील शेवटचा नागरिक डिजिटलदृष्ट्या साक्षर होत नाही, तोपर्यंत डिजिटल

गव्हर्नन्सचे अंतिम ध्येय म्हणजेच 'पूर्ण नागरिक सक्षमीकरण' साध्य होऊ शकत नाही.

शिफारशी :

डिजिटल दरी भरून काढण्यासाठी पुढील प्रकारच्या शिफारशी सुचवता येतील ,

प्रादेशिक भाषांचा वापरावर भर :

ॲप्स आणि पोर्टल्स मराठीसह सर्व प्रादेशिक भाषांमध्ये अत्यंत सोप्या स्वरूपात उपलब्ध असावेत.जेणेकरून त्यांना समजायला मदत होईल.वापर करायला सोपे जाईल.

डिजिटल साक्षरता मोहिमेचा विस्तार:

राष्ट्रीय डिजिटल साक्षरता अभियानाचा (NDLM) वेग वाढवून ग्रामीण भाग, वृद्ध आणि महिलांवर विशेष लक्ष केंद्रित केले जावे.

सायबर सुरक्षा बळकट करणे :

नागरिकांच्या डेटाच्या गोपनीयतेसाठी कडक कायदे असावेत आणि सायबर सुरक्षेबाबत जनजागृती केली जावी.

पायाभूत सुविधांचा विकास:

ग्रामीण आणि दुर्गम भागात अखंडित वीजपुरवठा आणि हाय-स्पीड इंटरनेट (5G/ब्रॉडबँड) सेवा पोहोचवणे गरजेचे आहे. त्यासाठी तंत्रज्ञानाच्या पुरेशा पायाभूत सुविधा उपलब्ध करणे आवश्यक आहे.

ऑफलाइन-ऑनलाइन समन्वय:

संपूर्ण डिजिटल व्यवस्था होईपर्यंत डिजिटल सेवा केंद्रांवर (CSC/महा-ई-सेवा केंद्र) नागरिकांना मदत करण्यासाठी सहाय्यकांची उपलब्धता असावी .त्यामुळे नागरिकांचा अनावश्यक त्रास वाचेल.

संदर्भ:

1. शासकीय अहवाल: इलेक्ट्रॉनिक्स आणि माहिती तंत्रज्ञान मंत्रालय , भारत सरकार, *वार्षिक अहवाल 2024-25*.
2. पुस्तक: डॉ. कुमार, सतीश (2023), *"भारतात ई-गव्हर्नन्स आणि सुशासन"*, के सागर पब्लिकेशन्स, पुणे.
3. संशोधन लेख: जाधव, ए. आणि पाटील, एस. (2022), "डिजिटल इंडिया मोहिमेचा ग्रामीण सक्षमीकरणावर झालेला परिणाम", *भारतीय समाजशास्त्र जर्नल्स*, खंड 12, पृष्ठ क्र. 88-95.
4. आंतरराष्ट्रीय अहवाल: युनायटेड नेशन्स (UN), *ई-गव्हर्नन्स सर्व्हे 2024: डिजिटल ट्रान्सफॉर्मेशन्स इन पब्लिक सर्व्हिसेस*.
5. वेबसाइट: www.nic.in

International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Artificial Intelligence in Language Learning and Digital Humanities: Opportunities, Challenges and Future Perspectives

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Abstract:

Artificial Intelligence (AI) is changing the way people learn languages and conduct research in the humanities. AI tools such as chatbots, machine translation, speech recognition, and writing assistants support language learning by providing personalised practice, immediate feedback, and flexible learning opportunities. In digital humanities, AI helps researchers analyse literary works, historical documents, cultural records, and multilingual texts. These technologies can save time, improve access to information, and support new forms of research. However, their use also creates challenges related to accuracy, privacy, academic integrity, and linguistic diversity. This paper examines the applications, opportunities, and challenges of AI in language learning and digital humanities. It follows a narrative literature review approach to discuss current developments and future possibilities. The paper argues that AI should support rather than replace teachers, learners, and researchers. Responsible use, human supervision, and critical thinking are necessary to ensure that AI contributes to effective learning and meaningful research.

Keywords: Artificial Intelligence, Language Learning, Digital Humanities, Generative AI, Natural Language Processing, Education.

Introduction:

Artificial Intelligence has become an important part of modern education and research. Developments in machine learning, natural language processing, and generative AI have made it possible for computers to understand, process, and generate human language. AI tools can translate texts, correct grammar, recognise speech, answer questions, and analyse large amounts of information.

Language learning traditionally depends on teachers, textbooks, classroom activities, and regular practice. Although these methods remain important, learners may not always receive individual attention or immediate feedback. AI-based applications can help address these difficulties by offering interactive exercises, conversation practice, and explanations of grammar and vocabulary. Learners can practise at their own pace and improve their skills beyond the classroom.

Digital humanities combines traditional humanities subjects, such as literature, history, linguistics, and cultural studies, with digital technology. Researchers use digital tools to study literary texts, historical records, cultural materials, and language patterns. AI extends these possibilities by helping researchers organise documents, identify themes, and examine large collections of information.

However, AI also has limitations. It may provide incorrect information, misunderstand cultural meanings, or produce biased results. Therefore, its use requires careful evaluation.

This paper discusses the role of AI in language learning and digital humanities, its major benefits and challenges, and the steps needed for responsible use.

Objectives and Methodology:

The main objective of this paper is to examine the role of AI in language learning and digital humanities. The study focuses on the following objectives:

1. To explain the major applications of AI in language education and humanities research.
2. To identify the benefits of AI for learners, teachers, and researchers.
3. To discuss the challenges related to accuracy, privacy, bias, and academic integrity.
4. To suggest future directions for the responsible use of AI.

The paper follows a narrative literature review approach. It draws on selected academic publications, research reviews, and educational guidelines related to AI, language learning, and digital humanities. The discussion is organised around applications, opportunities, challenges, and future developments.

This paper provides a general overview of the subject rather than a systematic review. It does not present original experimental data. Its purpose is to explain current developments and highlight areas that require further research.

Artificial Intelligence in Language Learning:

AI is becoming increasingly useful in language education. It supports the development of reading, writing, listening, speaking, grammar, and vocabulary skills. It can also provide additional learning opportunities outside traditional classrooms.

Personalised Learning:

One important benefit of AI is personalised learning. AI-based applications can adjust exercises according to learners' progress and difficulties. For example, learners who struggle with grammar can receive additional explanations and practice exercises, while those who need vocabulary development can focus on new words and their usage.

Personalised learning allows students to study at their own pace. It can also encourage independent learning by making educational support available outside classroom hours. However, the quality of learning depends on the accuracy of the system and the learner's ability to use its suggestions effectively.

Speaking and Pronunciation:

Speaking practice is essential for developing communication skills. However, some learners have limited opportunities to speak the target language regularly. AI chatbots can provide simulated conversations in which learners practise everyday situations, ask questions, and improve their confidence.

Speech recognition tools can also help learners identify pronunciation difficulties. Immediate feedback may help them recognise mistakes and practise more effectively. Nevertheless, these systems may not always understand different accents or regional variations. Therefore, AI feedback should be used alongside guidance from teachers and other speakers.

Writing and Grammar:

AI writing assistants can help learners correct grammatical errors, improve sentence structure, and develop vocabulary. They can explain language rules, suggest alternative expressions, and provide examples of clear writing.

These features can support the writing process and help learners understand their

mistakes. However, learners should not depend entirely on AI to complete writing assignments. Excessive dependence may reduce independent thinking and writing ability. AI should be used as a learning aid that helps students improve their own work.

Translation and Vocabulary:

Machine translation tools help learners understand unfamiliar words, sentences, and passages. AI dictionaries can provide meanings, synonyms, examples, and explanations of word usage. These tools are particularly useful in multilingual classrooms, where learners may need support in understanding educational materials.

However, direct translation may not preserve cultural meanings, idioms, humour, or expressions that depend on context. Learners should compare translations with reliable sources and consider the meaning of words within the wider passage.

Overall, AI can make language learning more flexible and interactive. Its success depends on responsible use, regular practice, and the continued involvement of teachers.

Artificial Intelligence in Digital Humanities:

Digital humanities uses digital technologies to study literature, history, language, culture, and society. AI provides additional methods for examining large collections of texts and identifying patterns that may be difficult to find through manual reading alone.

Literary and Textual Analysis:

AI tools can help researchers examine literary works by identifying repeated words, themes, language patterns, and relationships between texts. Natural language processing can support tasks such as text classification, sentiment analysis, and topic identification.

For example, researchers can compare literary works from different periods to explore changes in language or the treatment of particular themes. Analysing large collections of texts can help researchers identify patterns and develop new research questions.

However, literary interpretation involves more than identifying patterns. Metaphors, symbols, irony, historical background, and the author's purpose often require human understanding. AI can support textual analysis, but it cannot fully replace close reading and critical interpretation.

Historical Documents and Digital Archives:

Libraries, museums, and archives contain valuable materials such as manuscripts, letters, newspapers, and historical records. AI can help convert scanned documents into searchable text, organise digital collections, and identify relevant information.

These applications can save time and make historical materials more accessible to researchers and the public. They may also help preserve knowledge by improving access to documents that are difficult to handle or locate.

However, old documents may contain damaged pages, handwriting, unusual spelling, or unfamiliar languages. AI may misread these materials and produce inaccurate results. Researchers must check important information against the original documents before drawing conclusions.

Language and Cultural Research:

AI can support the study of multilingual texts, regional literature, cultural traditions, and oral histories. Translation and text analysis tools can help researchers explore materials written in different languages and identify connections between cultural traditions.

These applications may improve access to cultural resources and encourage research across disciplines. However, many AI systems work better with widely used languages than with languages that have limited digital resources.

Dialects, local expressions, and cultural meanings may also be misunderstood.

Researchers should therefore use AI carefully and ensure that local knowledge and cultural context remain central to their work.

Opportunities and Challenges:

AI offers several opportunities for education and research, but its benefits must be considered alongside its limitations.

Major Opportunities:

AI can make learning more accessible by providing flexible practice and immediate feedback. Learners can use digital tools to study at their own pace, while teachers can use them to prepare exercises and support different learning needs

AI can also save time by helping researchers organise documents, identify patterns, and perform repetitive tasks. This allows more time for interpretation, critical thinking, and the development of new ideas.

Another important opportunity is interdisciplinary collaboration. Language teachers, historians, literary scholars, and computer scientists can work together to explore research questions that combine technology with human knowledge.

AI may also support the preservation of cultural heritage by making historical documents and literary collections easier to search. When used responsibly, these applications can increase access to knowledge and support new forms of research.

Major Challenges:

One major challenge is accuracy. AI systems can produce incorrect information, unreliable translations, or references that do not exist. Such errors can create problems in academic work. Users must verify important information using reliable publications and original sources.

Academic integrity is another concern. Students and researchers need to distinguish between their own contributions and material generated by AI. Institutions and journals should provide clear guidelines on acceptable AI use and disclosure. Authors remain responsible for the accuracy and originality of their work.

Privacy is equally important. Entering personal information, unpublished research, or confidential documents into an AI platform may create risks. Users should understand the platform's data policies and follow their institution's rules for handling sensitive information.

AI systems may also reflect biases in their training data. Languages and cultures that are poorly represented in digital resources may receive less accurate support. This can increase existing inequalities. Greater attention should be given to regional languages, dialects, and underrepresented communities.

Finally, excessive dependence on AI may weaken independent learning and critical thinking. Learners may accept incorrect answers without checking them, while researchers may rely too heavily on automated analysis. Human judgement and careful evaluation must remain central to both education and research.

Future Perspectives:

The future use of AI should focus on improving accuracy, accessibility, transparency, and fairness. In language education, AI tools should help learners understand concepts and improve their skills rather than simply provide ready-made answers. Teachers should guide students in evaluating AI-generated information and using it responsibly.

Further research is needed to understand how AI affects language development, learner motivation, communication skills, and academic

performance. Studies should examine both its benefits and its possible negative effects.

In digital humanities, researchers should combine AI-based analysis with close reading, historical knowledge, and cultural interpretation. They should explain their methods, acknowledge the limitations of their tools, and verify important findings against original sources.

Developing AI resources for regional and low-resource languages should also be a priority. Better representation of different languages and cultures could improve access and reduce linguistic inequality.

Educational institutions, researchers, and technology developers should work together to establish clear guidelines for privacy, authorship, data protection, and responsible AI use. Regular evaluation will be necessary as AI technologies continue to develop.

Conclusion:

Artificial Intelligence is creating new opportunities in language learning and digital humanities. It can support personalised learning, speaking practice, writing improvement, translation, literary analysis, historical research, and digital archiving. These applications can improve access to information, save time, and support collaboration between different disciplines.

However, AI also presents challenges related to accuracy, privacy, bias, academic integrity, and overdependence on technology. Its outputs require careful checking, and its use must respect linguistic and cultural diversity.

AI should be viewed as a supportive tool rather than a replacement for teachers, learners, or researchers. Human judgement, critical thinking, and ethical responsibility remain essential. With proper guidance and careful implementation, AI can contribute to more accessible language education and more effective humanities research.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Biodiversity Conservation and Animal Health

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Abstract:

Biodiversity conservation is essential for maintaining ecological balance, protecting wildlife and ensuring the health and survival of animal population. This paper mainly focusses on impacts of invasive alien species and wildlife-human conflict on biodiversity conservation. As alien invasive species compete with native species for food and Habitat. And human wildlife conflict is a complex ecological and conservation challenge arising from interactions between human population and wildlife, often intensified by Habitat fragmentation and Land use change, and competition for natural resources.

Keywords: Biodiversity, Invasive Species, Human Wildlife Conflict, Kuno NP.

Introduction:

Biodiversity is increasingly threatened by on Sustainable exploitation of natural resources, extensive land use and land cover transformation and escalating environmental pollution which collectively contribute ecosystem degradation and the loss of biological diversity. (The conservation and management of biodiversity are crucial for achieving poverty reduction and sustainable development (Millennium Ecosystem Assessment 2005). Biodiversity conservation is essential for maintaining animal health because healthy ecosystem support animal survival, reproduction, genetic diversity, and disease resilience. Integrating ecological research, veterinary science, computational tools, and community participation can help to protect wildlife and promote the long-term health of ecosystems.

Major Threats to Biodiversity Conservation:

Compounding Ecological Impacts of Alien species on Biodiversity Conservation:

Invasive alien species is considered to be primary threats to biodiversity and ecosystem functioning globally (Vitousek et al. 1997: Steffen et al. 2015; Tilman et al. 2017). It is estimated that 25% of the mammals species, 13% of all bird species, and over 21000 species of plant face high probability of extinction within a 50-years window (Tilman et al. 2017). Theoharides and Dukes (2007) reviewed to the four stages of invasion 'pathways' (1) transport, (2) colonisation, (3) establishment, and (4) landscape spread. A species must typically pass through a variety of environmental filters at each of these stages before it be-comes invasive. (Theoharides and Dukes 2007; and Hellman et al. 2008).

1.Transport: Species are carried beyond their native range through human activities such as international trade, shipping and the transportation of goods through cold-chain

system. The rates at which species are transported across biogeographic zones has increased in intensity due to the rapid proliferation of trade networks (Seebens et al. 2015).

2.Colonisation: After successful transport, species are exposed to encounter novel environmental conditions, including variation in climate, hydrology, and habitat characteristics, as well as unfamiliar biological communities comprising autotrophs, heterotrophs and detritivores. Due to their high phenotypic plasticity, high capacity for hybridization, and broad environmental tolerance, the likelihood of successful colonisation of species that have survived the transport stage will possibly increase with climate change (Theoharides and Dukes 2007).

3.Establishment: Once a species successfully colonizes a new area, its ability to establish a self-sustaining and expanding population determines its successful establishment, is the third stage of the biological invasion pathway. Small subpopulations of individuals may be linked through dispersal, in an ecosystem where they either face reduced competition from native species, or represent functional groups either absent, or present in low abundance, within the community (Melbourne et al. 2007).

4.Landscape Spread: It refers to the expansion of an established invasive alien species across different habitats and geographical areas, facilitated by natural dispersal, human activities and environmental conditions. This final stage is represented by invasive species forming a regional meta-community, where groups of populations are connected through long-distance dispersal (Melbourne et al.2007).

India's National Biodiversity Action Plan (NBAP), which was drawn up in 2008 (MoEFCC 2008), listed a series of actionable stapes relating to invasive alien species, to be achieved within a 5-years time frame. A national brainstorming meeting on invasive species held at Punjab University in 2009, under the ministry of Environment and Forests. The focus of the meeting was to evolve coordinated National plan on managing invasive species and it also resulted in an edited volume on invasive species (Bhatt et al. 2012).

Human-Wildlife Conflict and Its Impact on biodiversity Conservation:

Wildlife human conflict are the result of a complex interplay of ecological and behavioural factors which have been categorised into the so-called 'proximate causes' and 'ultimate causes' in the language of evolutionary biology. (Sukumar 2016). Elephant raiding of cereal crops typically peaks towards the end of the rains and the beginning of the dry season when the plants flower or set grain and are ready for harvest (Sukumar 1989, 2003; Osborn 2004; Chiyo and Cochrane 2005), while African lion and Leopard (*Panthers pardus*) attack on livestock held within 'kraals' increases during the dry season(Butler 2000), though carnivores attack on livestock in some areas may intensify during the wet season when natural place are more difficult to locate because of poor visibility under condition of luxurient and vegetation (Patterson et al. 2004: kolowski and Holekamp 2006). One of the best-documented cases of increased wildlife human-conflict as a possible response to a severe drought comes from a study of Lion-human conflict during 1978-1991 in the Gir forest of Western India (Saberwal et al. 1994).

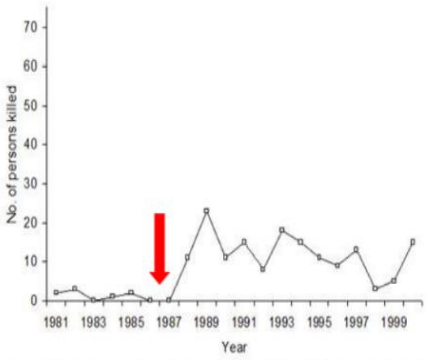


Figure 1. Number of people killed by elephants in south Bengal between 1980 and 1999. Arrow indicates El Niño event in 1986. Based on Sukumar (2003)

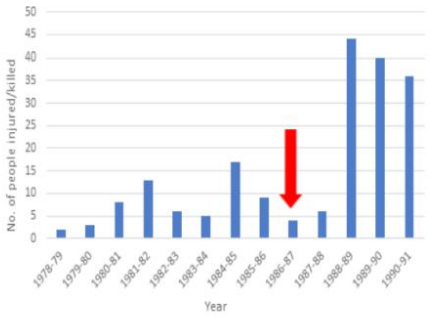


Figure 2. Number of people injured or killed by lions in and around Gir Forest, Gujarat, 1978-1991. Red arrow indicates the occurrence of severe drought associated with El Niño that began in March 1986 and ended in June 1988. Based on data presented in Saberwal et al. (1994).

Conservation and Management Strategies:

A. Computational tools and integrated approaches for biodiversity conservation and animal health: It comprises

- **Geographic information system (GIS):** Map Habitat Changes, species distribution, and environmental risk.
- **Remote Sensing:** Monitor deforestation, land-use changes, vegetation cover, and habitat degradation.
- **Species distribution models (SDM):** Predict changes in Species ranges under future climate scenarios.
- **Machine learning and artificial intelligence**: Identify patterns in this is outbreaks biodiversity loss and environmental changes, population viability analysis, estimate extinction the longterm survival of animal population.

B. Theoretical approaches:

- Develop mathematical models of population dynamics and extinction risk.
- Use ecological niche theory to predict Habitat suitability.
- Apply metapopulation theory to understand connectivity among fragmented habitats. Use community assembly theory to examine environmental filtering competition, and species coexistence.
- Apply eco-evolutionary and epidemiological models to study disease dynamics and adaptation.

C. Integrated Modelling Approaches:

- Combine field observations with mechanistic and statistical models.
- Calibrate and validate predictions using independent datasets.
- Use scenario analysis to compare alternative climate, land-use and conservation features.
- Apply sensitivity analysis and uncertainty quantification to identify key drivers of ecological change.
- Update models as new monitoring data become available. Population viability management include reduce avoidable mortality

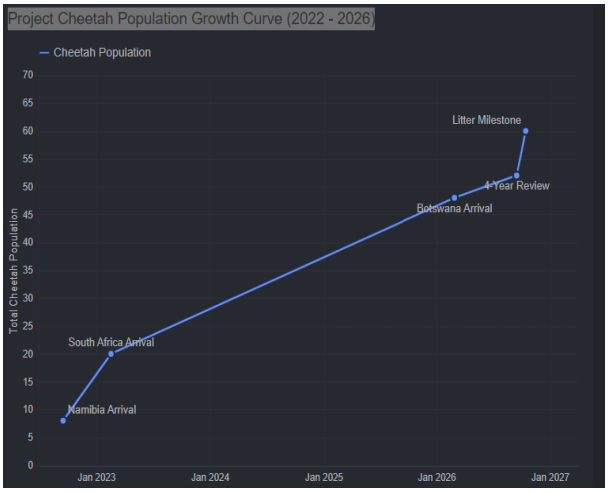
D. Recommended software or platforms for improving animal Health:

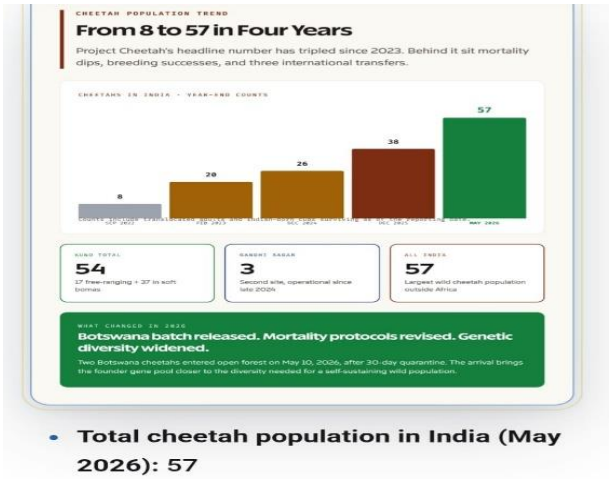
R, Python, QGIS, Maxent, EpiCollect5, WOAH-WAHIS, FAO EMPRES-I, Vortex, Movebank, Nextstrain, SISRS, NetLogo, NIMBLE or JAGS, Circuitscape.

E. Habitat protection and Restoration:

Project Cheetah: Advancing biodiversity conservation and Ecosystem Restoration in Kuno National Park (Madhya Pradesh). It is an important wildlife conservation initiative launched in India in 2022 to reintroduce Cheetahs, which had become extinct in the

country 1952. Its main objectives are- Restoration of an extinct species, Maintenance of ecological balance, Habitat restoration, Economic and social benefits, Scientific research and awareness. It also helps to maintain food-web relationships, maintain wildlife corridor. Conserve grassland and open woodland habitats, supports biodiversity conservation, protects ecosystem services. These are expected benefits of the conservation programme; their longterm achievements depend on effective habitat management, and prey availability. It also has contribution to global conservation effects with collaboration of international support and strengthening global biodiversity goals. It also benefits the local community for employment generation, greater public participation in wildlife protection and hospitality.





F. Integrated surveillance: Strengthening cross-sector coordination between environmental wildlife and veterinary authorities to monitor and detect animal disease early.

G. Policy integration: Incorporating wildlife and Ecosystem health into National and global agenda like the Convention on Biological Diversity (CBD) and World Organisation for Animal Health (WOAH).

Conclusion:

Combining computational tools with theoretical Ecology and empirical research provides a robust framework for understanding, predicting and mitigating the impacts on biodiversity conservation and animal health, population viability, and community assembly. This integrated approach supports evidence based conservation decisions, improves the identification of ecological risk, and helps develop adaptive management strategies that promote resilient ecosystems and sustainable wildlife populations.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Influence of sol aging, annealing temperature, and coating layers on optical properties of sol - gel derived nanostructured ZnO thin films

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DOI - 10.5281/zenodo.24338857

Abstract:

Achieving both high transparency and a clear, well-defined absorption edge is important when making nanostructured zinc oxide (ZnO) thin films for use in optoelectronics and sensors .In this study, we used a chemical sol-gel spin-coating method to deposit ZnO thin films onto glass .We closely examined how three main factors during the synthesis process affect the final properties: the time the precursor solution was left to age (24 hours, 48 hours, and 72 hours), the temperature used to heat the films after they were made (300°C versus 350°C) , and the number of layers in the film (8 layers versus 10 layers). Five different groups of samples (A_1 to A_5) were made and tested using UV-Vis spectrophotometry across the 300 to 800 nm range. The optical data shows that how the sol ripens in liquid form is just as important as the heating process in determining the quality of the film. Sample A_1, which had 10 layers, was annealed at 350°C after being aged for 48 hours, gave an excellent semiconductor behavior with a strong absorption edge for excitons below 380 nm ($A_{UV} \approx 0.18$ to 0.24) and a very low visible baseline that dropped to 0.02 (>95% transmission) .This resulted in a direct bandgap of Eg = 3.265 eV as found using Tauc analysis. On the other hand, sample A_2, which was made using an immature 24-hour aged sol and then heated at 350°C, showed a much higher baseline extinction across the visible spectrum ($A \approx 0.48$ to 0.50).This heavy absorption happened because of quick and intense solvent evaporation and breakdown of DEA, leading to issues like pinholes, uneven surfaces, and significant diffuse Mie scattering. Important to note, extending the sol aging time to 72 hours (A_5) allowed the sharp excitonic transition (Eg≈ 3.267 eV) to occur even at a lower annealing temperature of 300°C, while significantly reducing visible absorption ($A \approx 0.012$), resulting in an excellent optical contrast ratio of 9.83. These results show that longer liquid-phase aging reduces the energy needed to start crystallization, offering a more energy-efficient way to make high-quality ZnO.

Keywords: ZnO thin films, so – gel spin coating, sol aging kinetics, optical absorption, Tauc analysis, bandgap engineering.

Introduction:

Zinc oxide (ZnO) remains a popular topic in research because it's a direct, wide-band gap II-VI semiconductor with a bandgap energy of about 3.37 eV and a high exciton binding energy of 60 meV at room temperature [1, 4, 5]. This strong exciton stability means it doesn't break down easily under normal operating conditions [4, 5]. Along with high electrochemical performance, good optical transparency in the visible range,

non-toxic properties, and being widely available, ZnO thin films are used in many applications such as transparent conductive oxide (TCO) electrodes, ultraviolet (UV) photodetectors, piezoelectric transducers, solar cell window layers, and chemiresistive gas sensors [1, 4, 9]. Among various ways to make these films, the chemical sol-gel spin-coating method is especially useful because it's simple to do on a regular lab bench, low in cost, and allows for precise control over the molecular structure without needing expensive vacuum equipment [1, 8]. However, creating good quality, low-defect films with this method is still tough because the process involves three connected stages that need to work together properly [1,6,8]

Sol Ripening (Aging Kinetics):

When zinc precursors are mixed with alcohol, they go through hydrolysis and polycondensation to form colloidal networks of Zn-O-Zn structures before being spread on a substrate [1, 7, 8].

Layer Accumulation Dynamics:

How fast the spin-coating happens, how many times it's done, and how much heat is applied during drying affects how the layers pack together, how solvents evaporate, and how pinholes are filled [1, 10].

Thermal Sintering Budget:

After the film is deposited, heat treatment helps remove chemical binding agents, makes the inorganic structure denser, and starts the formation of the hexagonal wurtzite crystal structure [1, 6].

If these processes aren't properly balanced, the films can have issues like pinholes, cracks, and uneven surfaces [1, 8]. These problems cause light to scatter in different directions, which leads to unwanted absorption across the visible spectrum and negatively affects the performance of transparent devices [1, 8].

Before doing expensive and time-consuming tests that look at the structure and shape of the films, room-temperature optical absorption spectroscopy is a useful, non-destructive method that can help figure out the band-edge steepness, sub-bandgap losses, and electronic bandgap energy [1, 6].

In this study, we compare five different ZnO thin-film setups (A1–A5) [1].We look at how the time the solution is aged (24 h, 48 h, 72 h) [1, 7], the temperature used for calcination (300°C vs.350°C) [1, 6], and the number of layers (8 vs.10) [1, 10] affect the films. Our goal is to find an efficient way to make these films with good performance.

Experimental Details:

1. Precursor Formulation and Controlled Sol Aging:

We made a 0.4 M precursor solution by dissolving high-purity zinc acetate dihydrate [Zn(CH3COO)2·2H2O] in 2-methoxyethanol while continuously stirring it with a magnetic stirrer at a temperature between 60 and 70 degrees Celsius for one hour [1, 8].

To keep the solution stable and stop hydroxide from forming on its own, we slowly added ethanolamine (DEA) drop by drop as a chelating agent. We made sure the ratio of DEA to Zn2+ was exactly 1:1 [1, 8]. The resulting clear and uniform sol was put into sealed glass containers and left to age at room temperature in a dark area at 25 degrees Celsius for three different aging times: 24 hours, 48 hours, and 72 hours [1, 6, 7].

2. Substrate Cleaning and Thin Film Deposition:

Microscope glass slides were cleaned using ultrasonication in acetone, ethanol, and double-distilled deionized water for 15 minutes each [1]. The aged sols were spread onto the center of the cleaned substrates and spun using a programmable spin coater in two steps [1, 10].

Spreading Stage: 1500 rpm for 20 seconds [1]
Deposition Stage: 3000 rpm for 40 seconds [1]

After each coating step, the wet thin films were heated on a hot plate at 150 degrees Celsius for 5 minutes to remove the remaining liquid and harden the gel layer [1, 10]. This coating and drying process was repeated 8 and 10 times to create either 8 or 10 layers respectivelly[1, 10].

3. Post-Deposition Thermal Annealing:

After building up the layers, the multi-layer films were heated in a muffle furnace in regular air for one hour at either 300°C or 350°C [1, 6]. The details about the materials used and the sample names are listed in Table 1 [1].

Table 1: This table shows the different combinations of materials and settings used to make the ZnO thin films through the sol-gel method [1].

Sample Code	Coating Layers	Annealing Temperature (Ta)	Sol Aging Time (age)	Target Processing Regime
A1	10 Layers	350°C	48 hours	Higher temperature / Moderate sol ripening
A2	8 Layers	350°C	24 hours	Higher temperature / Short sol ripening
A3	10 Layers	300°C	24 hours	Lower temperature / Short sol ripening
A4	8 Layers	300°C	24 hours	Lower temperature / 8-layer accumulation
A5	10 Layers	300°C	72 hours	Lower temperature / Extended sol ripening

4. Optical Characterization:

For the optical characterization, absorption spectra were measured at room temperature across a wavelength range of 300 to 800 nm using a double-beam UV-Vis spectrophotometer [1]. A clear, untreated glass slide was placed in the reference beam path to remove any effects from the substrate [1].

Results and Discussion:

1. UV-Vis Optical Absorption Spectra:

The optical absorption profiles from 300 nm to 800 nm are shown in Figure 1 [1]. There are clear differences based on the thermal and chemical history of each sample [1]:

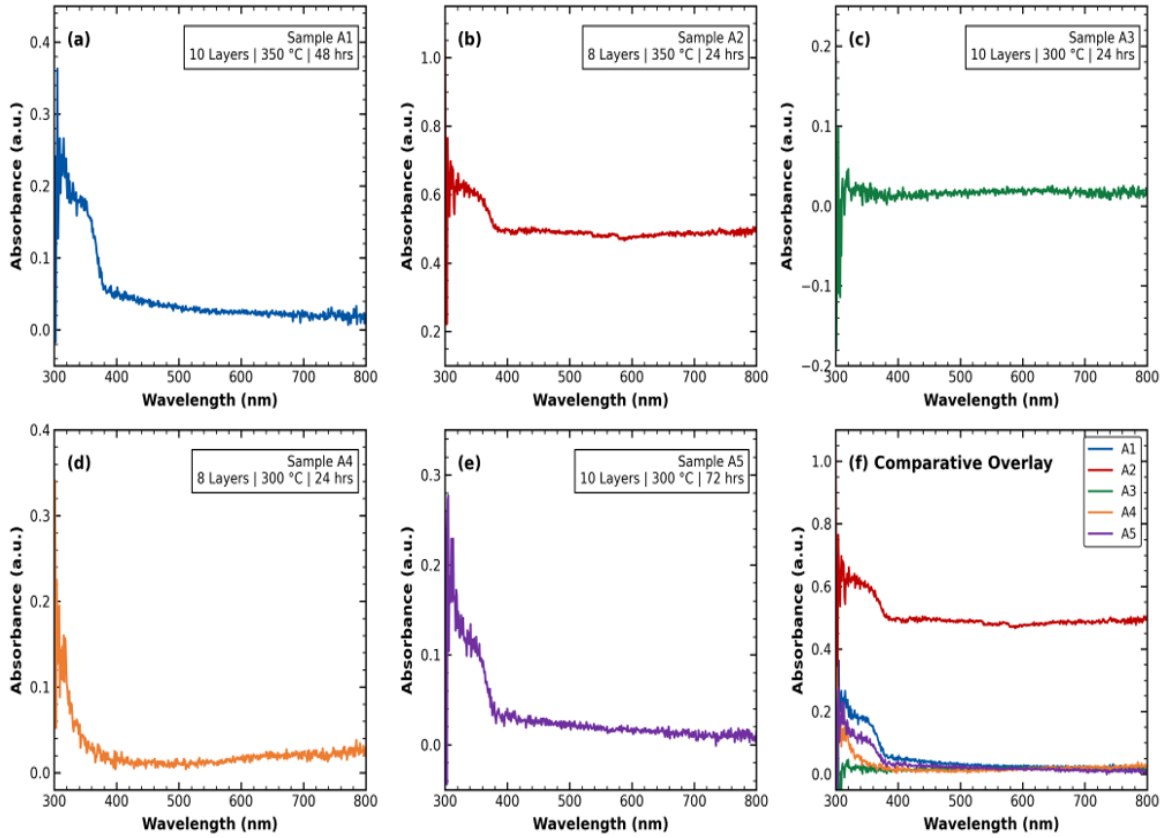

Figure 1: UV-Vis optical absorption spectra of sol-gel derived ZnO thin films: (a) Sample A1, (b) Sample A2, (c) Sample A3, (d) Sample A4, (e) Sample A5, and (f) Comparative overlay across 300 -- 800 nm [1].

Sample A_1 (10 L, 350°C, 48 h): Sample A_1 shows a typical optical absorption pattern of high-quality crystalline ZnO [1, 4]. It has a sharp, well-defined fundamental excitonic band edge below 380 nm, with optical absorbance reaching 0.18 to 0.24 in the near-UV range (320 -- 350 nm) [1]. After 400 nm, the absorbance drops sharply and remains flat near 0.02 across the entire visible range (400 -- 800 nm) [1]. This suggests visible transparency higher than 95% and low levels of defect-induced sub-bandgap scattering [1, 9].

Sample A_2 (8 L, 350°C, 24 h): In contrast, Sample A_2 shows a strong, elevated absorption plateau (A ≈ 0.48 -- 0.50) throughout the visible spectrum [1].

This baseline isn't due to real interband electronic absorption [1]. Because the sol was only aged for 24 hours, the colloidal oligomers weren't fully cross-linked [1, 8]. When this unripe sol was exposed to 350°C directly, it led to rapid thermal decomposition and strong gas release from leftover DEA chelates and solvent molecules [1, 8]. This sudden volatile release created rough surfaces, pinholes, and uneven layers, causing heavy diffuse Mie scattering [1, 8].

Samples A_3 and A_4 (300°C, 24 h): Both Samples A_3 (10 layers) and A_4 (8 layers) show almost no optical density across all measured wavelengths (A ≈ 0.01 -- 0.02) [1]. At a lower anneaing temperature of 300°C, a 24-hour aged sol doesn't have enough polycondensation to stick properly, leading to poorly formed films and low solid deposition [1, 7]. Sample A_4 only shows a weak absorption start below 340 nm [1].

Sample A_5 (10 L, 300°C, 72 h): By extending the sol aging time to 72 hours, the film formation at 300°C changed completely [1, 6, 7]. Sample A_5 fully regains the sharp UV absorption edge below

375 nm (A ≈ 0.12 -- 0.27) and reduces visible extinction to an exceptional Avis ≈ 0.012 [1]. Longer aging allows ongoing olation and oxolation reactions in the liquid phase, creating organized Zn-O-Zn polymeric networks [1, 7, 8]. This pre-condensation lowers the activation energy needed for solid-state crystallization, allowing sharp band-edge formation even at 300°C [1, 7, 8].

Table 2: Quantitative optical metrics extracted from UV-Vis absorption spectra [1].

Sample Code	Mean UV Absorbance (320 --350 nm})	Visible Baseline Absorbance (600 --750 nm})	Optical Contrast Ratio (A_{UV}/A_{vis})	Direct Optical Bandgap Eg (eV)	Film Quality Assessment
A1	0.181	0.021	8.62	3.265	Optimal: High clarity, sharp band edge
A2	0.612	0.488	1.25	—	Scattering-dominated: Severe visible extinction
A3	0.018	0.016	1.12	—	Under-developed: Incomplete deposition
A4	0.054	0.018	3.00	—	Incomplete: Weak band-edge definition
A5	0.118	0.012	9.83	3.267	Optimal: Low-temperature crystallization

2. Optical Bandgap Evaluation (Tauc Method):

To determine the direct allowed electronic transition, we deduced the absorption coefficient (α) using the Beer-Lambert relationship: [1]

$$\alpha = \frac{2.303 \times A}{d}$$

where A is the measured optical absorbance and d is the nominal film thickness [1]. The incident photon energy (h\nu) in electron-volts was converted via: [1]

$$hv = \frac{1239.84}{\lambda}$$

For direct allowed interband transitions across the fundamental band edge, the absorption behaviour obeys the classical Davis–Mott and Tauc formulation [1, 2, 3]:

$$(\alpha hv)^2 = B(hv - E_g)$$

where Eg is the optical bandgap energy and B is a transition probability parameter [1, 2, 3].

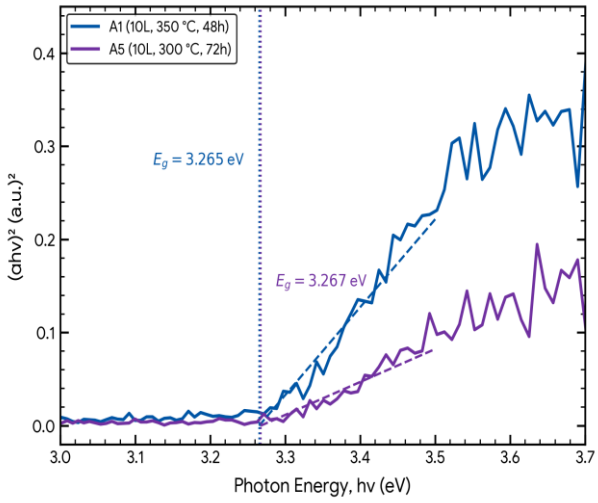

Figure 2: Tauc plot analysis showing $(\alpha hv)^2$ versus photon energy (hv) for optimal samples A_1 (10 L, 350° C, 48 h) and A_5 (10 L, 300° C, 72 h), illustrating direct bandgap extrapolation [1, 2].

By looking at the linear absorption onset of $(\alpha h\nu)^2$ and where it reaches zero on the energy scale [1, 2]:

Sample A1: Eg = 3.265 ± 0.01 eV [1]

Sample A5: Eg = 3.267 ± 0.01 eV [1]

Both of these values are very close to what is typically seen in standard pure wurtzite ZnO nanostructures [1, 4, 5].

To better understand how clear the films are, we used something called the Optical Contrast Ratio.

It is calculated by dividing the average UV absorbance (between 320 and 350 nm) by the visible light absorbance (between 600 and 750 nm) [1]. From Table 2, we can see that Sample A_5 had the highest contrast ratio of 9.83, followed by Sample A_1 at 8.62 [1]. On the other hand, Sample A_2 had a much lower ratio of only 1.25 [1].In Sample A_2, the strong scattering of light made it hard to see the excitonic onset, which means we couldn't accurately determine the bandgap [1].

The main point from Table 2 is that Sample A_5, which was processed at 300 °C and aged for 72 hours, has a bandgap that is just as sharp and clear as Sample A_1, which was processed at 350 °C and aged for 48 hours [1, 6].This shows that increasing the sol aging time by 48 hours can make up for a 50 °C decrease in the thermal annealing temperature [1, 6].

Conclusions:

In this study, we carefully looked at how different factors—like how long the sol is aged, the temperature used for thermal annealing, and how many times the coating is applied—affect the optical properties of ZnO thin films made using the sol-gel method [1].

The Main Findings are:

Critical Role of Sol Aging: The process of letting the sol sit and ripen in liquid form is just as important as the high-temperature calcination in removing unwanted visible light absorption [1, 7]. If we fire a sol that hasn't been ripened for 24 hours at 350°C (A_2), it causes a lot of scattered light (A ≈ 0.50) because of strong gas release [1, 8]. On the other hand, aging the sol for a moderate time (48 hours, A_1) results in very high transparency (>95%) and a clear excitonic absorption edge [1, 9].

Thermal Energy Economy: Extending the aging time to 72 hours (A_5) allows us to lower the calcination temperature by 50°C [1, 6]. This gives a direct bandgap of Eg ≈ 3.267 eV and the highest optical contrast ratio (9.83) [1]. This method is energy-efficient and works well with temperature-sensitive transparent materials [1, 6].

Technological Suitability: The configurations A_1 and A_5 are the best choices for applications like transparent conductive oxide windows, UV-blocking filters, and chemiresistive gas sensors [1, 4, 9].

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

शेती विकासात नव आधुनिक ड्रोन तंत्रज्ञानाची भुमिका

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DOI - 10.5281/zenodo.24338888

प्रस्तावना:

भारतात तंत्रज्ञानाची सुरवात कधी झाली हे निश्चित सांगता येणार नाही. परंतू भारताला १९४७ मध्ये स्वातत्र्य मिळाल्यानंतर व १९५१ मध्ये नियोजनाला सुरवात झाल्यावर तंत्रज्ञानाच्या विकासाला टप्याटप्याने सुरवात झाली. १९६०-१९७० च्या दशकात संगणक, अंतराळ संशोधन आणि वैज्ञानिक तंत्रज्ञानाचा विस्तार सुरु झाला. १९९१ च्या आर्थिक उदारीकरणामुळे संगणक व माहिती तंत्रज्ञान उद्योगाच्या विस्ताराला चालना मिळाली. तसेच २०२० चे दशक कृत्रिम बुद्धिमत्ता (AI) ड्रोन, रोबोटिक्स आणि आधुनिक डिजिटल तंत्रज्ञानाचा वापर मोठ्या प्रमाणात वाढला

संशोधनाचा उद्देश:

1. (AI) तंत्रज्ञान शेती विकासासाठी उपयुक्त आहे का?
2. ड्रोन तंत्रज्ञानातून शेतीचा विकास साध्य करता येईल का?
3. आदिवासी अल्प भुधारक शेतक-यांना ड्रोन चा वापर फायदेशीर आहे का?
4. नव तंत्रज्ञान ड्रोनचा किफायतशीर आहे का?
5. भारतातील अशिक्षित शेतकरी ड्रोनचा वापर करण्यास सक्षम आहेत का ?
6. सरकारला शेतीत ड्रोन वापराबाबत यश मिळाले आहे का?

संशोधनाची गृहिते:

संशोधन निबंधाची गृहिते पुढील प्रमाणे सांगता येतील

1. स्वांतत्र्यपूर्व काळात भारतात तंत्रज्ञानाचा वापराचा अभाव होता
2. भारतीय शेतकरी परंपरागत व जुनाट तंत्राचा वापर करत होते.
3. नियोजनाला सुरवात झाल्यानंतर तांत्रिक प्रगती टप्याटप्याने सुरु झाली
4. १९९१ च्या उदारीकरण धोरणामुळे तांत्रिक प्रगती खऱ्या अर्थाने सुरवात झाली आहे
5. २०२० चे दशक कृत्रिम बुद्धीमत्ता, ड्रोन व आधुनिक डिजिटल युग म्हणून ओळखले जाते
6. कृत्रिम बुद्धीमत्ता (AI) व ड्रोन तंत्रज्ञानामुळे अचुक माहिती मिळते

संशोधन पध्दती:

लघु शोधू निबंधाच्या शिर्षकानुसार लिखीत ग्रंथ, वर्तमानपत्रे, मासिके व ग्रंथ इत्यादी साहित्याचा आधार घेवून व शासकीय वेब,आणि कृषी विभागातील माहितीच्या आधारे विश्लेषण करण्यात आले आहे. प्राथमिक व दुय्यम स्त्रोताचा वापर करण्यात आला आहे.

संशोधनाचे महत्व:

भारतीय शेती व शेतकरी या विषयाचे अध्ययन करतांना, असे दिसून येते की, शेती, शेतकरी व ग्रामीण संस्कृती हे भारतीय समाज रचनेचे आहे. अभिन्न अंग आहे. ते एकरूप व एकमेकाशी निगडीत आहेत. शेती हा केवळ व्यवसाय नसून ती जीवन पद्धती आहे. त्यामुळे भारतीय समाजरचना व अर्थव्यवस्थेत शेतीला अनन्य साधारण महत्व आहे. यादृष्टीने विचार केला असता असे दिसून येते की, प्राचिन काळापासून तर आजच्या आधूनिक व डिजिटल युगात शेती व्यवसाय करण्याच्या पध्दतीत बराच अमुलाग्र बदल झाला आहे. विशेषतः २०२० नंतर कृत्रीम बुद्धिमत्ता व ड्रोन तंत्रज्ञान, रोबोटिक्स आणि आधुनिक डिजिटल तंत्रज्ञानाचा वापर वाढला आहे. आधुनिक भारतातील संगणक, माहिती तंत्रज्ञान, इंटरनेट, आणि डिजिटल सेवा, विकासाच्या दृष्टीने काही महत्वपूर्ण वर्ष व घटना पुढील प्रमाणे सांगता येतील

अ) १९५०**. चे दशक** :- या काळात काळात तंत्रज्ञानाची सुरवात झाली

ब) १९९० **चे दशक** :- १९९० चे दशक बऱ्याच घटनामुळे महत्वपुर्ण मानले जाते. या दशकात LGP चा म्हणजेच जागतिकीकारण, उदारीकरण, व खाजगीकारणाचा अवलंब करण्यात आला. यासह संगणक, इंटरनेट, माहिती तंत्रज्ञानाचा व्यापक वापर आणि विकास इत्यादीसह भारताने १९९५ मध्ये सार्वजनिक इंटरनेट सेवा सुरु केली

क) २०१० **नंतर चा कालावधी** :- २१ शतकाच्या प्रारंभिक दशकात स्मार्टफोन, डिजिटल पेमंट, आणि ऑनलाईन सरकारी सेवा: ऑनलाईन बँकींग सेवांचा मोठ्या प्रमाणावर वापर व विस्तार झाला,

ड) २०२० **चे दशक :-** २०२० चे दशक अतिशय महत्वपूर्ण म्हणून ओळखले जाते. या कालावधीत कृत्रीम बुध्दिमत्ता, ड्रोन आणि स्वयंचलित तंत्रज्ञानाचा वाढता वापर इत्यादी तांत्रिक बदल मोठ्या प्रमाणात झाल्याच दिसून येते.

कृत्रीम बुद्धिमत्ता (AI) आणि ड्रोन तंत्रज्ञान मानवी बुध्दीमत्ते प्रमाणे विचार करणे, माहितीचे विश्लेषण करणे, निर्णय घेणे आणि समस्या सोडविणारे तंत्रज्ञान म्हणजे (AI) कृत्रीम बुध्दीमत्ता होय.असा साधा-सरळ व सुलभ अर्थ AI बाबत सांगितला जातो. AI चा शिक्षण, आरोग्य, शेती, उद्योग, बँका, शोध-संशोधन आणि प्रशासन इत्यादी क्षेत्रात महत्वाची भुमिका पार पाडत आहे. तर ड्रोन तंत्रज्ञान म्हणजे स्वंयचलित पध्दतीने उडविले जाणारे मानवरहित हवाई वाहन होय. ड्रोन चा वापर अनेक क्षेत्रात होतांना दिसुन येता उदा. शेती, नकाशे तयार करणे, फोटोग्राफी, वाहतुक निरिक्षण, सिमा सुरक्षा अशा अनेक विध क्षेत्रात ड्रोन चा वापर केला जातो. AI व ड्रोन यांच्या संयुक्त वापरामुळे अचुक माहिती संकलन, जलद विश्लेषण, वेळेची बचत, आणि कार्यक्षमता वाढते. म्हणजे AI' व ड्रोन तंत्रज्ञान हे आधुनिक विकासाचे साधन म्हणून महत्वपुर्ण आहे.

संशोधन निबंधाचे स्पष्टीकरण:

भारत सरकारने शेतीमध्ये ड्रोनचा वापर वाढविण्यासाठी जनजागृती, प्रशिक्षण, प्रात्यक्षिके आणि अनुदानाच्या विविध उपाययोजना सुरू केल्या आहेत. ड्रोनचा वापर वाढला आहे की नाही, हे तपासण्यासाठी ड्रोनची संख्या, प्रत्यक्ष फवारणी केलेले क्षेत्र, ड्रोन सेवा घेणाऱ्या शेतकऱ्यांची संख्या आणि सरकारी योजनांमधून

झालेला वापर यांची आकडेवारी पाहणे आवश्यक आहे. सरकारी आकडेवारी भारत सरकारच्या कृषी मंत्रालयाने लोकसभेत दिलेल्या माहितीनुसार आणि जुलै २०२६ च्या अधिकृत प्रसिद्धीनुसार पुढील चित्र दिसते. २०२३–२४ ते २०२५–२६ या कालावधीतील आकडेवारी ४०,९२८ **ड्रोन प्रात्यक्षिके संख्या** :-४०,९१८ हेक्टर **प्रात्यक्षिकांचे एकत्रित क्षेत्र:**-४.५२ लाख**शेतकरी लाभार्थी संख्या :-** २१२२ तसेच सरकार मार्फत ड्रोनचा वापर व उपयुक्तता वाढावी यासाठी महिला बचत गटांच्या माध्यमातूनही ड्रोनचा वापर वाढविण्याचा प्रयत्न होत आहे. फेब्रुवारी २०२६ च्या सरकारी माहितीनुसार, 'नमो ड्रोन दीदी' योजनेअंतर्गत ५०० ड्रोन वितरित करण्यात आले होते; महाराष्ट्रातील बचत गटांना एकूण ६० ड्रोन वितरित झाल्याची माहिती जानेवारी २०२६ पर्यंत नोंदवली होती

शेतीमध्ये ड्रोन वापरण्याचे फायदे:

1. **वेळेची बचत:** मोठ्या क्षेत्रातील पिकांची पाहणी कमी वेळेत करता येते.
2. फवारणी सुलभ: कीटकनाशके व द्रवरूप खतांची फवारणी जलद करता येते.
3. **मजुरीचा खर्च कमी**: काही कामांसाठी मजुरांवरील अवलंबित्व कमी होते.
4. **पीक निरीक्षण:** पिकांवरील रोग, कीड आणि पाण्याची कमतरता ओळखण्यास मदत होते.
5. **पाण्याची बचत:** ठिबक सिंचन आणि पाणी व्यवस्थापनाचे नियोजन अधिक प्रभावी करता येते.
6. **उत्पादनात सुधारणा:** योग्य वेळी योग्य उपाय केल्यामुळे पीक उत्पादन आणि गुणवत्ता सुधारण्यास मदत होते.
7. **कठीण भागांत उपयोग:** डोंगराळ, दुर्गम आणि मोठ्या शेतांमध्ये निरीक्षण व फवारणी करणे सोपे

होते वरील प्रमाणे शेतीत ड्रोन चा वापर केला असता काही फायदे मिळतात. ड्रोन चा शेतीसाठी वापर केला असता काही फायदे निश्चित मिळतात परंतु ड्रोन वापराची दुसरी बाजू बघितली असता त्यांचे दोष व उणीवा आहेत त्याची माहिती पुढील प्रमाणे

शेतीमध्ये ड्रोन वापरण्याचे तोटे किंवा उणीवा:

1. **जास्त प्रारंभिक खर्च:** ड्रोन खरेदी, बॅटरी आणि इतर उपकरणांसाठी मोठी गुंतवणूक आवश्यक असते.
2. **प्रशिक्षणाची गरज:** ड्रोन चालविण्यासाठी तांत्रिक ज्ञान आणि आवश्यकतेनुसार अधिकृत प्रशिक्षण लागते.
3. **देखभाल खर्च:** दुरुस्ती, बॅटरी बदलणे आणि नियमित देखभाल यांचा खर्च होतो.
4. **हवामानाचा परिणाम**: जोरदार वारा, पाऊस आणि प्रतिकूल हवामानात वापर मर्यादित होतो.
5. **लहान शेतकऱ्यांसाठी अडचण:** वैयक्तिकरीत्या ड्रोन खरेदी करणे परवडेलच असे नाही.
6. **सुरक्षिततेचे धोके:** चुकीची फवारणी झाल्यास पिकांचे नुकसान, रसायनांचा संपर्क आणि पर्यावरणावर विपरीत परिणाम होऊ शकतो.
7. **तांत्रिक मर्यादा:** बॅटरी क्षमता उड्डाणाचा कालावधी आणि वजन वाहून नेण्याची मर्यादा यांमुळे कामावर बंधने येतात. वरील प्रमाणे ड्रोन वापराबाबत दोष दिसून येतात.

निष्कर्ष:

नवतंत्रज्ञान हे शेतकऱ्यांचे उत्पन्न वाढविण्यास, शेतीचा खर्च कमी करण्यास आणि शेती अधिक शाश्वत बनविण्यास महत्त्वपूर्ण ठरू शकते. मात्र, तंत्रज्ञानाचा लाभ

सर्व शेतकऱ्यांपर्यंत पोहोचविण्यासाठी परवडणारी उपकरणे, प्रशिक्षण, कर्ज व अनुदान सुविधा आणि बाजारपेठेशी जोडणी आवश्यक आहे. "नवतंत्रज्ञान, आधुनिक शेती आणि शेतकऱ्यांचे सक्षमीकरण यांचा समन्वय साधल्यास शेती अधिक समृद्ध, उत्पादक आणि शाश्वत होऊ शकते."

संदर्भ साहित्य:

1. भारत सरकार कृषी मंत्रालय व PIB
2. माऊली ग्रीन आर्मी
3. Sorghum (Jawar) Fileds Maharashtra
4. India Namo Drone Didi Scheme
5. Phulwabti Meena "The sole Drone pilot in Rajasthan's Pratapgarth Village
6. Drone- https://images.openai.com

International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

E-Commerce for Healthcare Services in Maharashtra: Evidences from Public Telemedicine Trends

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DOI - 10.5281/zenodo.24338924

Abstract:

This paper examines published administrative data for three public telemedicine programmes in Maharashtra and considers their relevance to healthcare e-commerce. It analyses annual figures for the state telemedicine-centre programme, Ayushman Arogya Mandir (AAM) teleconsultation and eSanjeevani OPD. The series follow different patterns, and the figures reported for 2024–25 cover only the period through December 2024. The English and Marathi versions of the government source also report different AAM figures for that period. The study compares each series separately because the source does not establish that their definitions and populations are mutually exclusive. The figures document activity in public telemedicine programmes; they do not measure paid transactions on private platforms, unique consumers or healthcare e-commerce revenue in Maharashtra. The paper identifies the additional data needed to assess those wider activities.

Keywords: Public Telemedicine; Healthcare Services; E-Commerce; Maharashtra; Digital Health; Administrative Data.

Introduction:

E-commerce is often associated with buying and selling goods online, but digital platforms also help people find, book, pay for and receive services. In healthcare, a consumer may use a website or application to locate a provider, book an in-person appointment, consult a doctor remotely or arrange a diagnostic test. These activities involve different stages of service delivery and should not automatically be treated as equivalent transactions.

The distinctions matter in healthcare. Telemedicine uses digital communication to provide clinical care remotely, whereas an online appointment may lead to an in-person visit. Public teleconsultation may also be provided without a payment by the patient. Medicine orders, consultations and registrations on digital health systems are different activities; a registration alone does not show that a service was completed. Any assessment of adoption or market size must therefore define what is being counted.

Maharashtra is a useful setting for examining public digital healthcare because the state reports activity through its telemedicine-centre programme, AAM teleconsultation and eSanjeevani OPD. Consumers also have access to private digital health platforms, but the government series do not describe that wider market.

This paper analyses the three published government series and uses selected academic studies to place them in context. It then considers

what these data can show about public telemedicine and which aspects of healthcare e-commerce remain unmeasured.

Research Focus, Objectives and Questions:

1. Research Problem:

Digital platforms can change how healthcare services are found, arranged and delivered, but the available indicators measure different activities. Public teleconsultation counts record activity in named programmes; they do not show the number of paid transactions on private platforms, unique consumers, market value or the proportion of Maharashtra's population using online healthcare. A state-level assessment must separate what the official figures show from questions they cannot answer.

The problem addressed here is the absence, within the sources reviewed, of a unified public dataset for measuring healthcare e-commerce in Maharashtra. The study examines public telemedicine as one observable part of digital healthcare delivery and considers the limits of using these programme figures to describe the wider service economy.

2. Objectives:

1. To explain the relevance of public telemedicine services to the broader concept of e-commerce for healthcare services.
2. To analyse year-wise performance figures published for selected public telemedicine services in Maharashtra.
3. To compare the reported trends across the state telemedicine-centre programme, AAM teleconsultation and eSanjeevani OPD, while keeping their programme definitions distinct.
4. To assess what the available official statistics can and cannot establish about e-commerce for healthcare services in Maharashtra.
5. To identify data gaps and indicators needed for a more comprehensive assessment of online healthcare service transactions.

3. Research Questions:

1. What types of healthcare services can be mediated by digital platforms in an e-commerce framework?
2. What year-wise patterns are reported in Maharashtra's selected public telemedicine programmes?
3. How do the three published programme series differ in their reported trajectories and measurement scope?
4. What can these official statistics establish—and what can they not establish—about healthcare e-commerce in Maharashtra?
5. What additional indicators would be required to assess the broader healthcare e-commerce ecosystem?

Literature Review and Research Gap:

1. Digital healthcare services and telemedicine:

Digital healthcare covers several kinds of activity. Telemedicine involves remote clinical interaction, while other digital services may support appointment booking, access to health records, diagnostic testing or medicine orders. These functions may be offered through the same platform, but they represent different operational and economic activities. The appropriate unit of analysis—such as a booking, completed consultation, order, payment or delivered service—depends on the research question.

2. Online consultation and appointment platforms in India:

Agarwal and Biswas (2020) examined Indian mobile health applications offering online doctor consultations, appointment booking or both. Their Google Play Store search identified 22 relevant applications from an initial set of 250 results. The study illustrates how digital

applications can facilitate both remote consultations and appointments for in-person care. It is not a current census of available platforms and does not report Maharashtra-specific transaction totals (Agarwal & Biswas, 2020).

3. Evidence on telemedicine services in India:

Ummer et al. (2025) mapped telemedicine services implemented in India between 2000 and 2023. Their scoping review included 151 studies and identified 115 services across public, private and public-private models. Evidence on impact was available for only some of the services, and the authors called for stronger research on care-seeking, quality, costs and health outcomes. Their review shows that the presence or scale of a service alone does not establish its impact (Ummer et al., 2025).

4. Evidence on eSanjeevani utilization:

Sood et al. (2025) analysed aggregated data from India's eSanjeevani platform for November 2019 to September 2023. They reported more than 163 million consultations nationally, with the provider-assisted eSanjeevani Ayushman Bharat–Health and Wellness Centre model accounting for more than 93% of use. These national findings provide context but cannot be treated as Maharashtra-specific figures. The study concerns a government telemedicine programme, not the commercial healthcare e-commerce market (Sood et al., 2025).

5. Evidence on user experience in online consultations:

Dhakate and Joshi (2023) analysed 38,019 online feedback records associated with 343 doctors to study patient sentiment about online consultations in India. Their work shows that service experience is another dimension of online healthcare, beyond consultation counts. However, online feedback may not represent all users, and the study does not provide a Maharashtra-specific satisfaction estimate (Dhakate & Joshi, 2023).

6. Research gap:

The studies reviewed cover Indian applications offering consultation or appointment booking, national eSanjeevani use, and feedback on online consultations. The Maharashtra Public Health Department separately reports annual figures for its telemedicine-centre programme, AAM teleconsultation and eSanjeevani OPD. Within the literature and official sources examined for this paper, we did not identify a single Maharashtra-level dataset covering private-platform transactions, paid consultations, online appointment and diagnostic bookings, medicine orders, transaction value and unique customers. This finding is limited to the sources reviewed; it does not prove that such data do not exist elsewhere. The study addresses part of this gap by comparing the public-programme series and identifying indicators needed for a wider assessment.

Conceptual Scope and Analytical Framework:

The framework separates healthcare e-commerce as a broad concept from the narrower measures available in this study. Digital platforms may support the discovery, booking, payment or delivery of healthcare-related services. A service may be delivered remotely, as in an online consultation, or arranged online and completed in person. The analysis therefore distinguishes the service involved, the stage of the transaction and the indicator actually reported.

- Remote clinical services: consultations delivered through digital communication.
- Appointment services: online discovery or booking that may lead to an in-person or remote consultation.
- Diagnostic services: online booking or coordination of laboratory and diagnostic tests.

- Medicine-related transactions: online ordering and purchase of medicines, treated separately from consultation activity.
- Digital infrastructure: registration, records and platform access that may enable a transaction but do not, by themselves, demonstrate that a service was completed or paid for.

The Maharashtra series record reported activity in three named public telemedicine programmes. They do not cover every stage or type of healthcare e-commerce and are not used as a proxy for the commercial market. The analysis examines changes within each series, the comparisons supported by the reported values, and the contribution these figures can make to understanding public digital healthcare delivery.

Methodology:

1. Research design:

This study uses descriptive analysis of published administrative statistics, supported by a focused, non-systematic review of peer-reviewed literature. The unit of quantitative analysis is the annual count reported for each programme, not an individual patient, unique user, paid transaction or platform. No primary survey or patient-level dataset was used. The literature was selected to provide context on Indian consultation and booking applications, telemedicine programmes and online consultation experience; it is not an exhaustive or systematic review.

2. Data sources:

The main quantitative source is the Government of Maharashtra Public Health Department webpage titled "Telemedicine," dated 16 January 2025 and last updated 22 July 2025. The page reports annual figures for (i) patients referred and receiving expert opinions through telemedicine centres, (ii) AAM teleconsultation, and (iii) eSanjeevani OPD online free health services. The department labels the 2024–25 figures as being through December 2024. The series are analysed separately because the source does not establish that their populations or counting definitions are mutually exclusive (Maharashtra Public Health Department, 2025a).

3. Data extraction and analysis:

The values in the English-language government table were transcribed by financial year under the department's programme labels. Comparisons are made within each series. Percentage changes are calculated only between full financial years; figures through December 2024 are retained as partial-year observations and are not treated as full-year totals. No market-size estimate is attempted because the source does not provide consistent measures of paid transactions, unique users or transaction value.

4. Source verification and calculation protocol:

The transcribed values and calculations were checked against the tables displayed on the government pages. The English and Marathi versions report different AAM figures for 2024–25 through December 2024; this discrepancy is reported. The annual AAM values displayed on the English page sum to its stated cumulative total. Because the source provides insufficient metadata to establish whether the programme series overlap, no combined total is calculated. These checks confirm consistency with the published figures, not the accuracy of the underlying administrative records.

5. Reproducibility and comparability:

Percentage change between two full-year values is calculated as [(later value − earlier value) / earlier value] × 100. The compound annual growth rate for eSanjeevani OPD from 2020–21 to 2023–24 is calculated over three annual intervals as [(2023–24 value / 2020–21 value)^(1/3) − 1] × 100. These calculations describe the published programme series only; they do not indicate equivalent growth in commercial healthcare e-commerce.

The 2024–25 figures are included for transparency but excluded from full-year growth calculations. The three programme counts are not added together because the source does not establish that their categories are mutually exclusive.

6. Methodological limitations:

The government page does not provide a complete technical account of counting rules, possible duplicate events, revisions or consistency across the three series. The literature review also lacks a documented database-by-database search protocol and inclusion flow; it is therefore described as focused, not systematic. The descriptive design cannot establish causal effects, population adoption rates, service quality or commercial transaction volumes from these counts alone.

The indicator table separates the administrative measures reported by the department from the wider measures needed to assess healthcare e-commerce. In the absence of supporting data, programme counts cannot be interpreted as unique customers, completed commercial transactions or revenue.

Findings: Public Telemedicine Trends:

1. State telemedicine-centre programme:

The state telemedicine-centre series records 31,286 patients referred and receiving expert advice in 2019–20. The count fell to 12,786 in 2020–21, then rose to 15,665 in 2021–22, 25,805 in 2022–23 and 27,400 in 2023–24. The department reports 21,306 for 2024–25 through December 2024. Because this is a partial-year figure, it should not be compared directly with full-year counts (Maharashtra Public Health Department, 2025a).

Financial year	Patients referred and receiving expert advice	Reporting status
2019–20	31,286	Full financial year
2020–21	12,786	Full financial year
2021–22	15,665	Full financial year
2022–23	25,805	Full financial year
2023–24	27,400	Full financial year
2024–25 (through Dec. 2024)	21,306	Partial year

From 2020–21 to 2023–24, the reported count increased by 114.3%. This is the change between two annual programme counts; it does not explain why the count changed, establish a change in the number of unique patients, or indicate growth in commercial healthcare e-commerce.

2. Ayushman Arogya Mandir teleconsultation:

The English-language department page lists AAM teleconsultation counts of 8,737 in 2020–21, 985,677 in 2021–22, 3,979,575 in 2022–23 and 2,110,961 in 2023–24. It reports 2,102,732 for 2024–25 through December 2024 and gives a cumulative total of 9,187,682. The displayed annual figures, including the partial-year value, sum to that total. The Marathi-language page reports 1,253,268 for the same partial-year period. The difference is retained as an unresolved source discrepancy (Maharashtra Public Health Department, 2025a, 2025b).

Financial year	Reported patients referred and receiving expert advice	Reporting status
2020–21	8,737	Full financial year
2021–22	985,677	Full financial year
2022–23	3,979,575	Full financial year
2023–24	2,110,961	Full financial year
2024–25 (through Dec. 2024)	2,102,732 (English page; Marathi page lists 1,253,268)	Partial year through Dec. 2024; source versions disagree

From 2021–22 to 2023–24, the AAM count increased by 114.2% overall. This net increase masks a sharp rise in 2022–23 followed by a decline in 2023–24. The unusually low 2020–21 value and the lack of detailed metadata limit interpretation of the scale and causes of these changes. The figures do not identify unique users or paid transactions.

3. eSanjeevani OPD online free health services:

For eSanjeevani OPD, the department reports 34,674 in 2020–21, 79,383 in 2021–22, 94,207 in 2022–23 and 102,039 in 2023–24. The figure for 2024–25 through December 2024 is 291,598. The page gives a total of 601,901, which matches the sum of the displayed annual values, including the partial-year count (Maharashtra Public Health Department, 2025a).

Financial year	Reported patients referred and receiving expert advice	Reporting status
2020–21	34,674	Full financial year
2021–22	79,383	Full financial year
2022–23	94,207	Full financial year
2023–24	102,039	Full financial year
2024–25 (through Dec. 2024)	291,598	Partial year

Between 2020–21 and 2023–24, the reported count increased by 194.3%. The compound annual growth rate over the three annual intervals was approximately 43.3%. These calculations apply only to the published eSanjeevani OPD series and are not estimates of growth across all online healthcare services in Maharashtra.

The partial-year count of 291,598 through December 2024 is substantially higher than the preceding full-year count of 102,039. The source does not explain the difference. Changes in reporting or programme activity are possible explanations, but neither is confirmed by the published table. The figure is therefore presented as reported, not annualised, and excluded from full-year growth calculations.

4. Comparability of the three series:

The department lists the three series under separate headings: telemedicine centres, AAM teleconsultation and eSanjeevani OPD. It does not establish that their populations, referral pathways or counting definitions are mutually exclusive. Adding the figures could double-count activity or combine unlike measures, so the series are presented separately.

The values in Sections 6.1–6.3 are administrative programme counts as labelled by the department. They are not survey estimates, counts of unique individuals, population adoption rates or commercial sales figures.

5. Implications for interpreting healthcare e-commerce:

The three series show different patterns. The state telemedicine-centre count recovered after falling in 2020–21; AAM counts peaked in 2022–23 before declining in 2023–24; and eSanjeevani OPD counts increased across the full financial years shown. These are descriptive findings. The published figures do not explain the changes or support a valid ranking of programme effectiveness, since common definitions, denominators and outcome measures are not provided.

The figures do not quantify private-platform use, online appointment bookings, paid consultations, diagnostic bookings, medicine orders, transaction value, revenue, repeat use or unique consumers. They also provide no population denominator for estimating statewide adoption. The results therefore describe reported public-programme trends, not the size of Maharashtra's commercial healthcare e-commerce market.

Discussion and Implications:

The results show that the three public telemedicine series followed different trajectories and should be interpreted separately. The state telemedicine-centre count fell in 2020–21 and then recovered through 2023–24. AAM activity peaked in 2022–23 before declining the following year, while eSanjeevani OPD increased across the full-year period from 2020–21 to 2023–24. The unusually high eSanjeevani partial-year count and the conflicting AAM partial-year figures remain unresolved source issues; the available evidence does not establish their causes.

The series cannot be treated as a single market measure. They appear under separate programme headings, and the source does not establish whether their populations, referral pathways or counting rules overlap. Public programmes may prioritise access and service delivery, while private platforms may facilitate bookings or payments. Without comparable indicators, differences in counts cannot be interpreted as differences in commercial performance or service effectiveness.

The literature provides context rather than a direct benchmark for the Maharashtra figures. Agarwal and Biswas (2020) describe Indian mobile applications that offer consultations and appointment booking, while Ummer et al. (2025) document public, private and public-private telemedicine models. These studies illustrate the variety of digital healthcare arrangements but do not provide a comprehensive estimate of paid healthcare e-commerce transactions in Maharashtra.

A broader assessment would require consistently defined data on paid online consultations, online appointment and diagnostic bookings, medicine orders, completed and cancelled services, transaction value or revenue, and unique and repeat customers. The data would need clear time periods and geographic attribution, as well as definitions that distinguish a booking from a completed service and a transaction from a unique person. Aggregated platform reporting, administrative data with published metadata or a carefully designed consumer survey could help address these gaps, subject to privacy safeguards.

1. Areas for further assessment:

- Online appointment services may help consumers find providers and arrange visits, but their scale and effects cannot be inferred from the telemedicine counts analysed here. Further research should distinguish bookings made, appointments attended and consultations completed.
- Remote consultations may improve access where in-person care is difficult to obtain. Assessing this possibility requires evidence

on access, follow-up, service quality and relevant outcomes; consultation counts alone are insufficient.

- Online diagnostic booking and medicine ordering form part of the broader healthcare e-commerce framework, but neither is measured by the three public telemedicine series used here. Their scale in Maharashtra remains unquantified in this study.
- Future research could seek aggregated, anonymised data from private platforms, examine other relevant government records or conduct a consumer survey with a clear sampling design. Any new data collection should define the unit of analysis and distinguish public services from commercial transactions.
- A state-level measurement framework should report public programme activity separately from commercial transactions. It should also distinguish service events from unique users, completed services from bookings, and transaction volume from transaction value. These distinctions would make comparisons more meaningful without treating one indicator as a measure of the entire sector.

2. Policy, research and reporting implications:

Consistent indicators would help policymakers monitor digital healthcare delivery. Public dashboards should specify whether figures refer to consultations, referrals, patients, completed interactions or unique individuals, and should state the reporting cut-off date. Where possible, published statistics should include metadata on counting methods and revisions.

Researchers need aggregated, anonymised platform statistics to examine activity beyond public telemedicine programmes. Useful measures include completed online bookings and consultations, cancellations, diagnostic bookings, medicine orders, payment values and repeat use. Where privacy safeguards permit, these data could be disaggregated by period and geography. Analyses should distinguish public from private services and should not assume that digital availability equals consumer adoption.

Platform operators could support more reliable evaluation by using consistent service definitions and reporting practices. Reporting should protect identifiable health information and comply with applicable privacy and regulatory requirements.

Conclusion:

This paper examined published administrative figures for three public telemedicine programmes in Maharashtra and considered their relevance to healthcare e-commerce. The series follow different patterns and cannot be combined without evidence that their definitions and populations are compatible. The English and Marathi versions of the department's page report different AAM figures for 2024–25 through December 2024. Although the English page's annual AAM values sum to its stated cumulative total, the difference between language versions remains unresolved.

The findings show that public telemedicine activity is recorded in Maharashtra, but these counts do not measure the size or revenue of the healthcare e-commerce market. The state telemedicine-centre and eSanjeevani OPD series increased between the full-year endpoints examined; AAM activity peaked in 2022–23 and fell in 2023–24. The data do not establish the causes of these changes, their effects on health outcomes or the scale of private-platform use.

The paper's contribution is to compare the published programme series without treating them as equivalent to commercial transactions. A broader assessment would need consistent data from public and private channels on service types, completed transactions, unique users and transaction value. Until such data are available

and their definitions can be checked, conclusions about the overall healthcare e-commerce market in Maharashtra must remain limited.

Limitations:

- The quantitative analysis relies on published administrative statistics from one state government webpage.
- The three programme series are presented separately because the source does not establish that their definitions and populations are mutually exclusive.
- The 2024–25 figures cover only the period through December 2024 and are not treated as full-year totals. The AAM figure is also flagged because the English and Marathi versions disagree.
- The source does not provide complete technical metadata on counting rules, possible duplicate events, revisions or overlap. The English page's displayed AAM annual values sum to its stated cumulative total of 9,187,682, but the Marathi page reports a different AAM figure for 2024–25 through December 2024.
- The figures do not measure private-platform transactions, consumer spending, market revenue, unique users or overall adoption.
- The literature review is focused and is not a systematic review of all published studies.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Algal Biodiversity of Kankraj Dam Taluka Parola, Dist. Jalgaon

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DOI - 10.5281/zenodo.24338946

Abstract:

Although several researchers have studied diatom taxonomy in Maharashtra, the diatom flora of North Maharashtra remains relatively less explored. The present study was conducted to investigate the diversity of diatoms belonging to the genera Cymbella and Stauroneis in Kankraj Dam, Taluka Parola, District Jalgaon, Maharashtra. A total of six diatom taxa were recorded from five sampling stations, designated as KS-1, KS-2, KS-3, KS-4, and KS-5. Of these, four species belonged to the genus Cymbella and two species to the genus Stauroneis. The findings contribute to the documentation of freshwater diatom diversity in Kankraj Dam and provide baseline information for further taxonomic studies in North Maharashtra.

Keywords: Biodiversity, Algae, Diatoms, Cymbella and Stauroneis.

Introduction:

Diatoms are an important group of microscopic algae found in freshwater and marine environments. They are commonly present in rivers, lakes, ponds, dams, and other aquatic habitats. Diatoms are characterized by a siliceous cell wall called a frustule, which has different shapes and ornamentation patterns. They play an important role in aquatic ecosystems by contributing to primary productivity and serving as a food source for various aquatic organisms. Due to their wide distribution and diversity, diatoms are important subjects for taxonomic and ecological studies.

The distribution of diatoms depends on several environmental factors, such as water temperature, pH, nutrient availability, light, and the nature of the substratum. Different species may occur under different environmental conditions. Therefore, the study of diatom diversity helps in understanding the composition of aquatic communities and the ecological characteristics of freshwater habitats. Proper identification of diatoms is also important for documenting biodiversity and understanding their distribution in different geographical regions.

The genera Cymbella and Stauroneis belong to the group of diatoms commonly studied in freshwater habitats. The genus Cymbella is generally characterized by asymmetrical valves, while members of Stauroneis usually possess symmetrical valves with a distinct central area called the stauros. These genera can be identified by examining their valve shape, size, striation,

and other morphological features. Taxonomic studies of these genera are useful for documenting diatom diversity and understanding their occurrence in different aquatic ecosystems.

Several researchers have studied the taxonomy and diversity of diatoms in different parts of Maharashtra. However, compared with other regions, the diatom diversity of North Maharashtra has received relatively less attention, particularly in some local freshwater habitats. Further studies are therefore necessary to document the diatom flora of this region and provide information about the occurrence of different taxa.

Kankraj Dam, located in Parola Taluka of Jalgaon District, Maharashtra, provides a suitable site for investigating freshwater diatom diversity. The present study was carried out at five sampling stations of the dam, designated as KS-1, KS-2, KS-3, KS-4, and KS-5. The study focused on the taxonomic investigation of the genera Cymbella and Stauroneis. A total of six diatom taxa were recorded, including four species of Cymbella and two species of Stauroneis. The findings contribute to the documentation of diatom diversity in Kankraj Dam and provide useful baseline information for further taxonomic studies of freshwater diatoms in North Maharashtra.

Materials and Methods:

Algal samples were collected from five different stations (KS-1, KS-2, KS-3, KS-4, and KS-5) of Kankraj Dam, Taluka Parola, District Jalgaon, Maharashtra. Samples were collected from suitable aquatic habitats for the study of diatom diversity, particularly the genera Cymbella and Stauroneis.

The collected samples were processed using standard methods for diatom isolation and cleaning. The cleaned diatom material was washed several times with distilled water to remove impurities and chemical residues. The prepared samples were mounted on glass slides using a suitable mounting medium for microscopic examination.

Identification of diatom taxa was carried out by observing morphological characteristics, including valve shape, size, striation patterns, and raphe structure. Standard monographs and relevant taxonomic literature were used for identification. The identified taxa were documented and classified according to their respective genera and species.

Bacillariophyta:

Class : Diatomatae

Order : Pennales

Genus : Stauroneis Ehrenberg

1. Stauroneis anceps Ehr. (Pl.1, Fig.1)
2. Stauroneis thernicola (Boye Pet.) Lund. (Pl.1, Fig.2)

Genus : Cymbella

3. Cymbella amphicephala Naeg. (Pl.1, Fig.3)
4. Cymbella chandolensis Gandhi (Pl.1, Fig.4)
5. Cymbella cistula (Hemp.) Grun. V. woosyngenesis (Pl.1, Fig.5)
6. Cymbella gracilis (Rabh.) Cleve v. aurangabadensis v. nov. (Pl.1, Fig.6)

Melosira Agardh:

1. Stauroneis anceps Ehr. (Pl. 1, Fig. 1)

Hustedt 1930, p. 256, f. 405.

Valves 35-58 µm broad, elliptic-lanceolate with constricted, capitate and broadly rounded ends; raphe thin, threadlike, straight with slightly curved terminal fissures; axial are narrow, linear; central area wide and stauroid, widening towards the margins; striae 22-24 in 10 µm, finely punctate and radial throughout.

Habitat: Kankaraj Dam Station I, III.

2. Stauroneis thernicola (Boye Pet.) Lund. (Pl.1, Fig.2)

Lund I 945, P61, Pl.11, f.229.

Valves 21 µm-23 µm long, 4.5 µm broad. Linear to linear lanceolate with very constricted, produced, rounded ends; raphe thin and straight; axial area narrow; central area large, a rectangular stauros widening towards the margins; striae 18-20 in 10 µm in the middle and up to 25 in 10 µm towards the ends.

Habitat: Kankaraj Dam Station I, III.

3. Cymbella amphicephala Naeg. (Pl.1, Fig.3)

Voigt 1943, p.6, pl.1, f.11

Valves 27-32 µm long, 7-8 µm broad, asymmetrical, semi lanceolate; dorsal side strongly convex; ventral side slightly convex in the middle; ends constricted, produced and capitate; raphe thin and straight with terminal fissures dorsally bent; axial area very narrow; central area small; striae 12-14 in 10 µm on the dorsal side and 14-16 µm in 10 µm on the ventral side, very slightly radial.

Habitat: Kankaraj Dam Station I, III, IV.

4. Cymbella chandolensis Gandhi (Pl.1, Fig.4)

Gandhi 1964, p. 369, f.61, 62.

Valves 18-24 µm long, 4-5 µm broad, with dorsal margin uniformly convex and ventral margin straight; ends indistinctly constricted, produced acutely rounded; raphe thin and straight, close to the ventral side, central pores distinct and terminal fissures ventrally directed; axial area very narrow, linear, central area slightly formed towards the dorsal side: striae 16-18in 10 µm, fine and slightly radial.

Habitat: Kankaraj Dam Station III, IV.

5. Cymbella cistula (Hemp.) Grun. V. woosyngenesis (Pl.1, Fig.6)

Voigt 1943, p.16, pl. 1, f.17.

Valves 80-10 µm long, 20-23 µm broad, asymmetrical, with dorsal margin strongly convex and ventral margin almost straight or slightly, concave and slightly inflated in the middle; ends broadly rounded; raphe thick and straight with central pores curved towards the dorsal side, striar 8-9 in 10 distinctly punctate and radial.

Habitat: Kankaraj Dam Station II, V.

6. Cymbella gracilis (Rabh.) Cleve v. aurangabadensis v. nov. (Pl.1, Fig.6)

Sarode and Kamat 1984, P.306, Pl.20, Fig.452.

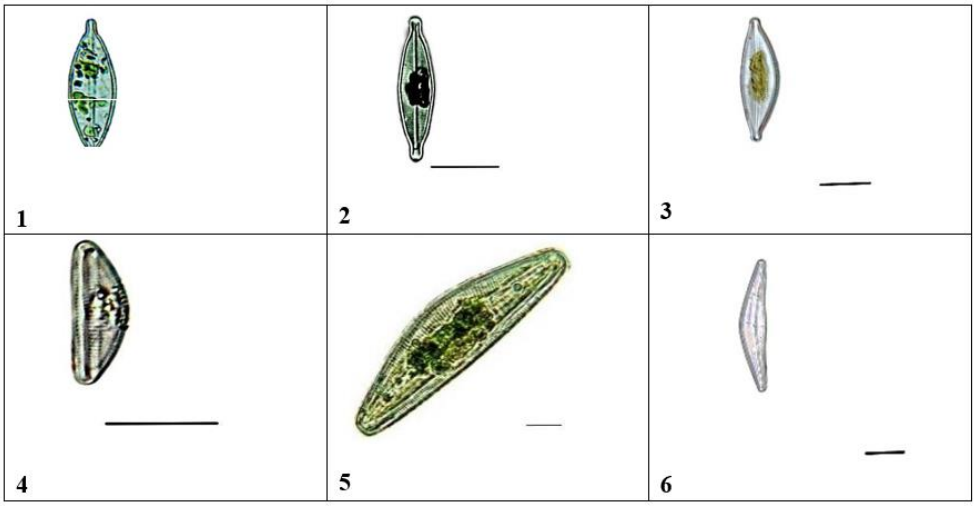
Valves 34.4- 52 µm long, 6.7- 8 µm broad, asymmetrical with dorsal margin convex and ventral margin straight or slightly concave with a strong inflation in the middle; ends produced and rounded; raphe thin and straight close to the ventral margin with central pores dorsally directed and terminal fissures ventrally curved; axial area narrow; central area small; striae 12-14 in 10 µm, fine, slightly radial, at the ends slightly convergent to the ventral side.

Habitat: Kankaraj Dam Station I, II.

PLATE: 1

1. Stauroneis anceps Ehr.
2. Stauroneis thernicola (Boye Pet.) Lund.
3. Cymbella amphicephala Naeg.
4. Cymbella chandolensis Gandhi
5. Cymbella cistula (Hemp.) Grun. V. woosyngenesis
6. Cymbella gracilis (Rabh.) Cleve v. aurangabadensis v. nov.

Plate: 1



Results and Discussion:

A total of six diatom taxa belonging to two genera, Stauroneis and Cymbella, were recorded from five sampling stations (KS-1 to KS-5) of Kankraj Dam, Taluka Parola, District Jalgaon, Maharashtra. The genus Stauroneis was represented by two taxa, while Cymbella comprised four taxa. The recorded taxa contribute to the documentation of diatom diversity in North Maharashtra.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

The Study of *Citrus Limetta* Peel Extract Against *Tribolium Castaneum* (Herbst) As an Insecticide and Its Influence on Insect Reproduction

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DOI - 10.5281/zenodo.24338968

Abstract:

The Department of Zoology PG and Research, NYNC College, Chalisgaon, Jalgaon District, evaluated the efficacy of citrus limetta fruit peel extract as an insecticide against Tribolium castaneum (Herbst). In the experimental design, researchers blended varying amounts of Citrus limetta extract—0, 2, 4, 6, and 8 grams per 50 grams of rice (0, 4, 8, 12, and 16% w/w)—with the rice to ensure even distribution. We tested each concentration in four replicates to improve statistical reliability and minimize experimental error. The study measured mortality rates, tracked larval growth and adult emergence from treated rice, and assessed total rice weight loss caused by Tribolium castaneum (Herbst) infestation. This study evaluated the effect of citrus extract on pest numbers and grain quality improvement. At 8% and 10% w/w, sweet orange and tangerine peel were more effective than the other treatments, significantly increasing mortality, reducing oviposition and larval development, preventing adult emergence, and reducing weight loss. Higher concentrations increased effectiveness. Therefore, tangerine and sweet lime peel extract can protect against T. Castaneum.

Keywords**: **Citrus limetta peel, Tribolium Castaneum, Mortality, Development, Oviposition, Tangerine, Sweet Orange.

Introduction:

The red flour beetle (*Tribolium castaneum* (Herbst)) is a major pest of flour and other milled products and a secondary pest of stored grains mainly in undeveloped areas, causing significant quantitative and qualitative losses. This species dominates environments that process and store grain-based products, including flour mills, warehouses, retail shops, and households. Long-term infestation by *Tribolium castaneum* affects stored grains and infests a wide range of commodities, including cereal flour, peas, beans, nuts, and dried fruits. Members of the *Tribolium* genus secrete toxic quinones into stored goods, posing notable risks to human health. (Wirtz & Fruin, 1982) Currently, *T. castaneum* frequently infests groundnut seeds, legumes, and other grains, also causing substantial storage losses because of its high reproductive capacity. (Applebaum, 1969) In warmer climates, the beetle can reproduce year-round. Pesticides or other non-chemical methods can manage damage caused by this pest.

Chemical control, primarily through synthetic pesticides, is widely practiced but poses risks to human health and the environment. As a result, synthetic pesticides for pest control are increasingly discouraged. Plants are being recognised as effective sources of grain preservatives, and recent research highlights the potential of low-risk pesticides such as methoprene. (Arthur, 2019) Other important storage pests include *Rhizopertha dominica* (Fabricius), *Cryptolestes ferrugineus* (Stephens),

and *Oryzaephilus surinamensis* (L.). (Saw-toothed grain beetle, Oryzaephilus surinamensis, an internationally important stored product pest, 2023) The literature documents methoprene's efficacy against various insect species. Studies have also shown the effectiveness of botanical pesticides, with plant powders and extracts showing strong repellent properties that may help protect the grains. (Dehghanizadeh et al., 2023)

Many plants used as crop preservatives are considered safe for human consumption. Numerous plant-derived products have demonstrated efficacy against major stored-grain pests by inhibiting oviposition, reducing dietary intake, and retarding pest growth. (Nikolaou et al., 2021) Most plant products are non-polluting, less toxic, easily available and highly biodegradable. (Visakh et al., 2022) In this study, we applied citrus peel extract as a biopesticide to manage T. castaneum. This research aims to evaluate the efficacy of citrus peels in controlling T. castaneum infestations.

Materials and Methods:

Insect Culture:

We established the test insect culture using naturally infested Rice obtained from the regular granary of Pimpalgaon, Chalisgaon. We then reared the 50 weevils on uninfested rice at room temperature (25-30°C) in the laboratory. We reared them in a white, transparent container covered with a muslin cloth to allow ventilation, securing the muslin cloth with rubber bands. We labelled the container with the date and time.

Collection of Citrus Peels:

We collected fresh, sweet lemon "Mosambi" (*Citrus limetta*) fruits from a local farm in Shamwadi, Chalisgaon, to ensure fresh and quality fruit. A botanist identified the specific fruit variety to confirm its authenticity. To ensure cleanliness, we used a sharp, clean knife to peel the collected citrus fruits. We then shade-dried the peels in a well-ventilated environment until they became crisp and fully dry. Once dried, we sliced the peels into small, uniform pieces. We ground these pieces separately in a thoroughly sterilised electric grinder to prevent contamination, then passed the material through a 0.5 mm mesh to obtain a fine, consistent powder. We then stored the resulting plant powders separately in white, transparent, clearly labelled containers at ambient laboratory temperature before further processing.

Preparation of Citrus Peels Extract:

To prepare the extract, we boiled the powdered citrus peel in water for 60 minutes to isolate heat-stable compounds. We then filtered the resulting extract thoroughly and stored it for subsequent experiments. During preparation, we ensured that all water content was completely removed before storing and using the extract for further experimentation.

Toxicity Assays:

We mixed the citrus peel extract separately with rice in rearing containers at 0, 2, 4, 8, and 10 mL per 50 g of rice. We shook the mixture for 2-5 minutes to ensure homogeneity. We obtained 50 unsexed,d 24-hour-old *T. castaneum* adults from the cultures and introduced them into each container, including the control (untreated). We then covered the containers with muslin cloth and secured them with rubber bands. The treatments were replicated three times. The experiment followed a completely randomised design.

Data Collection:

We collected data on adult mortality at 12, 24, 48, 72, and 96-hour intervals and monitored larval development. We evaluated the extract's effects on adult emergence and insect productivity after 4 days, along with counts of feeding holes and grain weight loss. We recorded adult mortality rates on days 1 to 4. We separated dead weevils from the containers using forceps

and calculated adult mortality percentage using the relevant formula. We repeated this process for 30 days.

Adult Emergence:

We identified, counted, and recorded adult weevils that emerged at the end of the 30-day observation period.

Grain Weight Loss:

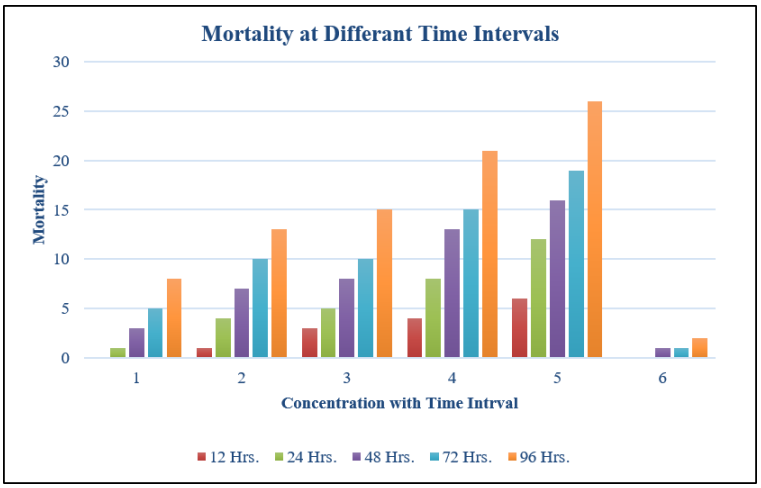
We weighed the grains before and after weevil attack using an electronic weighing balance. We determined rice weight loss after the 30-day observation period using the formula.

Results:

All assessed parameters—including mortality, feeding hole counts, adult emergence, insect productivity, and grain weight loss—varied significantly ($p < 0.05$) by treatment and application level. Citrus peel extract, particularly from sweet orange, significantly increased *T. castaneum* mortality compared with other treatments. Mortality rates generally increased with higher citrus peel extract concentrations. The 10% concentrations of sweet orange, tangerine, and lemon peel extract were significantly more effective than the 4%, 6%, and 8% concentrations. Additionally, 4%, 6%, and 8% sweet orange and tangerine peel powder concentrations were as effective as 10% and 12% grape and lime peel extract concentrations. Petri dishes treated with sweet orange and tangerine peel powders had significantly fewer feeding holes than those treated with lemon peel powder. Citrus peel extract produced significantly more feeding holes than the other treatments. Untreated seeds (0%) had the most feeding holes. Regardless of citrus species, 4%, 6%, 8%, and 10% w/w citrus peel extract applications significantly reduced feeding sites compared with 0% applications.

Table 1- Mortality of *Tribolium castaneum* after using Citrus limetta essential oil at different time intervals at various concentrations.

Essential Oil	Concentration in %	Mortality at Different Time Intervals				
		12 Hrs.	24 Hrs.	48 Hrs.	72 Hrs.	96 Hrs.
Citrus limetta	2	0	1	3	5	8
	4	1	4	7	10	13
	6	3	5	8	10	15
	8	4	8	13	15	21
	10	6	12	16	19	26
Control	0	0	0	1	1	2



Different citrus peel extract applications also significantly reduced adult emergence compared with 2%, 4%, 6%, 8%, and 10% w/w applications. Application levels differed significantly ($p < 0.05$), with the control (0% application) showing the highest number of emerged adults. The 8% and 10% concentrations did not differ significantly and were both highly effective. The 10% citrus extract application was significantly ($p < 0.05$) more effective than other application levels across all assessed parameters, followed closely by the 8% concentration. Citrus peel extract application significantly affected weight loss. Rice treated with citrus extract showed significantly ($p < 0.05$) less weight loss than untreated seeds. The 10% citrus species extract application was significantly ($p < 0.05$) more effective than the 2%, 4%, 6%, and 8% concentrations and the control.

Discussion:

The high insecticidal potency of citrus peel extract in controlling the voracious attack of *T. castaneum* on stored grains is not surprising, as shown in this study. A review of the literature on botanical controls for insect pests shows that citrus peels are highly toxic to stored-grain pests. (Su et al., 1972) One study reported that citrus oils from lemon, grapefruit, lime, kumquat, and tangerine, applied topically, were highly toxic to *Callosbrachys maculatus and Sitophilus oryzae,* which agrees with the results of this study. They also reported that an application of extracted lyophilised oils to the surface of black-eyed peas (cowpea) prevented the development of progeny of *C. maculatus*. They reported that bruchid larvae did not develop in pea flour containing 0.1–0.5% of different citrus oils, which is consistent with the high oviposition-inhibiting properties of citrus peels in this study. (Su et al., 1972) The mortality of *T. castaneum* caused by citrus peel extract may be attributed to several chemical metabolites, such as terpenes (e.g., limonene) and hydrocarbons, which can be both toxic and repellent to the test organism. (Khemis et al., 2023) Consequently, natural products with insecticidal activity are an important alternative for environmentally friendly pest management without affecting human health. Plants always show chemical defence properties. Among these natural products, terpene compounds have shown significant potential for insect control. (Diksha et al., 2023)

However, this research indicated that orange fruit peel extract was the most potent and highly toxic, resulting in high mortality of *T. castaneum*. This result agrees with an earlier report that orange peel oil at a high concentration of 750 mg litre-1, applied at 3 ml, caused 100 per cent mortality in *Zabrotes subfasciatus* after four days of application. showed that the insecticidal activities of *C. sinensis* (orange peel) may be attributed to a chemical metabolite called d-limonene. They added that d-limonene (LD50 values of 74.73, 85.37, and 79.78) showed contact toxicity to *Rhyzopertha dominica, S. oryzae,* and *T. castaneum.* The study also agrees with reports on the effective use of *C. sinensis* powder against legume pests. They attributed the effectiveness of their extracts to silica-like components that are abrasive and can adhere to the grain. (Çiçek et al., 2024)

Furthermore, citrus extract as a protectant could have killed the pest because it tends to block the insect's spiracles, impairing respiration and leading to death, which agrees with the reports. (Nta et al., 2017) All treatments significantly reduced F1 adult emergence compared to the untreated experiment. Still, the extent to which orange fruit peel powder affected subsequent progeny survival varied among other citrus peels. This finding is similar to results

reporting a 94.5 per cent reduction in *T. castaneum oviposition* after application of orange peel oil. Similarly, reduced oviposition and egg hatching were observed in potato tuber moth, *Phthorimaea operculella,* exposed to 220ml of orange peel oil. It was also reported that 1ml of orange peel oil suppressed oviposition in the Mediterranean fruit fly, *Ceratitis capitata*. (Sharaby, 2011) This suggests that plant extracts (citrus peel powder) contain toxic factors that negatively affect insect survival. The significant reduction in weight due to *T. castaneum damage* indicates the higher protective potential of these materials (i.e., citrus peels) against pest damage. They also reported anti-feedant and toxic effects of some plant extracts on *Onyponomeuta malinellus* larvae and adults. They also reported significantly higher mortality in *Rhyzopertha dominica* and *T. confusum* when exposed to maize treated with three different silica nanoparticle formulations. The plant materials were highly effective and significantly reduced damage to maize grains compared with the control (untreated). (Vayias et al., 2006)

Conclusion:

According to the research, higher concentrations and longer exposure to Citrus limetta essential oil increased the death rate. After 96 hours, the highest mortality (26) was observed at 10% concentration, and 21 at 8%. Conversely, at 2% concentration after 96 hours, mortality was lowest (8). After 96 hours, the control group had only two deaths, indicating a relatively lower natural mortality rate. Overall, the findings show that higher doses of Citrus limetta essential oil were more effective at gradually increasing mortality.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

A Study of Business Ethics in Traditional Trade System

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Introduction:

The Business ethics refers to the moral principles, values, and standards that guide business activities and decision-making while performing the business activities. It always plays an important role in maintaining honesty, fairness, transparency, and trust between all related parties as well as the buyers and sellers of the particular business.

The traditional trade system means to the old methods of buying and selling goods and services to the consumers, which existed before the development of modern digital and highly organized markets. Traditional trade included local markets, weekly bazaars, village shops, agricultural markets, barter systems, and small-scale businesses.

The ethical business always helps to improve in the overall progress of the particular business or organisation. In traditional trade, business relationships were largely based on personal contact, mutual trust, social values, honesty, and long-term relationships. Therefore, studying business ethics in the traditional trade system helps us understand how moral values influenced commercial activities.

Meaning of Business Ethics:

Business ethics means using all moral values and principles to business activities. Basically it includes; Honesty in business transactions with their customer and other related parties, adoption of fair pricing of goods and services, maintain quality and standard of products and services, Respectful treatment of all customers, Transparency in financial and all economical transactions, Avoiding cheating with customers and society, avoiding the frauds and exploitation of customers and Social responsibility towards society. Also the business should adopt good pricing standards, and operational information accessible and honest. Taking personal and organizational responsibility for decisions, actions, and their consequences. Treating workers, customers, and partners equitably without abusing authority or misleading others. Delivering truthful advertising, honouring commitments, and avoiding deceptive practices. Minimizing ecological harm and striving for sustainable practices while operating the business activities.

Meaning of Traditional Trade System:

Basically the traditional trade system is a system of exchange in which goods and services are purchased and sold through conventional methods. It included the weekly village markets operations regarding the business activities, Local grocery shops to the nearby society, Agricultural products selling and purchasing markets, Wholesale and retail markets, Barter exchange systems procedure of rural area, Traditional

handicraft businesses operates in the rural area and Family-owned businesses are involve in the concept of the Traditional Trade System.

The traditional businesses adopted a proper ethical practices for their businesses it involve the following principles of business ethics while performing there small businesses in their particular area.

1. Honesty regarding their business operation: Traders were expected to provide correct information about products, their quality, and prices.
2. Fair Pricing for all purchaser to their goods and services: Sellers were expected to charge reasonable prices without exploiting customers.
3. Trust and Reliability: Business relationships were often built on mutual trust and long-term associations.
4. Quality of Goods products and services: Maintaining product quality was an important ethical responsibility.
5. Commitment of the ethical business process: Traders were expected to fulfil promises regarding delivery, payment, and product quality.
6. Focus on the Customer Satisfaction: Customer needs and satisfaction were important for maintaining business relationships.
7. Social Responsibility: Traditional businesses often contributed to community development and local economic activities.

Following are some Importance of Business Ethics in Traditional Trade; Builds trust between buyers and sellers, Develops long-term business relationships, Promotes fair business practices, Reduces cheating and fraudulent activities, Improves customer satisfaction, Maintains social harmony, Encourages sustainable business development, Protects the interests of consumers, Unethical Practices in Traditional Trade are done in the following pattern; despite the importance of ethical values by the businessman, certain unethical practices were also present in traditional trade while performing their business. The common unethical practice is using incorrect weights and measurements of goods or the products. Some of the vendors are use these types' practices in the market for cheating the customers.

Selling adulterated products; many of the customers know the adulteration done by the seller but they cannot prove it. For example the milk seller sale us the adulterate milk but we cannot oppose him because we don't have the instrument to find out the water adulated in the milk.

Some vendors charging excessive prices to the customers for the particular product they don't take money as per the MRP. When the customer does not have any other seller for purchase the particular products that time the seller take the advantaged or we can say they use the monopoly system. Other than the above examples seller's applying hoarding essential commodities, Providing misleading information to the customers, Exploiting rural farmers and small producers, Delaying payments to their suppliers, Creating artificial shortages of goods in the seasonal period, These practices negatively affected consumer confidence and economic development and the overall development of the businessman.

Challenges of Business Ethics in Traditional Trade:

- Lack of formal business education: Many traditional traders, small businessman have lack formal training in business ethics and management while performing their business.
- Limited consumer awareness: we know the consumers may not know their rights,

product quality standards, or fair prices. The customer education should be increases.

- Absence of proper documentation: Some of the small traders do not maintain proper bills, receipts, or business records as per their transaction and it cause to the bad business practices.
- Unorganized business practices; Traditional trade often relies on informal methods, making business operations less systematic. Lack of standardized pricing; Prices may vary from customer to customer, leading to unfair pricing practices. Limited legal awareness; Traders may not be fully aware of business laws, consumer protection rules, and tax regulations.
- Exploitation of weaker sections; Poor consumers, workers, and small suppliers may face unfair treatment or exploitation. Difficulty in maintaining product quality; Lack of proper storage, quality checks, and standardization can affect product quality and safety.
- The Role of Business Ethics in Sustainable Development; Business ethics contributes to sustainable economic development by encouraging responsible production, fair trade, consumer protection, and environmental awareness.

Traditional businesses can promote sustainable development through:

Supporting local producers, Encouraging indigenous products, Using environmentally friendly materials, Reducing unnecessary wastage, Providing fair compensation to workers and Preserving traditional skills and occupations.

Objectives of the Study:

The following objectives can be considered for this research study:

1. To study the concept and importance of business ethics in traditional trade systems.
2. To understand the ethical values followed by traditional traders.
3. To analyse the relationship between business ethics and customer satisfaction.
4. To examine unethical business practices in traditional trade.
5. To analyse the role of honesty, trust, and transparency in traditional business activities.
6. To compare ethical practices in traditional and modern trade systems.
7. To suggest measures for improving ethical standards in traditional trade system.

Research Methodology:

The study can be conducted using both primary and secondary data.

Primary Data involve the Interviews with traditional traders, Questionnaires for customers, Discussions with shopkeepers and Observations of local markets.

Secondary Data involve the Books on business ethics, Research journals, Published articles, Government reports, Newspapers and websites.

Researcher done this study with 100 100 respondents (depending on the research requirements) and used the Convenience sampling or purposive sampling for this study.

Findings and Suggestions:

As per this study it is found that trust and honesty are important elements of traditional trade.

Personal relationships influence customer loyalty and the relationship between the trader and customers.

The ethical practices contribute to business reputation and the it is directly effect on the overall development of the business.

While performing the business operation by the traders fair pricing and correct measurement improve customer confidence.

It is also found the unethical practices negatively affect business sustainability.

This study search and faith that the modern technology can improve transparency in traditional businesses.

It is found that traders should maintain honesty and transparency in the rural area as compare to the urban area.

For the overall development of the business the correct weights and measurements should be used. Consumers should be provided with quality products.

Fair prices should be maintained by the traders. Traders should follow consumer protection laws. Digital payment and billing systems should be encouraged and Ethical business education should be provided to small traders.

Conclusion:

Business ethics has played a significant role in the development of traditional trade systems. Honesty, trust, fairness, transparency, and commitment have historically been important values in commercial relationships.

Traditional trade was not merely a system of exchanging goods and services; it was also a system of social and economic relationships. Although modern business practices have introduced technological advancement and professional management, traditional ethical values remain relevant.

Therefore, combining traditional ethical principles with modern business practices can help create a fair, transparent, responsible, and sustainable business environment.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Digital Transformation and Gold Jewellery Consumer Behaviour: A Conceptual Framework for Rural and Urban Markets

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Abstract:

Digital transformation has significantly influenced consumer behaviour across various retail sectors, including the gold jewellery market. The growing use of digital platforms, social media, online advertisements, digital payment systems, and virtual jewellery displays has created new opportunities for consumers to search for information, compare prices, evaluate designs, and make informed purchasing decisions. However, the adoption and influence of these digital tools may differ between rural and urban consumers because of variations in digital literacy, internet accessibility, consumer awareness, trust, and purchasing preferences.

This conceptual paper aims to examine the potential relationship between digital transformation and gold jewellery consumer behaviour, with particular emphasis on rural and urban markets. Drawing on relevant consumer behaviour theories and existing literature, the paper proposes a conceptual framework connecting digital marketing exposure, online information accessibility, digital payment adoption, digital literacy, and consumer trust with purchase intention, perceived value, and customer satisfaction. Rural–urban differences are considered as a contextual factor that may influence these relationships. The paper adopts a conceptual research approach based on secondary sources and theoretical analysis rather than primary empirical data. It seeks to provide a foundation for understanding the changing dynamics of gold jewellery purchasing in the digital era and offers implications for jewellery retailers, policymakers, and future researchers. The proposed framework may support more inclusive, transparent, and consumer-oriented digital practices in the gold jewellery market.

Keywords: Digital Transformation, Gold Jewellery, Consumer Behaviour, Rural–Urban Markets, Digital Marketing, Consumer Trust, Customer Satisfaction.

Introduction:

Gold jewellery occupies an important position in Indian society because of its cultural, traditional, emotional, and economic significance. It is purchased for weddings, festivals, family occasions, personal adornment, and investment purposes. Consumer decisions in the gold jewellery market are influenced by several factors, including price, purity, design, brand reputation, trust, family preferences, and perceived value.

The rapid development of digital technology has transformed the way consumers interact with businesses. Digital marketing, social media platforms, e-commerce websites, online product catalogues, virtual jewellery displays, and digital payment facilities have expanded the ways in which consumers can obtain information and engage with jewellery retailers.

Consumers can now explore designs, compare product information, follow jewellery brands, and examine available offers before

visiting a physical showroom. Digital tools may therefore influence different stages of the consumer decision-making process, from recognising a need to evaluating alternatives and assessing satisfaction after purchase.

However, digital transformation may not affect all consumers equally. Urban consumers may have greater access to digital retail services, while rural consumers may encounter different levels of internet accessibility, digital literacy, and confidence in online information. These differences should not be assumed to be universal; they require contextual examination.

Against this background, the present conceptual paper proposes a framework for understanding how digital transformation may influence gold jewellery consumer behaviour in rural and urban markets, with relevance to Jalgaon district, Maharashtra.

Statement of the Problem:

Although digital technologies have expanded opportunities for product discovery, communication, and payment, gold jewellery remains a high-value purchase for which physical inspection, confidence in purity, transparent pricing, and retailer credibility may be especially important.

Consumers may use digital platforms to collect information but still prefer to complete their purchases in physical jewellery shops. Others may use digital payment facilities or digital catalogues while relying on established relationships with local jewellers.

The extent to which digital transformation shapes purchase intention, consumer trust, and satisfaction may vary across rural and urban settings. A conceptual framework is therefore useful for organising the relevant factors and identifying relationships that can be examined in future empirical research.

Objectives of the Study:

1. To examine the role of digital transformation in shaping gold jewellery consumer behaviour.
2. To identify the major digital factors that may influence consumer purchase intention and satisfaction.
3. To conceptualise potential differences in digital engagement between rural and urban consumers.
4. To examine the theoretical role of digital literacy, consumer trust, and perceived value in digital
5. jewellery retailing.
6. To propose a conceptual framework for future research on gold jewellery consumers in rural and urban markets.

Research Methodology:

The present study adopts a conceptual research approach based on secondary sources and theoretical analysis. It does not involve primary data collection, questionnaire administration, or statistical hypothesis testing.

The proposed framework draws on established theories of consumer behaviour and technology adoption, including the Technology Acceptance Model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT), and consumer decision-making theory. Relevant academic literature, research publications, and credible institutional sources can be examined to develop the conceptual relationships.

The focus is on digital transformation in gold jewellery retailing, particularly the possible influence of digital marketing, online information, digital payments, digital literacy, and consumer trust on purchase intention and customer satisfaction in rural and urban markets.

Conceptual Background:

1. Digital Transformation in Gold Jewellery Retailing:

Digital transformation refers to the integration of digital technologies into business activities, customer interactions, and service delivery. In jewellery retailing, it may include social media marketing, online product catalogues, digital advertisements, customer relationship management, virtual product displays, online enquiries, and digital payment facilities.

These technologies may improve access to product information and communication between retailers and customers. Nevertheless, the perceived usefulness of digital tools may depend on product characteristics, consumer preferences, and confidence in the information provided.

2. Digital Marketing and Online Information:

Social media, websites, online advertisements, and digital catalogues provide opportunities for consumers to explore jewellery designs and compare available products. Digital information may influence brand awareness, product preferences, and purchase intentions.

For high-value products such as gold jewellery, consumers may also seek confirmation of purity, hallmarking, making charges, return policies, and seller credibility before making a final decision.

3. Digital Payments and Purchase Convenience:

Digital payment facilities can provide convenient transaction options and reduce dependence on cash. Their influence on gold jewellery purchasing may depend on consumers' familiarity with digital payments, perceived security, transaction limits, retailer acceptance, and personal preferences.

Digital payment adoption should be distinguished from online jewellery purchasing: consumers may use digital payments when buying jewellery in a physical showroom.

4. Consumer Trust and Perceived Risk:

Trust is particularly relevant to high-value purchases. Consumers may assess the credibility of online information, the reputation of a jewellery brand, the reliability of digital transactions, and the transparency of product information.

Concerns about product authenticity, online fraud, inaccurate product representation, privacy, and payment security may reduce consumers' willingness to rely on digital channels.

5. Rural–Urban Context:

Rural and urban markets may differ in digital infrastructure, internet access, digital literacy, retail availability, and consumer preferences. These factors may shape how consumers use digital tools and how much importance they attach to digital information.

However, rural–urban differences should be treated as potential contextual variations rather than fixed characteristics. Individual consumers within either group may demonstrate different levels of digital adoption and trust.

Proposed Conceptual Framework:

The paper proposes that digital transformation may influence gold jewellery consumer behaviour through several interconnected factors.

Independent factors:

- Digital marketing exposure
- Online information accessibility
- Digital payment adoption
- Digital literacy

Potential mediating factors:

- Consumer trust
- Perceived value and convenience
- Perceived risk

Potential consumer outcomes:

- Purchase intention
- Channel preference
- Customer satisfaction

Contextual Factor:

Rural–Urban Market Setting:

The framework suggests that digital tools may influence consumer outcomes directly or through trust, convenience, perceived value, and perceived risk. Rural–urban context may influence the strength or nature of these relationships.

Proposed Conceptual Propositions:

Proposition 1: Greater exposure to relevant digital marketing may be associated with stronger awareness of gold jewellery products and brands.

Proposition 2: Greater accessibility of reliable online information may support consumers' product evaluation and purchase decisions.

Proposition 3: Perceived security and convenience of digital payment facilities may influence consumers' willingness to use digital payment options for jewellery purchases.

Proposition 4: Consumer trust may play an important role in the relationship between digital engagement and purchase intention.

Proposition 5: Digital literacy may influence consumers' ability to access, evaluate, and use digital jewellery retail services.

Proposition 6: Rural and urban contexts may shape the relationships between digital engagement, consumer trust, purchase intention, and customer satisfaction.

These propositions are conceptual and require empirical testing before any conclusions about actual effects or rural–urban differences can be established.

Implications for Jewellery Retailers:

Jewellery retailers may consider the following practices:

1. Provide accurate and accessible online information about product designs, gold purity, hallmarking, pricing, and making charges.
2. Maintain consistent information across digital platforms and physical showrooms.
3. Offer secure and convenient digital payment options alongside traditional payment methods.
4. Improve customer communication through digital channels without neglecting face-to-face service.
5. Provide clear information about exchange policies, product certification, returns, and customer support.
6. Design digital communication strategies that consider different levels of digital familiarity and access.

These practices may help retailers strengthen consumer confidence and create more accessible customer experiences.

Implications for Consumer Empowerment:

Digital transformation may support consumer empowerment by increasing access to product information, enabling comparisons, improving communication, and offering convenient transaction options.

For these benefits to be realised, consumers need reliable information, awareness of product certification, digital literacy, and protection against misleading advertisements and online fraud. Inclusive digital retailing should therefore combine technological convenience with transparency, security, and accessible customer support.

Limitations and Scope for Future Research:

This paper presents a conceptual framework and does not report primary empirical findings. The proposed relationships have not been statistically tested.

Future researchers may use a structured questionnaire to investigate rural and urban consumers in Jalgaon district. Variables such as digital literacy, social media exposure, trust, perceived risk, purchase intention, and customer satisfaction could be measured and compared using appropriate statistical methods.

Future studies could also examine differences by age, education, income, purchasing frequency, and familiarity with digital payment systems. Such research could help determine which factors are most relevant to different consumer groups.

Conclusion:

Digital transformation offers new opportunities to understand and improve consumer engagement in the gold jewellery market. Digital marketing, online information, and digital payment facilities may influence how consumers discover products, evaluate alternatives, and interact with retailers. However, the role of digital technology is likely to depend on consumer trust, digital literacy, perceived risk, convenience, and the context in which purchasing decisions are made.

The conceptual framework presented in this paper connects these factors with purchase intention, channel preference, and customer satisfaction while recognising rural–urban market context as a potentially important consideration. It provides a foundation for future empirical investigation, particularly in Jalgaon district, Maharashtra. By combining digital innovation with transparent information, secure transactions, and inclusive customer service, jewellery retailers may be better positioned to support informed consumer decisions and strengthen consumer empowerment.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

कृत्रिम बुद्धिमत्तेमधील मराठी भाषेचे सक्षमीकरण : एक अभ्यास

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DOI - 10.5281/zenodo.24339068

प्रस्तावना:

भाषा हे मानवी ज्ञान, संस्कृती, परंपरा आणि सामाजिक संवादाचे प्रमुख माध्यम आहे. कोणत्याही भाषेची वाटचाल हि केवळ साहित्यनिर्मितीवर अवलंबून नसून शिक्षण, प्रशासन, विज्ञान, तंत्रज्ञान, व्यापार आणि डिजिटल माध्यमांमधील तिच्या वापरावरही अवलंबून असते. माहिती तंत्रज्ञानाच्या वाढत्या प्रभावामुळे भाषांना डिजिटल स्वरूपात उपलब्ध असणे आणि नवनवीन संगणकीय प्रणालींच्या भाषेतील माहिती समजणे आवश्यक झाले आहे. मराठी भाषेला दीर्घ साहित्यिक परंपरा लाभली आहे. त्यात प्रामुख्याने संत साहित्य, लोकसाहित्य, आधुनिक साहित्य, पत्रकारिता, शिक्षण आणि लोकसंवाद या क्षेत्रांत मराठीचे महत्त्व अनन्यसाधारण आहे. त्यामुळे डिजिटल तंत्रज्ञानातील अनेक साधने आणि माहिती - संग्रह इतर भाषेच्या तुलनेत भारतीय भाषांसाठी समान प्रमाणात उपलब्ध नाहीत. त्यामुळे मराठी भाषेतील ज्ञाननिर्मिती, माहितीचा शोध, डिजिटल सेवा आणि आधुनिक तांत्रिक व्यवहार यांना अधिक सक्षम करण्याची गरज आहे. परंतु, कृत्रिम बुद्धिमत्तेच्या माध्यमातून मराठी भाषेचे सक्षमीकरण म्हणजे केवळ इंग्रजी मजकुराचे मराठीत भाषांतर करणे नव्हे. मराठीतील स्वतंत्र ज्ञाननिर्मिती, भाषेची अचूकता, स्थानिक बोलींचे जतन, तांत्रिक शब्दसंपदेचा विकास आणि मराठी भाषिकांचा डिजिटल व्यवहारातील सहभाग वाढविणे यांचाही त्यात समावेश होतो. त्यामुळे, प्रस्तुत अभ्यासात कृत्रिम बुद्धिमत्ता आणि मराठी भाषा यांच्यातील संबंधांचा अभ्यास करून मराठी भाषेच्या डिजिटल भविष्यासाठी आवश्यक उपाय शोधण्याचा प्रयत्न केला आहे.

साहित्य आढावा:

मराठी भाषा प्रक्रियेवरील संशोधन:

A Survey on NLP Resources, Tools, and Techniques for Marathi Language Processing या संशोधन आढाव्यात मराठी भाषेच्या संगणकीय प्रक्रियेसाठी उपलब्ध माहिती-संग्रह, साधने आणि तंत्रांचा अभ्यास केला आहे. मराठी मजकूर - संग्रह, भाषांतरासाठी समांतर मजकूर, नामनिर्देशित घटक ओळख (Named Entity Recognition) आणि इतर भाषा प्रक्रिया कार्यांसाठी संसाधनांची आवश्यकता या संशोधनातून स्पष्ट होते. या आढाव्यात मराठी भाषेसाठी विविध प्रकारचे मजकूर - संग्रह उपलब्ध असल्याचे दिसून येते. मात्र, केवळ मोठ्या प्रमाणात माहिती उपलब्ध असणे पुरेसे नसून तिची गुणवत्ता, विविधता, अचूकता आणि प्रतिनिधित्वही महत्त्वाचे आहे. [१]

AI4Bharat आणि भारतीय भाषांचे तंत्रज्ञान:

AI4Bharat हा भारतीय भाषांसाठी मुक्त स्रोत माहिती-संग्रह, भाषा प्रारूपे आणि तांत्रिक साधने विकसित करणारा IIT मद्रासशी संबंधित संशोधन उपक्रम आहे. या उपक्रमात यंत्रभाषांतर, लिप्यंतरण, स्वयंचलित वाणी ओळख, वाणी संश्लेषण आणि मोठी भाषा प्रारूपे अशा क्षेत्रांमध्ये काम केले जाते.IndicTrans2, IndicXlit आणि भारतीय भाषांसाठी विकसित केलेली इतर साधने ही भाषिक अडथळे कमी करण्याच्या दृष्टीने महत्त्वाची उदाहरणे आहेत. अशा उपक्रमांमुळे मराठीसारख्या भारतीय भाषांसाठी तंत्रज्ञान विकसित करण्यासाठी आवश्यक पायाभूत सुविधा उपलब्ध होण्यास मदत होते. [२]

भारतीय भाषांसाठी उपलब्ध डिजिटल संसाधने:

AI4Bharat च्या IndicNLP संसाधन-सूचीत भारतीय भाषांसाठी मजकूर-संग्रह, लिप्यंतरण साधने, भाषा प्रक्रिया ग्रंथालये, नामनिर्देशित घटक ओळखण्यासाठी माहिती-संच आणि भाषांतराशी संबंधित संसाधने यांचा समावेश आहे.या साधनांचा उपयोग भाषिक संशोधन, मजकूर वर्गीकरण, भाषांतर, माहिती शोध आणि मराठीसाठी नवीन AI प्रणाली विकसित करण्यासाठी होऊ शकतो. [३]

साहित्य आढाव्यातून दिसणारी संशोधनाची गरज:

मराठी भाषेच्या उपलब्ध साहित्याचा विचार करता, मराठीसाठी भाषा तंत्रज्ञान विकसित करण्याचे प्रयत्न सुरू असले तरी प्रमाणभाषेच्या पलीकडे जाऊन बोलीभाषा, ग्रामीण शब्दसंपदा, स्थानिक ज्ञान, तांत्रिक शब्दावली आणि दैनंदिन संभाषण यांचा समावेश करणे आवश्यक आहे. तसेच AI प्रणालींची भाषिक अचूकता, सांस्कृतिक संदर्भांचे आकलन, वापरकर्त्यांचा विश्वास आणि प्रत्यक्ष सामाजिक उपयोगिता यांचे स्वतंत्र मूल्यमापन होणे गरजेचे आहे.

संशोधनाची उद्दिष्टे:

प्रस्तुत संशोधनाची प्रमुख उद्दिष्टे पुढीलप्रमाणे आहेत.

१. कृत्रिम बुद्धिमत्तेच्या माध्यमातून मराठी भाषेचे सक्षमीकरण कशा प्रकारे होऊ शकते याचा अभ्यास करणे.
२. मराठी भाषेसाठी उपलब्ध AI आधारित भाषा तंत्रज्ञान आणि डिजिटल साधनांचा आढावा घेणे.
३. मराठी भाषेतील यंत्रभाषांतर, वाणी ओळख, मजकूरनिर्मिती यांच्या उपयोगांचा अभ्यास करणे.
४. शिक्षण, प्रशासन, कृषी, पत्रकारिता आणि डिजिटल संवाद या क्षेत्रांत मराठी AI च्या संभाव्य उपयुक्ततेचे विश्लेषण करणे.
५. मराठी भाषेच्या संगणकीय प्रक्रियेत येणाऱ्या तांत्रिक, भाषिक आणि सामाजिक अडचणींचा शोध घेणे.
६. मराठीच्या प्रादेशिक बोली, स्थानिक ज्ञान आणि सांस्कृतिक वैशिष्ट्यांचे डिजिटल जतन करण्यासाठी उपाय सुचविणे.
७. मराठी भाषेच्या दीर्घकालीन डिजिटल विकासासाठी संशोधन, धोरण आणि तंत्रज्ञानविकासाच्या दिशा निश्चित करणे.

संशोधनाची गृहीतके:

प्रस्तुत अभ्यासासाठी पुढील गृहीतके मांडण्यात आली आहेत.

१. कृत्रिम बुद्धिमत्तेवर आधारित भाषा साधनांमुळे मराठी भाषेत डिजिटल माहिती मिळविणे आणि निर्माण करणे अधिक सुलभ होऊ शकते.
२. मराठीतील दर्जेदार, विविधतापूर्ण आणि प्रमाणित माहिती-संग्रह उपलब्ध झाल्यास मराठी भाषा

प्रक्रिया प्रणालींची कार्यक्षमता सुधारण्यास मदत होऊ शकते.

३. शिक्षण, कृषी, प्रशासन आणि सार्वजनिक माहितीसेवा यांमध्ये मराठी AI चा वापर वाढल्यास मराठी भाषिकांचा डिजिटल सेवांमधील सहभाग वाढण्याची शक्यता आहे.

४. मराठीच्या प्रादेशिक बोली, स्थानिक शब्दसंपदा आणि सांस्कृतिक संदर्भांचा समावेश न केल्यास AI प्रणालींच्या भाषिक अचूकतेवर आणि सर्वसमावेशकतेवर मर्यादा येऊ शकतात.

५. भाषातज्ज्ञ, तंत्रज्ञ, शिक्षक आणि स्थानिक भाषिक समुदाय यांच्या सहभागातून विकसित केलेली AI साधने अधिक संदर्भानुरूप व उपयुक्त ठरण्याची शक्यता आहे.

संशोधन पद्धती आणि माहिती संकलन:

संशोधनाचे स्वरूप प्रस्तुत अभ्यास वर्णनात्मक, विश्लेषणात्मक आणि दुय्यम माहितीवर आधारित आहे. कृत्रिम बुद्धिमत्ता आणि मराठी भाषा यांच्यातील संबंध समजून घेण्यासाठी प्रकाशित संशोधन लेख, उपलब्ध डिजिटल भाषा संसाधने आणि संशोधन संस्थांची माहिती यांचा अभ्यास करण्यात आला आहे. माहितीचे स्रोत या अभ्यासासाठी पुढील दुय्यम स्रोतांचा विचार करण्यात आला आहे. मराठी नैसर्गिक भाषा प्रक्रियेवरील संशोधन आढावे. AI4Bharat आणि IndicNLP यांसारख्या उपक्रमांची अधिकृत संकेतस्थळे व संसाधन – सूची Association for Computational Linguistics च्या Anthology मधील मराठी बोली आणि यंत्रभाषांतरावरील संशोधनमराठी भाषा तंत्रज्ञान, भाषांतर आणि डिजिटल भाषिक साधनांशी संबंधित प्रकाशित साहित्य माहिती संकलनाची प्रक्रिया प्रथम मराठी भाषेच्या संगणकीय प्रक्रियेशी संबंधित संशोधन साहित्याची निवड करण्यात आली. त्यानंतर उपलब्ध साधने, भाषिक माहिती-संग्रह, यंत्रभाषांतर, वाणी प्रक्रिया आणि बोलीभाषांसंबंधी निष्कर्ष यांचे विषयानुसार वर्गीकरण करण्यात आले.

या माहितीचे पुढील प्रमुख घटकांनुसार विश्लेषण करण्यात आले:

१. तांत्रिक क्षमता आणि उपलब्ध साधने.

२. मराठी भाषिक वापरासाठी संभाव्य उपयोग.

३. भाषिक अचूकता आणि माहितीच्या गुणवत्तेशी संबंधित समस्या.

४. प्रादेशिक बोली आणि सांस्कृतिक संदर्भांचे प्रतिनिधित्व.

५. मराठीच्या डिजिटल विकासासाठी आवश्यक उपाय.

संशोधनाची व्याप्ती:

या अभ्यासाची व्याप्ती प्रामुख्याने मराठी भाषा आणि कृत्रिम बुद्धिमत्तेच्या परस्परसंबंधांपुरती मर्यादित आहे. यंत्रभाषांतर, वाणी ओळख, मजकूरनिर्मिती, लिप्यंतरण, भाषा-संसाधने आणि डिजिटल समावेशन या विषयांचा विचार केला आहे. संशोधनाच्या मर्यादा हा अभ्यास उपलब्ध दुय्यम साहित्यावर आधारित आहे. यात वापरकर्त्यांच्या मुलाखती, प्रश्नावली, प्रत्यक्ष निरीक्षण किंवा विविध AI प्रणालींचे तुलनात्मक प्रयोग केलेले नाहीत. त्यामुळे निष्कर्ष हे उपलब्ध साहित्याच्या विश्लेषणातून काढलेले आहेत; ते सर्व मराठी भाषिकांच्या अनुभवांचे प्रतिनिधित्व करतात असे मानता येणार नाही. माहितीचे विश्लेषण आणि चर्चा उपलब्ध संशोधन साहित्य आणि भाषा तंत्रज्ञानविषयक संसाधनांच्या आधारे मराठी भाषेच्या सक्षमीकरणाचे पुढील प्रमुख पैलू स्पष्ट होतात.

मराठीतील यंत्रभाषांतर:

यंत्रभाषांतरामुळे इंग्रजी आणि इतर भारतीय भाषांतील माहिती मराठीत आणणे शक्य होते. तसेच मराठीतील साहित्य, शैक्षणिक माहिती आणि स्थानिक ज्ञान इतर भाषांतील वाचकांपर्यंत पोहोचविण्यास मदत होऊ शकते.IndicTrans2 सारखी भारतीय भाषांसाठी विकसित केलेली भाषांतर साधने या क्षेत्रातील तांत्रिक प्रगतीची उदाहरणे आहेत. [२]

तथापि, भाषांतर करताना म्हणी, वाक्प्रचार, संदर्भाधारित अर्थ आणि सांस्कृतिक सूक्ष्मता यांचे अचूक रूपांतर करणे कठीण असू शकते. त्यामुळे साहित्यिक, कायदेशीर, वैद्यकीय आणि शैक्षणिक मजकुरासाठी मानवी संपादन व पडताळणी आवश्यक आहे.विश्लेषणात्मक निरीक्षण: यंत्रभाषांतर मराठीतील ज्ञानप्रवेश वाढविण्यास उपयुक्त आहे; परंतु भाषांतराची गुणवत्ता ही प्रणालीची क्षमता आणि मूळ मजकुराचे स्वरूप या दोन्हींवर अवलंबून असते.

मराठी वाणी ओळख आणि ध्वनी तंत्रज्ञान:

स्वयंचलित वाणी ओळख (Automatic Speech Recognition - ASR) हे बोललेले शब्द मजकुरात रूपांतरित करणारे तंत्रज्ञान आहे. मजकूर-ते-वाणी (Text-to-Speech - TTS) तंत्रज्ञान लिखित मजकूर ध्वनीरूपात सादर करू शकते. या तंत्रज्ञानांचा उपयोग पुढीलप्रमाणे होऊ शकतो.

मराठी भाषेतील व्याख्याने आणि संभाषणे मजकुरात रूपांतरित करणे. विद्यार्थ्यांसाठी श्रवणाधारित अध्ययनसाहित्य तयार करणे. दृष्टिदोष असलेल्या व्यक्तींना मराठी मजकूर ऐकण्याची सुविधा उपलब्ध करणे.आवाजाच्या माध्यमातून डिजिटल सेवांचा वापर सुलभ करणे. मुलाखती, बैठका आणि मौखिक इतिहासाचे दस्तऐवजीकरण करणे. AI4Bharat च्या संशोधन कार्यात भारतीय भाषांसाठी वाणी ओळख आणि वाणी संश्लेषण यांसंबंधी साधने विकसित केली जात आहेत. [२]

मराठीतील मजकूरनिर्मिती आणि ज्ञानविस्तार:

जनरेटिव्ह AI च्या साहाय्याने मराठीत लेखांचे प्रारूप, शैक्षणिक टिपणे, प्रश्नोत्तरे, सारांश, भाषांतर आणि माहितीपर सामग्री तयार करता येऊ शकते. या सुविधांमुळे शिक्षक, विद्यार्थी, लेखक, पत्रकार आणि संशोधकांना मदत होऊ शकते. विशेषतः इंग्रजीतील संकल्पना मराठीत समजावून सांगणे, तांत्रिक विषयांचे सुलभ स्पष्टीकरण तयार करणे आणि अभ्यासासाठी पूरक साहित्य विकसित करणे यासाठी या साधनांचा उपयोग होऊ शकतो.

मात्र, AI कडून व्याकरणदृष्ट्या योग्य दिसणारा पण तथ्यात्मकदृष्ट्या चुकीचा मजकूर तयार होण्याची शक्यता असते. काही वेळा इंग्रजी वाक्यरचनेचा प्रभाव मराठी मजकुरावर पडतो किंवा भाषिक संदर्भ चुकीचा समजला जातो.

विश्लेषणात्मक निरीक्षण:

मराठीतील AI आधारित मजकूरनिर्मिती ज्ञानप्रसाराला मदत करू शकते; परंतु भाषिक संपादन, तथ्य पडताळणी आणि प्रमाणित संज्ञांचा वापर आवश्यक आहे. मराठीच्या प्रादेशिक बोलींचे सक्षमीकरणमराठी भाषेची समृद्धी तिच्या विविध बोली, स्थानिक शब्दसंपदा आणि सांस्कृतिक अभिव्यक्तींमध्ये आहे. प्रमाणभाषेबरोबरच वऱ्हाडी, अहिराणी, मालवणी आणि इतर प्रादेशिक भाषिक स्वरूपांचे दस्तऐवजीकरण करणे आवश्यक आहे.कडोडी बोलीवरील Dabre आणि सहकारी संशोधकांच्या अभ्यासातून प्रादेशिक बोलींच्या भाषांतरासाठी स्वतंत्र माहिती-संचाची गरज अधोरेखित होते. [४] AI च्या

साहाय्याने स्थानिक लोककथा, म्हणी, गाणी, लोकपरंपरा आणि मौखिक इतिहास यांचे ध्वनिमुद्रण, लिप्यंतरण आणि वर्गीकरण करता येऊ शकते. मात्र, स्थानिक भाषिकांच्या संमतीने माहिती संकलित करणे आणि त्यांचे सांस्कृतिक हक्क जपणे आवश्यक आहे.विश्लेषणात्मक निरीक्षण: मराठीचे सक्षमीकरण हे केवळ प्रमाणभाषेच्या तांत्रिक विकासापुरते मर्यादित न राहता भाषिक विविधतेच्या जतनाशी जोडले गेले पाहिजे. डिजिटल शिक्षण आणि मराठीतील ज्ञानप्रवेशAI च्या मदतीने मराठी भाषेत वैयक्तिक अध्ययन सहाय्य, सराव प्रश्न, सोपी स्पष्टीकरणे आणि अभ्यासक्रमाशी संबंधित पूरक साहित्य तयार करता येऊ शकते.ग्रामीण आणि निमशहरी भागांतील विद्यार्थ्यांसाठी मातृभाषेत तांत्रिक संकल्पना उपलब्ध होणे विशेष उपयुक्त ठरू शकते. मात्र, प्रत्यक्ष लाभासाठी इंटरनेट सुविधा, डिजिटल उपकरणे, शिक्षकांचे प्रशिक्षण आणि विश्वासार्ह शैक्षणिक सामग्री आवश्यक आहे. AI निर्मित मजकुरातील तथ्यात्मक चुका आणि सांस्कृतिक गैरसमज या अडचणी दूर करण्यासाठी भाषातज्ज्ञ, संगणकशास्त्रज्ञ, शिक्षक, लेखक, पत्रकार आणि स्थानिक भाषिक समुदाय यांचा सहभाग आवश्यक आहे.

संशोधनातून प्राप्त निरीक्षणे:

साहित्य आढाव्यातून पुढील प्रमुख निरीक्षणे समोर येतात.

१. मराठी भाषेसाठी नैसर्गिक भाषा प्रक्रिया, यंत्रभाषांतर, लिप्यंतरण आणि वाणी तंत्रज्ञानाच्या क्षेत्रांत उपयुक्त संसाधने उपलब्ध आहेत.

२. मुक्त स्रोत माहिती-संग्रह आणि भाषा प्रारूपांमुळे मराठी भाषा तंत्रज्ञानाच्या विकासासाठी संशोधनाच्या संधी वाढतात.

३. मराठी भाषिकांसाठी AI चा संभाव्य उपयोग शिक्षण, माहितीप्रवेश, कृषी, प्रशासन आणि डिजिटल संवाद या क्षेत्रांत होऊ शकतो.

४. प्रमाणभाषेच्या तुलनेत काही प्रादेशिक बोलींसाठी माहिती-संग्रह आणि तांत्रिक साधनांची कमतरता ही महत्त्वाची संशोधन समस्या आहे.

५. मराठीतील AI साधनांची उपयुक्तता केवळ उपलब्धतेवर अवलंबून नसून भाषिक अचूकता, संदर्भांचे आकलन आणि वापरकर्त्यांच्या गरजांशी सुसंगतता यांवरही अवलंबून आहे.

६. मराठीचे डिजिटल सक्षमीकरण करण्यासाठी माहिती-संग्रह निर्मिती, भाषिक पडताळणी, तंत्रज्ञानाचे मूल्यमापन आणि जनजागृती या बाबींना प्राधान्य देणे आवश्यक आहे.

वरील निरीक्षणे दुय्यम माहितीच्या अभ्यासातून प्राप्त झाली आहेत. त्यांना प्राथमिक सर्वेक्षणातून सिद्ध झालेले निष्कर्ष समजू नये.

निष्कर्ष:

कृत्रिम बुद्धिमत्तेच्या माध्यमातून मराठी भाषेच्या विकासासाठी महत्त्वपूर्ण संधी उपलब्ध होत आहेत. यंत्रभाषांतर, वाणी ओळख, मजकूरनिर्मिती, लिप्यंतरण आणि नैसर्गिक भाषा प्रक्रिया या तंत्रज्ञानांमुळे मराठी भाषेतील माहितीचे डिजिटल स्वरूपात संकलन, प्रसारण आणि वापर अधिक सुलभ होऊ शकतो.उपलब्ध संशोधन साहित्यावरून असे स्पष्ट होते की भारतीय भाषांसाठी विकसित होणारी मुक्त स्रोत साधने आणि माहिती-संग्रह मराठीच्या तांत्रिक विकासासाठी उपयुक्त पाया निर्माण करतात. त्याच वेळी, मराठीच्या प्रादेशिक बोली, भाषिक सूक्ष्मता, सांस्कृतिक संदर्भ आणि तांत्रिक शब्दसंपदा यांचा समावेश करणे ही महत्त्वाची गरज आहे.मराठी भाषेचे

सक्षमीकरण म्हणजे केवळ आधुनिक साधनांचा मराठीमध्ये वापर नव्हे, तर मराठी भाषेला ज्ञाननिर्मिती, संशोधन, शिक्षण, प्रशासन आणि डिजिटल व्यवहार यांसाठी सक्षम माध्यम बनविणे होय. यासाठी भाषातज्ज्ञ, तंत्रज्ञ, शिक्षक, संशोधक, शासन आणि स्थानिक भाषिक समुदाय यांनी समन्वयाने काम करणे आवश्यक आहे.अशा प्रकारे, कृत्रिम बुद्धिमत्ता मराठी भाषेच्या डिजिटल विस्तारासाठी प्रभावी साधन ठरू शकते. मात्र, हा विकास अचूकता, भाषिक विविधता, गोपनीयता, सांस्कृतिक संवेदनशीलता आणि मानवी देखरेख यांच्या आधारावर झाला पाहिजे. मराठी भाषेच्या सर्वांगीण सक्षमीकरणासाठी तंत्रज्ञान आणि भाषिक-सांस्कृतिक मूल्ये यांचा समतोल राखणे अत्यावश्यक आहे.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

धडगाव तालुक्यातील दुर्गम भागातील नर्मदा सरोवर प्रकल्पग्रस्थाचे विस्थापन व नक्षलमुक्त क्षेत्र

प्रा. नरेद्र पांडूरंग विभाडींक

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DOI - 10.5281/zenodo.24339091

प्रस्तावना:

1 जुलै 1998 रोजी धुळे जिल्हयातून नंदुरबार जिल्हा आदिवासी, जिल्हा म्हणून नव्याने उदयास आला. नंदूरबार जिल्याची प्रशासकीयंत्रणा निर्माण करण्यात आली. त्यात 1 जिल्हा परिषद 6 पचायत समित्या व ५०१ ग्रामपंचायत असून एकुण नंदूरबार जिल्हयात समाविष्ट करण्यात आली त्यात धडगाव (अक्राणी), तळोदा, शहादा नंदूरबार, अक्कलकुवा, नवापूर दिसून येतात. जिल्हयात ४ नगरपरिषदा व १ नगरपंचायत आहे. नंदूरबार जिल्हा साधारपणे गोलाकार असून भौगोलिक दृष्टीने उंचसखलपणा, हवामान, पर्जन्यमान, व जमिनीच्या प्रतिनुसार तिन विभाग पडतात. पहिल्या विभागात आदिवासी वस्ती असलेल्या सातपुडा पर्वतरांगातील जंगल व डोंगराळ भागाचा समावेश होतो, तर दुसऱ्या विभागात सदन तापी खो-याचा भाग आहे. आणि तिसन्या विभागात दक्षिणेकडील सह्याद्री पर्वताचा प्रदेश समाविष्ट आहे.

नंदुरबार जिल्हा आदिवासी जिल्हा ओळखला जातो . महाराष्ट्रातील आदिवासी लोकसंख्या असलेला तिसऱ्या क्रमांकाचा जिल्हा आहे. जिल्ह्यांची 2011 च्या जनगणने नुसार सर्वसामान्य लोकसंख्या 16,48,295 दिसून येते. त्यात 11,14,933 एवढी आदिवासी लोकसंख्या होती.जिल्यात ३५१७.५० हेक्टर आदिवासी उपयोजना क्षेत्राचे क्षेत्रफळ आहे. धडगाव, अक्कलकुवा, तळोदा, नवापूर हे चार तालुके पुर्णतः आणि शहादा, नंदूरबार हे अंशतः आदिवासी उपयोजना क्षेत्रात येतात.

जिल्यात प्रामुख्याने भिल्ल, पावरा, कोकणी, गावित (गामित) धानका व नाईक या मुख्य आदिवासी जमाती दिसून येतात आदिवासी नागरिकांकरिता शासनाने 1 एप्रिल 1977 पासून आदिवासी उपयोजना (TSP) सुरु केली असून तळोदा व नंदूरबार येथे एकात्मिक आदिवासी प्रकल्य कार्यालय स्थापन करण्यात आली ओहेत.

संशोधन निबंधाच्या शीर्षका नुसार धडगाव प्रकल्पग्रस्ताचे विस्थापन व नक्षलमुक्त क्षेत्र, या विषयानुसार अध्ययन करताना धडगाव तालुक्याचे की, भौगोलिक स्थान विचारात घेतांना असे दिसून येते की, धडगाव (अक्राणी महल) तालुका सातपुडा पर्वतरांगाच्या डोंगरदऱ्यात वसलेला आहे. तालुक्याच्या पश्चिम दिशेला अक्कलकुवा तालुका असून, पुर्वेला मध्यप्रदेश राज्यांची सिमा आहे. तर उत्तर दिशेला नर्मदा नदी ही प्रमुख नदी आहे.

संशोधनाचा उद्देश:

अ) धडगाव भागात नक्षलवाद निर्माण न होण्याची कारणे तपासणे.

ब) नक्षलवादी चळवळीचे अध्ययन करणे.

क) शैक्षणिक कार्याचा आदिवासी जमातीवर झालेला परिणांमा चा अभ्यास करणे.

ड) नक्षलवादाच्या उदयाची कारणे अभ्यासणे.

ई) विस्थापित नागरिकांच्या पुनर्वसनाचा अध्ययन करणे.

संशोधन निबंधाची गृहितके:

१) धडगाव,अक्कलकुवा भागात वेठ बिगारी पद्धत प्रचलित होती.

२) आदिवासी जमातींचे आर्थीक, शारीरिक, मानसिक शोषण केले जात होते.

३) शिक्षण, आरोग्य, रस्ते, दळणवळण इत्यादी सुविधांचा अभाव होता.

४) शैक्षणिक व सामाजिक कार्याचा नागरिकांवर सकारात्मक परिणाम झाला आहे.

महाराज जनार्दन वळवी यांचे शैक्षणिक कार्य महत्वपूर्ण आहे

संशोधन पद्धती :

प्रस्तुत संशोधन निबंधाच्या अध्ययनासाठी दुय्यम साधनांचा अवलंब करण्यात आला आहे. तथ्य संकलन,मासिके, वृत्तपत्रे, संदर्भग्रंथ विकिपीडिया,इंटरनेट इत्यादी साधनांच्या वापरा बरोबर संशोधकाने प्रत्यक्ष मुलाखत घेऊन माहिती संकलन करून शोधनिबंधाचे विवेचन करण्यात आलेले आहे.

शोधनिबंधाचे स्पष्टीकरण :

स्वातंत्र्यपूर्व व स्वातंत्र्योत्तर काळात भारतातील शोषित, वंचित, आदिवासी, कष्टकरी, भूमीहीन, वर्गाचे भारतातीलच उच्चभ्रु, वरिष्ठ व उच्चवर्णीय समाजाने शोषण केल्याचे दिसून येते. गेल्या 76 वर्षात पाहिजे तेवढ्या प्रमाणात यात बदल झालेला दिसून येत नाही.

आदिवासी व वंचित घटकांसाठी संविधानिक कायद्याच्या व सरकारच्या आदेशांचा योग्य परिणाम झाला नसल्यामुळे व आदिवासी जमातीतील लोकांना शोषणमुक्त करणे हे एकमेव ध्येय डोळ्यासमोर ठेवून उच्च विद्या आर्थिकदृष्ट्या सबळ घरातील तरुण मंडळी नक्षलवादी चळवळीकडे वळल्यामुळे नक्षलवादाचा उदय झालेला साधारणपणे मार्च १९६७ च्या जवळपास सशस्त्र किसान आंदोलनातून पश्चिम बंगालच्या सिलिगुडी जिल्ह्यातील उपविभागात नक्षलबाडी येथे नक्षलवाद्यांच्या उदय झाल्याचे सांगण्यात येते. पश्चिम बंगाल पासून आंध्रप्रदेश, मध्यप्रदेश, बिहार, केरळ इत्यादी राज्यांपर्यंत नक्षलवाद पोहोचलेला दिसून येतो. महाराष्ट्रात नक्षलवादाची गडचिरोली व चंद्रपूर जिल्ह्यातील अहेरी, ऐटापल्ली, सिरोचा तेथून ठाणे जिल्ह्यापर्यंत त्याचा विस्तार झाल्याचे दिसून येते.पीपल्स वार ग्रुप, माओवादी, भारतीय कम्युनिस्ट पक्ष (मार्क्स-लेनिनवादी) अशा अनेक डाव्या चळवळींचा नक्षलवादी चळवळींचा संबंध दिसून येतो. पश्चिम बंगाल पासून सुरू झालेला नक्षलवाद शहर मुंबईच्या जवळपास असलेल्या ठाणे जिल्हा पर्यंत पोहचलेला दिसून येत.आहे.

नक्षलवादाचा अर्थ :

"नक्षलवाद म्हणजे शस्त्राच्या बळावर हिंसक मार्गाचा वापर करुन समाजात भितीचे वातावरण निर्माण करून आपले ध्येय साध्य करणारी संघटना होय" असा नक्षलवादाचा साधारपणे अर्थ सांगितला जातो.

नक्षलवादाची व्याख्या :

जॉन रॉल च्या मते "राजकीय उहिष्ट्ये प्राप्त करण्यासाठी अवैधानिक मार्गाचा अवलंबणारी आणि हिंसात्मक कार्य करणारी संस्था म्हणजे नक्षलवाद होय" म्हणजे जी संघटना हिंसेचा वापर करुन आपला उद्देश साध्य करण्यासाठी तयार असते अशी संस्था म्हणजे नक्षलवाद होव असे जॉन रॉल यांचे मत दिसून येते.

धडगाव (अक्राणी) तालुक्यातील नर्मदा सरोवर प्रकल्पग्रस्तांची माहिती:

महाराष्ट्रातील नर्मदा सरोवर प्रकल्प म्हणजेच सरदार सरोवर प्रकल्पामुळे नंदुरबार जिल्ह्यातील अक्कलकुवा आणि धडगाव (अक्राणी) या दोन तालुक्यांतील आदिवासी गावांचे मोठ्या प्रमाणावर विस्थापन झाले.महाराष्ट्र शासनाच्या नंदुरबार जिल्ह्याच्या सामाजिक व आर्थिक समालोचन अहवालानुसार, या प्रकल्पामुळे दोन्ही तालुक्यांतील मिळून ३३ गावे आणि ४,२७९ कुटुंबे बाधित झाली होती.

महाराष्ट्रातील बाधित गावे व कुटुंबांची संख्या:

अक्कलकुवा तालुक्यातील बाधित गावे : 09

धडगाव(आक्रणी) तालुक्यातील बाधित गावे : 24

दोन्ही तालुक्यांतील एकूण गावे : 33

बाधित कुटुंबे (नंदुरबार जिल्हा सामाजिक-आर्थिक समालोचन) : 4279

गुजरातमध्ये पुनर्वसन झालेली कुटुंबे : 784

नंदुरबार जिल्ह्यात पुनर्वसन झालेली कुटुंबे : 3443

स्रोत: महाराष्ट्र शासन, जिल्हा सामाजिक व आर्थिक समालोचन २०२१–२२, नंदुरबार जिल्हा.

पुनर्वसन किती कुटुंबांचे झाले?

केंद्र शासनाच्या १० ऑगस्ट २०१७ रोजीच्या लोकसभेतील उत्तरानुसार, महाराष्ट्रातील सरदार सरोवर प्रकल्पासाठी खालील आकडे नोंदवले आहे

बाधित गावांची संख्या : 33

एकूण प्रकल्पबाधित कुटुंबे : 4307

गुजरातमध्ये पुनर्वसित : 754

महाराष्ट्रात पुनर्वसित : 3530

एकूण पुनर्वसन झालेली म्हणून नोंद : 4284

उर्वीरित नोंद : 23

या २३ कुटुंबांमध्ये शासनाच्या नोंदीनुसार वारस नसलेली ३ मृत व्यक्तींची प्रकरणे आणि शोधता न आलेली २० कुटुंबे होती. त्यांच्यासाठी पुनर्वसनाकरिता जमीन व भूखंड उपलब्ध असल्याचे केंद्र शासनाने नमूद केले होते.

धडगाव तालुक्याची स्वतंत्र माहिती:

एक महत्त्वाची मर्यादा आहे: उपलब्ध जिल्हास्तरीय अहवालात अक्राणी तालुक्यातील २४ गावे दिली आहेत; परंतु त्या २४ गावांतील एकूण विस्थापित कुटुंबे आणि त्यांपैकी प्रत्यक्ष पुनर्वसन झालेली कुटुंबे यांची स्वतंत्र, अद्ययावत संख्या या स्रोतामध्ये स्पष्ट नाही.

तसेच ४,२७९ आणि ४,३०७ या दोन अधिकृत नोंदी वेगवेगळ्या वर्षांच्या किंवा सर्वेक्षणांच्या आहेत. त्यामुळे त्यांची सरळ बेरीज किंवा एकाच आकड्याप्रमाणे तुलना करणे योग्य ठरणार नाही.

शांतिदूत कर्मयोगी महाराज जनार्दन वळवी यांचे कार्य:

गुलामगिरी व शूदत्वाचे एकमेव कारण म्हणजे अज्ञान, अशिक्षितपणा हे होय असे क्रांतीसुर्य म. जोतिराव फुले यांनी सांगितलेले आहे. अविद्या ही शोषणाची जननी आहे. असे ठाम मत त्यांनी मांडले आहे. तसेच

डॉ.बाबासाहेब आंबेडकर म्हणतात "शिक्षणाच्या अभावामुळे माणसाला माणूस पण मिळत नाही" ते पुढे असे म्हणतात "शिक्षण हे वाघिणीचे दूध आहे जो प्राशन करेल तो गुरगुरल्या शिवाय राहणार नाही" याचा अर्थ शिक्षणाच्या अभावामुळे माणसाला पशुतुल्य वागणूक मिळते, या उक्ती प्रमाणे महाराज जनार्दन वळवी यांनी पहिल्या पाच वर्षांच्या विधानसभा सदस्यत्वा नंतर राजकीय निवृत्ती घेऊन शैक्षणिक कार्याला सुरुवात केली. जनार्दन महाराजांचे असे मत होते की "जोपर्यंत आदिवासी समाजाला शिक्षण देऊन सज्ञान केले जात नाही तोपर्यंत शासनाच्या कितीही विकास योजना आखल्या व करोडो कृपये खर्च केले तरी त्याचा उपयोग होणार नाही." ही गोष्ट त्यांनी वास्तवात उतरवण्यासाठी वयाच्या अवघ्या ३३ व्या वर्षी राजकीय निवृत्ती घेवून सामाजिक व शैक्षणिक कार्याला सुरुवात केली. धडगाव, अक्कलकुवा या भागाला पूर्वी अंदमान निकोबार म्हणून संबोधले जात होते. या ठिकाणी घनदाट अरण्य, वन्य पशू-प्राण्याचे अस्तीत्व, डोंगराळ व दुर्गम भाग, व रहदारीसाठी पायवाट देखील नव्हती. धडगाव, अक्कलकुवा भागात आदिवासी जमातीचे १००% वास्तव्य आहे. पूर्वीच्या काळी मीठ, मिरची, कपडे-लत्ते या जीवनावश्यक वस्तू घेण्यासाठी म्हसावद, शहादा, तळोदा येथे बाजारहाट करण्यासाठी जावे लागत असे. अशा बिकट स्थितीत महाराजांनी मोलगी भागात विविध व्यावसायिकांना आणून बाजारपेठ वसवली. नक्षलवादाची सर्वसामान्य जी कारणे वरील प्रमाणे सांगितले आहेत.

इतर कारणे देखील या भागात अस्तित्वात होती ती पुढील प्रमाणे.

१) ढेप अथवा पेंड खाण्याची प्रथा :

२) पाठीवर बसून ने-आण करणे :

३) व्यापारी दलालांकडून होणारे शोषण :

४) सरकारी अधिकाऱ्यांकडून होणारे शोषण :

५) सावकारी प्रथा :

६) विस्थापन व पुर्नवसनचा प्रश्न :

७) पडीत जमिनीचा प्रश्न :

वरील सर्व स्पष्टीकरणावरून असे दिसन येते की नक्षलवादाची जी कारणे सांगितली जातात त्या का स्थळसापेक्ष कारणे देखील धडगाव-अक्कलकुवा भागात दिसन येत होती. या सर्व समस्या व कारणांचा महाराज जनार्दन महाराज बाबा यांनी वेळीच विचार करून बंदोबस्त केला. खेड्यापाड्यावर अति दुर्गम भागात त्यांनी शाळा,जंगल कामगार सोसायटी सुरू केल्या. भष्ट्राचारी व शोषक कर्मचारी अधिकारी, वन विभागांचे कर्मचारी, ग्रामसेवक, पोलीस, तलाठी यांचा वेळीच बंदोबस्त केला त्यांना समज दिली. तसेच काही अधिकारी कर्मचारी यांनी सामाजिक व शैक्षणिक दृष्टिकोनाचा अंगीकार करून महाराज जनार्दन बाबा वळवी यांना सहकार्य व मदत केली. वेळप्रसंगी महाराजांच्या सोबात पाड्या -पाडयावर जाऊन लोकांना मदत केल्याचे दिसून येते.

उपाययोजना :

शासनाने नक्षलवादाचे समूळ उच्चाटन करण्यासाठी कोट्यावधी रुपये खर्च केलेत. आदिवासी नागरिक, पोलीस दल, सैन्यदल नक्षलवादी यांच्या हत्या झाल्यात. सालवाजुड्म (स्वच्छता मोहीम) व नंतर ग्रीनहंट सारख्या योजना राबवून नक्षलवाद समूट नष्ट करण्याचा प्रयत्न करत आहे. तरीही नक्षलवादाचे समूळ उच्चाटन करण्यात सरकार, पोलीस प्रशासन राज्यकर्ते यांना पूर्णतः अपयशी ठरल्याचे दिसून येते. त्यासाठी खालील उपाय योजना करणे आवश्यक आहे.

१) जनतेचे आधिक शोषण होणार नाही याची दखल घेतली पाहिजे.

२) सुशिक्षित तरुणांना नोकरी अथवा व्यवसायासाठी मदत केली पाहिजे.

३) नक्षलग्रस्त व दुर्गम भागात काम करणाऱ्या कर्मचारी वर्गास प्रोत्साहन देण्याची योजना आखली पाहिजे.

४) आदिवासी भागातील नैसर्गिक साधन संपत्ती व वनसंपत्तीचे रक्षण

५) आदिवासी भागातील शाळा, महाविद्यालयांना सुरुवातीपासून १००% अनुदान दिले पाहिजे.

६) आरोग्य सुविधांमध्ये सुधारणा केली

७) व्यापारी, दलालकडून आदिवासिंचे शोषण थांबविण्यासाठी कायद्याची योग्य अंमलबजावणी पाहिजे.

८) संविधानातील ५ वी व ६ वी सूचीची योग्य अंमलबजावणी झाली पाहिजे.

९) सरदार सरोवरामुळे विस्थापित झालेल्या नागरिकांचे पुनर्वसन झाले पाहिजे.

उपंसहार :

सर्वसामान्य आदिवासी व्यक्ती हा नक्षलवादी व सरकार यांच्या दुहेरी कचाट्यात अडकून भरडला जात आहे. एकीकडे सरकारचे ग्रीनहंट वाले बंदूकधारी व दुसऱ्या बाजूला नक्षलवादी अण्णांचा बंधुकधारी यांच्यात मरणारे व मारणारे दोन्ही आदिवासी आहेत. अशी परिस्थिती नक्षलवादामुळे निर्माण झालेली आहे. परंतु धडगाव भागात विविध गंभीर समस्या असूनही या भागात नक्षलवादा उदय झालेला दिसून येत नाही. त्याला एकमेव कारण म्हणजे सातपुड्यातील महाराज जनार्दन पोहऱ्या वळवी यांचे सामाजिक व शैक्षणिक कार्य होय. त्यांच्या अथक परिश्रमातून आज अति दर्गम भागातील झोपडीत ज्ञानाचा, शिक्षणाचा, सज्ञानाचा, शोषण मुक्तीच्या मार्ग निर्माण झाला आहे. त्यांनी वेगवेगळ्या प्रकारचे होणारे शोषण वेळीच रोखले व त्यातून एक सुज्ञ, समजदार व जबाबदार नागरिक निर्माण केले. त्यांनी या भागात पायपिट करून आदिवासी बांधवांना शिक्षण प्रवाहात आणले. त्यांचा त्याग, समर्पण, कष्ट, यातनांची दखल घेऊन सरकारने घेतली नाही, ही खेदाची गोष्ट आहे.

संदर्भ ग्रंथ :

१) रमाकांत पाटील " सातपुड्यातील कर्मयोगी महाराज जनार्दन पोहऱ्या वळवी "

२) डॉ. गोविंद गारे "नक्षलवादी व आदिवासी"

३) मोरे माधव बंडू "आदिवासी बोलू लागला"

४) रमाकांत पाटील "अंतरंग नंदुरबार जिल्ह्याचे"

५) डॉ. विलास संगवे "आदिवासीचे सामाजिक जीवन "

६) डोंगरे मा.ग. "वेघ नक्षलवादी चळवळीचा" बाबूलाल नाईक "दरीतील कर्मयोगी"

७) बाबूलाल नाईक "दरीतील कर्मयोगी"

८) डॉ. तुकाराम रॉगटे "आदिवासी आयकॉन"

International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

The Role of Fintech in Empowering Women Entrepreneurs in Dhule District

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DOI - 10.5281/zenodo.24339118

Abstract:

Abstract FinTech, or financial technology, is crucial to the growth of contemporary companies. Digital payments, online banking, mobile banking, online lending, and other technology-based financial services are all included. These services can assist female entrepreneurs in receiving payments, managing their company's finances, saving time, and becoming more financially independent. The current study intends to investigate how FinTech empowers female entrepreneurs in Maharashtra's Dhule District. A sample of 125 female entrepreneurs is suggested for the study, which runs from April 2025 to March 2026. A systematic questionnaire will be used to gather primary data. FinTech awareness, utilization, advantages, and difficulties will all be examined using percentage analysis. It is anticipated that the study would offer insightful information about how digital financial services support women's economic empowerment and entrepreneurship.

Keywords: Fintech, Women Entrepreneurs, Digital Payments, Financial Inclusion, And Economic Empowerment.

Introduction:

Women's entrepreneurship fosters economic expansion, employment development, and social empowerment. Women entrepreneurs operate retail establishments, tailor shops, beauty salons, food businesses, handicrafts, and home-based enterprises. However, they may struggle with marketing, funding, computer literacy, and accessibility to banking services.

The use of technology to provide financial services is known as financial technology, or FinTech. Digital lending platforms, online and mobile banking, UPI payments, and QR codes are some significant examples. These programs facilitate corporate financial management, transaction monitoring, payment receipt, and money transfer for female businesses.

FinTech may give women in Dhule District the chance to enhance their financial independence and company operations. However, its use may be limited by cybersecurity issues, internet issues, digital illiteracy, and restricted credit availability. Thus, the current study looks at how FinTech empowers female entrepreneurs in Dhule District.

The Study's Objectives:

1. To research women entrepreneurs' knowledge of and use of fintech.
2. To investigate how mobile banking and digital payments are used in business operations.
3. To comprehend how fintech contributes to business growth and financial independence.
4. To determine the difficulties female business owners encounter when utilizing digital financial services.

5. To make recommendations for ways to increase women entrepreneurs' embrace of FinTech.

Research Techniques:

Research approach: This study employs a descriptive research approach.

- The Dhule District of Maharashtra is the study area.
- April 2025–March 2026 is the study period.
- 125 female entrepreneurs make up the sample size.

Sampling Technique: Depending on how respondents are actually chosen, either convenience or purposeful sampling may be employed.

Primary Data: A systematic questionnaire and in-person conversations with female entrepreneurs will be used to gather primary data.

Secondary Data: Reports from the Reserve Bank of India, official publications, books, research journals, and pertinent websites will all be used.

Tools of Analysis: The results will be presented using charts, frequency tables, and percentage analysis.

(Number of Respondents ÷ Total Respondents) x 100 is the percentage.

FinTech's Contribution to Women's Empowerment:

1. Electronic Payments:

Women entrepreneurs can accept payments fast and easily with the use of digital payment methods like UPI and QR-code transactions. They facilitate transactions for clients and business owners and lessen reliance on cash.

2. Obtaining Banking Services:

Without regularly visiting bank offices, female businesses can monitor transactions, transfer money, and check account balances through mobile and online banking. This streamlines money management and saves time.

3. Financial Access:

Women entrepreneurs can investigate business loans and other financial goods with the aid of digital financial services. Financial documentation may be supported by digital transaction records. However, eligibility, lender restrictions, and repayment capacity all play a role in loan approval.

4. Self-Sufficiency in Money:

Fintech has made it possible for women to oversee business activities and monitor their income and expenses. 4.5 Development of Businesses

Online platforms and digital payments can assist female businesses in contacting clients outside of their local marketplaces. Additionally, digital transaction records can help with business planning, sales tracking, and budgeting.

Analysis of Primary Data:

The survey results might be presented in the format shown in the following tables. Before the work is presented as empirical study, the figures—which are merely illustrative—must be substituted with genuine questionnaire data.

Table 1: Awareness of FinTech

Respondents	Percentage	Level of Awareness
50	40%	High
45	36%	Moderate
30	24%	Low
125	**100%**	**Total**

Interpretation: In this case, 24% of respondents have poor understanding about FinTech, compared to 40% who have strong awareness. This emphasizes how crucial digital financial literacy initiatives are.

Table 2: Principal Difficulties with FinTech

Challenges	Respondents	Percentage
Lack of digital knowledge	35	28%
Fear of online fraud	30	24%
Internet problems	25	20%
Difficulty obtaining loans	20	16%
Other difficulties	15	12%
Total	**125**	**100%**

Interpretation: The main obstacles in this sample scenario are a lack of digital literacy and a fear of online fraud. These obstacles might be removed with the aid of cybersecurity knowledge, training, and readily available customer service.

Findings:

The 125 female entrepreneurs' real responses must serve as the basis for the final conclusions. The research ought to determine:

- The degree of FinTech uptake and awareness.
- The digital banking services that are most widely used.
- FinTech's advantages for financial management and business transactions.
- The main issues pertaining to technology, finances, and security.
- Is using FinTech linked to financial empowerment?
- The aforementioned illustrated tables do not establish actual findings for Dhule District; rather, they show the format of the presentation.

Suggestions:

- Programs for digital financial literacy for female entrepreneurs should be organized by banks and educational institutions.
- It is important to educate female entrepreneurs on online fraud prevention, secure digital payments, and OTP protection.
- Financial institutions ought to offer details on government-sponsored programs and appropriate company financing.
- Marathi and other languages that are understood locally should be used for training.
- Through financial advice, digital skills training, and entrepreneurship development initiatives, government organizations and business associations should assist female entrepreneurs.

Conclusion:

By enhancing access to financial services, streamlining payments, assisting with financial management, and promoting business growth, fintech has the potential to empower female entrepreneurs. Women can handle business transactions more conveniently and save time by using digital banking and payment platforms.

Effective FinTech applications in Dhule District could support women's business growth and financial independence. However, its advantages rely on cybersecurity awareness, internet connection, digital literacy, and availability to appropriate financing.

Understanding these potential and obstacles is the goal of the planned research of 125 female entrepreneurs from April 2025 to March 2026. The actual poll results will be used to determine local needs and offer useful suggestions for enhancing women entrepreneurs' access to digital finance.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
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केळी पीक व त्यावर आधारित रोजगाराच्या संधी
जळगाव जिल्ह्यातील रावेर आणि यावल तालुक्यांचा भौगोलिक अभ्यास

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सारांश:

केळी हे जळगाव जिल्ह्यातील महत्त्वाचे नगदी फळपीक असून रावेर आणि यावल तालुके केळी उत्पादनासाठी ओळखले जातात. केळी उत्पादनाबरोबरच केळी चिप्स, बिस्किटे, पावडर, पीठ, सेंद्रिय खतनिर्मिती, केळीच्या खोडापासून तंतू व प्लेट निर्मिती, रोपवाटिका, पॅकिंग आणि निर्यात यांसारखे उद्योग विकसित करता येतात. या उद्योगांमुळे स्थानिक युवक, महिला आणि शेतकऱ्यांना स्वयंरोजगाराच्या संधी मिळू शकतात. तसेच केळी पिकाच्या अवशेषांचा उपयोग केल्यामुळे कृषी कचऱ्याचे प्रमाण कमी होऊन पर्यावरणपूरक विकासाला चालना मिळते. सदर संशोधनात रावेर व यावल तालुक्यांतील केळी पिकावर आधारित रोजगाराच्या संधी, प्रक्रिया उद्योगांची क्षमता आणि स्थानिक आर्थिक विकासातील त्यांचे योगदान यांचा भौगोलिक दृष्टिकोनातून अभ्यास करण्यात आला आहे. अभ्यासासाठी प्रकाशित संशोधन लेख, आणि कृषी विज्ञान केंद्राच्या उपलब्ध प्रकाशनांचा आधार घेतला आहे.

मुख्य शब्द: केळी पीक, ग्रामीण रोजगार, रावेर तालुका, यावल तालुका, पर्यावरणपूरक, केळी प्रक्रिया, तंतू, कृषी अर्थव्यवस्था.

प्रस्तावना:

भारत हा कृषिप्रधान देश असून भारतीय अर्थव्यवस्थेत शेती व्यवसायाला महत्त्वाचे स्थान आहे. शेती हा ग्रामीण भागातील लोकांच्या उपजीविकेचा प्रमुख आधार आहे. शेतीच्या माध्यमातून केवळ अन्नधान्याचे उत्पादन होत नाही, तर विविध कृषी उत्पादनांवर आधारित उद्योग आणि रोजगारांच्या संधीही निर्माण होतात. महाराष्ट्र राज्यातील जळगाव जिल्हा केळी उत्पादनासाठी विशेष प्रसिद्ध आहे. या जिल्ह्यातील रावेर आणि यावल तालुके केळी लागवडीच्या दृष्टीने महत्त्वाचे आहेत. या भागातील भौगोलिक परिस्थिती, हवामान, तापी नदीच्या खोऱ्यातील जलस्रोत, सिंचन सुविधा आणि सुपीक जमीन यांमुळे केळी पिकाच्या विकासाला अनुकूल परिस्थिती निर्माण झाली आहे.

केळी पिकाचा उपयोग केवळ फळ म्हणून मर्यादित नसून त्यावर आधारित प्रक्रिया उद्योगांच्या विकासालाही मोठी संधी आहे. केळीपासून चिप्स, पीठ,लाडू, बिस्किटे, पापड आणि इतर खाद्यपदार्थ तयार करता येतात. तसेच केळीच्या खोडापासून तंतू निर्मिती, सेंद्रिय खत, पशुखाद्य आणि इतर उपयुक्त उत्पादने तयार करण्याचीही क्षमता आहे.

याशिवाय केळीच्या पानांचा वापर, खोडापासून हस्तकला वस्तू आणि पर्यावरणपूरक उत्पादनांची निर्मिती यांद्वारे ग्रामीण भागात लघुउद्योग विकसित होऊ शकतात. रावेर व यावल तालुक्यांमध्ये केळी पिकावर आधारित प्रक्रिया उद्योग, कृषीपूरक व्यवसाय आणि स्थानिक बाजारपेठांचा विकास केल्यास ग्रामीण युवक, महिला बचत गट आणि लहान उद्योजकांसाठी रोजगाराच्या नवीन संधी निर्माण होऊ शकतात. या संशोधनामध्ये रावेर व यावल तालुक्यांतील केळी उत्पादनाचे भौगोलिक महत्त्व, केळी पिकावर आधारित रोजगारांच्या संधी, कृषी प्रक्रिया उद्योगांची क्षमता आणि ग्रामीण आर्थिक विकासातील त्यांचे योगदान यांचा अभ्यास करण्यात येणार आहे. केळी पिकाच्या प्रत्येक टप्प्याशी संबंधित रोजगारांचे स्वरूप समजून घेऊन स्थानिक संसाधनांवर आधारित लघुउद्योगांच्या विकासासाठी उपाययोजना सुचविणे हा या संशोधनाचा प्रमुख उद्देश आहे

अभ्यास क्षेत्र:

प्रस्तुत संशोधनासाठी महाराष्ट्र राज्यातील जळगाव जिल्ह्यातील रावेर व यावल या दोन तालुक्यांची निवड करण्यात आली आहे. हे क्षेत्र केळी उत्पादनासाठी प्रसिद्ध आहे. या अभ्यासात केळी पिकावर आधारित प्रक्रिया उद्योग, खोडापासून तंतू निर्मिती, वाहतूक, पॅकिंग या संदर्भात रोजगारांच्या संधींचा अभ्यास करण्यात येणार आहे.

संशोधनाची उद्दिष्टे:

1. केळी पिकाच्या विविध टप्प्यांवर उपलब्ध होणाऱ्या रोजगाराच्या प्रकारांची ओळख करून घेणे.
2. केळी प्रक्रिया व केळी खोडापासून तंतू निर्मिती यांसारख्या उपयुक्त संधी तपासणे.
3. केळी पिकाशी संबंधित ग्रामीण स्वयंरोजगार वाढविण्यासाठी उपाय सुचविणे.

संशोधन पद्धती:

1. **प्राथमिक माहिती** :- प्रश्नावली, वैयक्तिक मुलाखती आणि प्रत्यक्ष निरीक्षणातून पद्धतीद्वारे केळी उत्पादक शेतकरी, शेतमजूर, व्यापारी, पॅकिंग केंद्रे आणि प्रक्रिया उद्योजक यांच्या मुलाखती.
2. **द्वितीय माहिती**:- केळी पिका संबंधी शोधनिबंध, लेख, कृषी माहिती पुस्तिका, कृषी विज्ञान केंद्र यांचे पुस्तके, वर्तमान पत्रातील संबंधित लेख, मासिके.
3. संशोधनासाठी वर्णनात्मक व विश्लेषणात्मक पद्धती वापर केला आहे.

केळी उत्पादनाशी संबंधित रोजगाराच्या संधी:

1) केळी पासून चिप्स उद्योग :

रावेर व यावल तालुक्यांमध्ये केळीचे मोठ्या प्रमाणावर उत्पादन होत असल्यामुळे केळीपासून चिप्स तयार करण्याचा उद्योग स्थानिक युवक व महिलांना रोजगाराच्या संधी उपलब्ध करून देत आहे. हा व्यवसाय सध्यातरी रस्त्याच्या कडेला छोटेसे दुकान तयार करून रावेर व यावल तालुक्यात ठीक ठिकाणी सुरु असल्याचे दिसते. परंतु चिप्सची गुणवत्ता, आकर्षक पॅकिंग, व मार्केटिंग यांच्या माध्यमातून या उत्पादनांची महाराष्ट्रासह देशातील इतर बाजारपेठांमध्ये विक्री करता येईल. आवश्यक गुणवत्ता मानके, अन्नसुरक्षा नियम आणि निर्यातीच्या अटी पूर्ण केल्यास परदेशातही केळी चिप्सची निर्यात करता येऊ शकते. त्यामुळे स्थानिक अर्थव्यवस्थेला चालना मिळून ग्रामीण भागातील स्वयंरोजगाराच्या संधी वाढू शकतात.

अग्रोवन Sign in

शेती उत्पादन वाढवा ॲग्रो विशेष मार्केट इन्टेलिजन्स ह

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चंद्रकांत जाधव : अॅग्रोवन वृत्तसेवा

Published on :04 Nov 2023, 10:30 AM IST

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CHHATRAPATI SAMBHAJINAGAR: A farmer from Jalgaon district's Yawal taluka has received a patent from the Centre for biscuits he made from bananas.

The 70-year-old farmer, Ganesh Gade, is exporting his biscuits to Orissa and West

2) केळीपासून बिस्किट निर्मिती उद्योग:

रावेर व यावल तालुक्यात केळीपासून बिस्किटे तयार करणे हा रोजगारनिर्मितीचा एक चांगला पर्याय ठरू शकतो. केळीच्या गराचा वापर करून बिस्किटे तयार केली जातात. या प्रक्रियेमुळे केळीची उपयुक्तता वाढते आणि स्थानिक पातळीवर लघुउद्योग विकसित होण्यास मदत होते. बिस्किट निर्मिती, पॅकिंग, वाहतूक व विक्री यांमधून स्थानिक युवकांना आणि महिलांना रोजगाराच्या संधी उपलब्ध होऊ शकतात. तसेच योग्य बाजारपेठ मिळाल्यास या उत्पादनाची इतर शहरांमध्ये आणि निर्यात बाजारपेठेतही विक्री करता येऊ शकते. जळगाव जिल्ह्यातील यावल तालुक्यात केळीपासून बिस्किटे तयार करण्याचा अभिनव प्रयोग करण्यात आला आहे. श्री. अशोक गडे यांनी केळीपासून बिस्किटे तयार करून त्यासाठी पेटंट मिळविला आहे. केळीपासून बिस्किटे तयार करणे हा केळी प्रक्रिया उद्योगातील एक महत्त्वाचा पर्याय आहे.

3) केळीपासून पावडर, पीठ आणि लाडू निर्मिती :

रावेर व यावल तालुक्यात केळी पिकावर आधारित केळी पावडर, केळीचे पीठ आणि केळीचे लाडू तयार करण्याचे लघुउद्योग सुरू करता येऊ शकतात.

- **केळी पावडर निर्मिती :** पिकलेली किंवा योग्य अवस्थेतील केळी स्वच्छ करून, काप करून वाळवली जातात. त्यानंतर त्यांची बारीक पावडर तयार करून पॅकिंग केले जाते.
- **केळीच्या पिठाची निर्मिती** : कच्च्या केळ्यांच्या साली काढून त्यांचे तुकडे केले जातात. हे तुकडे वाळवून दळले जातात. तयार पीठ विविध खाद्यपदार्थ बनवण्यासाठी वापरता येते.
- **केळीचे लाडू निर्मिती :** केळीची पावडर किंवा पीठ, गूळ, तूप आणि सुका मेवा यांचा वापर करून लाडू तयार करता येतात. त्यांचे आकर्षक पॅकिंग करून स्थानिक बाजारपेठेत विक्री करता येते.

या उद्योगांमुळे ग्रामीण भागातील युवकांना व महिलांना रोजगार मिळू शकतो. स्थानिक शेतकऱ्यांना

बाजारपेठ उपलब्ध होते आणि लघुउद्योगांच्या माध्यमातून उत्पन्नाचे नवीन स्रोत निर्माण होऊ शकतात.

4) केळीच्या खोडापासून तंतू निर्मिती उद्योग:

रावेर आणि यावल तालुक्यांत केळीचे उत्पादन मोठ्या प्रमाणावर होत असल्यामुळे केळीच्या खोडापासून तंतू निर्मिती हा एक महत्त्वाचा लघुउद्योग ठरू शकतो. केळीचा घड काढल्यानंतर उरलेले खोड सामान्यतः शेतात टाकले जाते. या खोडावर प्रक्रिया करून यंत्राच्या साहाय्याने नैसर्गिक तंतू काढले जातात. हे तंतू स्वच्छ करून वाळवले जातात आणि विक्रीसाठी तयार केले जातात.

- **तंतूंचा उपयोग** : केळीच्या तंतूंपासून पिशव्या, दोरखंड, चटया, कागद, कापड आणि सजावटीच्या वस्तू तयार करता येतात.
- **रोजगाराच्या संधी :** या उद्योगामुळे केळीचे खोड गोळा करणे, तंतू काढणे, वाळवणे, पॅकिंग आणि वस्तुनिर्मिती अशा विविध कामांमध्ये रोजगार निर्माण होऊ शकतो. ग्रामीण युवक आणि महिलांना स्वयंरोजगाराची संधी मिळते. तसेच केळीच्या टाकाऊ खोडाला आर्थिक मूल्य प्राप्त होऊन शेतकऱ्यांना अतिरिक्त उत्पन्न मिळू शकते

5) खोडापासून प्लेट निर्मिती उद्योग :

केळीच्या खोडापासून प्लेट तयार करणे हा कृषी अवशेषांचा उपयोग करणारा एक पर्यावरणपूरक लघुउद्योग होऊ शकतो. रावेर आणि यावल तालुक्यांत केळीचे उत्पादन मोठ्या प्रमाणावर होत असल्यामुळे या उद्योगाला संधी उपलब्ध होऊ शकते.

- **प्लेट निर्मिती प्रक्रिया:** केळीचे खोड कापून त्यातील बाहेरील आवरण वेगळे केले जाते. योग्य आकाराचे

आवरण निवडून स्वच्छ केले जाते. आवरण वाळवून आवश्यकतेनुसार मऊ केले जाते. साच्याच्या साहाय्याने हायड्रॉलिक प्रेस मशीनमध्ये प्लेटचा आकार दिला जातो. प्लेटची स्वच्छता, गुणवत्ता तपासणी व पॅकिंग केले जाते.

- **प्लेटचा उपयोग:** लग्नसमारंभ आणि कार्यक्रम , हॉटेल व खानावळी ,खाद्यपदार्थांची दुकाने पर्यावरणपूरक डिस्पोजेबल वस्तूंची बाजारपेठ

6) केळीच्या अवशेषांपासून सेंद्रिय खतनिर्मिती:

केळीची काढणी झाल्यानंतर केळीची खोडे, पाने, पानांचे देठ आणि इतर जैविक अवशेष मोठ्या प्रमाणावर शेतात उपलब्ध होतात. या अवशेषांचा योग्य वापर न केल्यास ते शेतात कुजतात किंवा त्यांची विल्हेवाट लावावी लागते. मात्र, या अवशेषांचा उपयोग करून सेंद्रिय खतनिर्मितीचा लघुउद्योग सुरू करता येतो.

रोजगारनिर्मितीच्या संधी:

केळीच्या अवशेषांपासून सेंद्रिय खत तयार करणे हा ग्रामीण भागातील एक महत्त्वाचा कृषीपूरक उद्योग ठरू शकतो. या उद्योगासाठी केळीचे अवशेष गोळा करणे, त्यांची वाहतूक करणे, तुकडे करण्यासाठी यंत्र चालवणे, खतनिर्मितीची प्रक्रिया सांभाळणे, तयार खताचे पॅकिंग करणे आणि त्याची विक्री करणे अशा विविध कामांची आवश्यकता असते. त्यामुळे स्थानिक युवक, महिला बचत गट, शेतकरी उत्पादक गट आणि लहान उद्योजकांना रोजगाराच्या संधी उपलब्ध होऊ शकतात. शेतकरी स्वतःच्या शेतातील अवशेषांचा वापर करून लहान प्रमाणात खतनिर्मिती करू शकतात. तसेच अनेक शेतकऱ्यांचे अवशेष एकत्र करून सामूहिक खतनिर्मिती केंद्र सुरू करता येऊ शकते. तयार खत स्थानिक शेतकरी, रोपवाटिका, फळबाग उत्पादक आणि सेंद्रिय शेती करणाऱ्यांना विकता येते.

7) केळीची रोपे तयार करणे व नर्सरी उद्योग:

केळीची रोपे तयार करणे व नर्सरी उद्योग नर्सरीच्या माध्यमातून शेतकऱ्यांना दर्जेदार, निरोगी आणि रोगमुक्त केळीची रोपे उपलब्ध करून देणे हा रोजगारनिर्मितीचा केळीवर आधारित एक स्थानिक व महत्त्वाचा व्यवसाय आहे.

रोजगाराच्या संधी :

- केळी रोपांची नर्सरी सुरू करणे.
- टिश्यू कल्चर रोपांची विक्री करणे.
- रोपांची वाहतूक आणि वितरण करणे.
- नर्सरीमध्ये स्थानिक युवक व महिलांना रोजगार उपलब्ध होऊ शकतो.

8) केळीच्या खोडा पासून कागद निर्मिती उद्योग:

संबधित तालुक्यात केळीची भरपूर उपलब्धता असल्यामुळे केळीचे घड निघाल्यावर खोडाचा वापर केला जात नाही. ते टाकाऊ म्हणून फेकले जाते. त्या टाकाऊ खोडाचा लगदा तयार करून त्या पासून कगद निर्मिती उद्योग तयार होऊ शकतो. परंतु त्यासाठी मोठ्या प्रमाणात तंत्रज्ञान व भांडवलाची आवशकता असते. त्या मुळे हा उद्योग खर्चीक ठरू शकतो.

केळी प्रक्रिया उद्योगातील समस्या:

रावेर आणि यावल तालुक्यांमध्ये केळी पिकावर आधारित प्रक्रिया उद्योग विकसित होण्यास मोठी संधी आहे. मात्र, या उद्योगांच्या विकासामध्ये पुढील समस्या दिसून येतात.

- **भांडवलाची कमतरता:** केळी प्रक्रिया उद्योग सुरू करण्यासाठी यंत्रसामग्री, जागा आणि इतर साधनांसाठी

मोठ्या भांडवलाची आवश्यकता असते. (उदा. तंतू निर्मिती उद्योग व प्लेट निर्मिती उद्योग मशनरी)

- **आधुनिक तंत्रज्ञानाचा अभाव**: केळी चिप्स, बिस्किटे, पावडर आणि इतर पदार्थ तयार करण्यासाठी आधुनिक यंत्रसामग्री सहज उपलब्ध होत नाही. अभावी सीमित उत्पादन होते.
- **बाजारपेठेची समस्या**: तयार उत्पादनांना योग्य बाजारपेठ मिळविणे आणि मोठ्या कंपन्यांशी स्पर्धा करणे कठीण जाते. (उदा. केळी चिप्स ची स्पर्धा बटाटा चिप्स कंपनी सोबत स्पर्धा)
- **प्रशिक्षणाचा अभाव:** स्थानिक युवक आणि महिलांना केळी प्रक्रिया उद्योगाचे तांत्रिक प्रशिक्षण पुरेशा प्रमाणात मिळत नाही.
- **वीज आणि वाहतूक समस्या:** वीजपुरवठ्यातील अडथळे आणि वाहतुकीचा खर्च यांमुळे उत्पादन खर्च वाढतो.
- **साठवणुकीची समस्या:** तयार उत्पादनांचे दीर्घकाळ संरक्षण करण्यासाठी योग्य पॅकिंग आणि साठवणूक सुविधांची आवश्यकता असते.
- **जाहिरात आणि प्रसिद्धीचा अभाव**: स्थानिक पातळीवर तयार होणाऱ्या केळीच्या पदार्थांची पुरेशी जाहिरात होत नसल्यामुळे ग्राहकांपर्यंत पोहोचण्यात अडचणी येतात.
- **निर्यातीतील अडचणी:** आंतरराष्ट्रीय बाजारपेठेत उत्पादनांची विक्री करण्यासाठी आवश्यक गुणवत्ता मानके, प्रमाणपत्रे आणि निर्यात प्रक्रियेची माहिती असणे गरजेचे असते.
- **कुशल कामगारांची कमतरता**: प्रक्रिया उद्योग चालविण्यासाठी प्रशिक्षित कामगार आणि तांत्रिक मनुष्यबळाची आवश्यकता असते.

उपाययोजना व शिफारसी:

- रोजगारनिर्मिती : स्थानिक युवक व महिलांना केळी प्रक्रिया उद्योगांचे प्रशिक्षण देऊन स्वयंरोजगाराच्या संधी उपलब्ध करून द्याव्यात.
- शीतगृह व साठवणूक सुविधा : केळीचे नुकसान टाळण्यासाठी शीतगृहे, योग्य पॅकिंग आणि साठवणूक सुविधांचा विकास करावा.
- निर्यातीला प्रोत्साहन : दर्जेदार केळी उत्पादन, आधुनिक पॅकिंग आणि वाहतूक सुविधांच्या माध्यमातून आंतरराष्ट्रीय बाजारपेठेत निर्यातीच्या संधी वाढवाव्यात.
- शासकीय योजनांची माहिती : केळी उत्पादक शेतकरी व उद्योजकांना अनुदान, कर्ज आणि कृषी प्रक्रिया उद्योगांसाठी उपलब्ध असलेल्या शासकीय योजनांची माहिती द्यावी.
- बाजारपेठेचा विकास : केळी उत्पादक शेतकरी, व्यापारी आणि प्रक्रिया उद्योग यांच्यात समन्वय निर्माण करून उत्पादनाला योग्य बाजारपेठ उपलब्ध करून द्यावी.
- नर्सरी उद्योगाला प्रोत्साहन : शेतकऱ्यांना दर्जेदार केळीची रोपे उपलब्ध करून देण्यासाठी आधुनिक रोपवाटिकांचा विकास करावा.
- केळी प्रक्रिया आणि अन्नसुरक्षा विषयक प्रशिक्षण स्थानिक युवक व महिला बचत गटांना उपलब्ध करून द्यावे.

- तंतू प्रकिया उद्योग तसेच प्लेट निर्मिती उद्योग साठी लागणाऱ्या मशीन महाग असल्यामुळे त्यावर अनुदान असल्यास त्या विषयी माहितीचा प्रसार, प्रचार सामान्य जनतेपर्यंत करावा.
- कृषी विज्ञान केंद्र व कृषी विभागाच्या तांत्रिक मार्गदर्शनाचा लाभ घ्यावा.
- मजुरांच्या सुरक्षिततेसाठी प्रशिक्षण, योग्य उपकरणे आणि कामाच्या ठिकाणी सुरक्षित पद्धती वापराव्यात.

निष्कर्ष:

केळी या पिकाच्या माध्यमातून रोजगारनिर्मितीच्या अनेक संधी उपलब्ध होऊ शकतात. उत्पादनाबरोबरच केळी चिप्स, बिस्किटे, पावडर, पीठ, लाडू, केळीच्या खोडापासून तंतू व प्लेट निर्मिती, सेंद्रिय खतनिर्मिती, रोपवाटिका आणि केळी पॅकिंग व निर्यात अशा विविध पूरक उद्योगांना मोठा वाव आहे. या उद्योगांमुळे स्थानिक युवक, महिला आणि शेतकरी यांना स्वयंरोजगाराच्या संधी मिळू शकतात. तसेच केळीच्या अवशेषांचा उपयोग केल्यामुळे कृषी कचऱ्याचे प्रमाण कमी होऊन पर्यावरणपूरक विकासाला चालना मिळते. त्यामुळे रावेर आणि यावल तालुक्यांमध्ये केळीवर आधारित लघुउद्योगांना प्रोत्साहन देणे, आधुनिक तंत्रज्ञानाचा वापर करणे आणि बाजारपेठ उपलब्ध करून देणे आवश्यक आहे. यामुळे शेतकऱ्यांचे उत्पन्न वाढण्यासोबतच ग्रामीण अर्थव्यवस्था मजबूत होऊन स्थानिक रोजगारनिर्मितीला चालना मिळेल.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Classical 2-Absorbing Subsemimodules of Semimodules

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DOI - 10.5281/zenodo.24339183

Abstract:

The concept of classical 2-absorbing submodules over commutative rings was introduced by Mostafanasab, Tekir and Oral. In this paper, we extend this concept to the framework of the theory of subsemimodules for semimodules over semirings. We establish characterizations of classical 2-absorbing subsemimodules and examine the relationships of classical 2-absorbing subsemimodules in both a semimoduleMover a semiringRand the quotient R-semimodule M/N $_{(Q)}$, where N is a partitioning subsemimodule of M. Our results address gaps in previous research and provide new structural insights into prime-like substructures within semimodules over semirings.

1. Introduction

Weakly prime ideals in a commutative ring with non-zero identity have been introduced and studied by D. D. Anderson and E. Smith in [1]. This notion has since been extended and studied in various algebraic settings, including semirings and modules (see, for example, [2], [3], [7], [10]). Recently, the notion of a classical 2-absorbing submodule of a module over a commutative ring R was introduced by H. Mostafanasab, Ü. Tekir and K. H. Oral [10]. In the present work, we establish characterizations of classical 2-absorbing subsemimodules and examine the relationships of classical 2-absorbing subsemimodules in both a semimodule M over a semiring R and the quotient R-semimodule $M/N_{(Q)}$, where N is a partitioning subsemimodule of M. Our results address gaps in previous research and provide new structural insights into prime-like substructures within semimodules over semirings.

To proceed further, we first set up the necessary notations, definitions and terminologies. For the definitions of monoid, semiring and radical of an ideal, we refer to [9]. All semirings in this paper are commutative with non-zero identity. $\mathbb{Z}_0^+$ ($\mathbb{N}$) will denote the set of all non-negative (positive) integers. An ideal I of a semiring R is called a subtractive ideal (= k-ideal) if $a, a+b \in I$, $b \in R$, then $b \in I$.

Definition 1.1. Following the terminology of [3], an ideal I of a semiring R is termed *2-absorbing* provided that for any elements $a, b, c \in R$, the condition $abc \in I$ implies at least one of ab, bc, ac belongs to I.

Definition 1.2. A left R-semimodule consists of a commutative monoid $(M, +)$ with identity 0_M, equipped with a scalar multiplication map $R \times M \to M$, $(r, x) \mapsto rx$, satisfying the following axioms for all $r, r' \in R$ and $x, y \in M$:

(1) $(rr')x = r(r'x)$;
(2) $r(x+y) = rx + ry$;
(3) $(r+r')x = rx + r'x$;
(4) $1_R x = x$;
(5) $r0_M = 0_M = 0_R x$.

A non-empty subset N of a left R-semimodule M is called a subsemimodule of M if N is closed under addition and closed under scalar multiplication. Throughout this paper, by an R-semimodule we mean a left semimodule over a semiring R. Every semiring R is a $(\mathbb{Z}_0^+, +, \cdot)$-semimodule [9, p. 151]. An R-semimodule M is said to be *zerosumfree* if $x + y = 0$ with $x, y \in M$, then $x = 0$ and $y = 0$. An R-semimodule M is said to be *entire* if $rm = 0$ with $r \in R$, $m \in M$, then either $r = 0$ or $m = 0$.

Definition 1.3. In accordance with [4], a subsemimodule N of an R-semimodule M is termed *subtractive* (or a k-subsemimodule) whenever the conditions $x, x + y \in N$ with $y \in M$ force y to lie in N.

If N is a proper subsemimodule of an R-semimodule M, then we denote $(N :_R M) = \{r \in R : rM \subseteq N\}$ and clearly $(N :_R M)$ is an ideal of R. Also, $(N :_R m) = \{r \in R : rm \in N\}$, where $m \in M$, is an ideal of R.

Definition 1.4. A proper subsemimodule N of an R-semimodule M is said to be *2-absorbing* if for any $a, b \in R$ and $m \in M$ with $abm \in N$, at least one of the following holds: $am \in N$, $bm \in N$, or $ab \in (N :_R M)$.

Definition 1.5. Following [11], a proper subsemimodule N of an R-semimodule M is called *3-absorbing* whenever $abcm \in N$ for $a, b, c \in R$ and $m \in M$ guarantees that $abm \in N$, $acm \in N$, $bcm \in N$, or $abc \in (N :_R M)$.

Definition 1.6. A subsemimodule N of M is called *partitioning* (or a Q-subsemimodule) if there exists a subset $Q \subseteq M$ such that:

(1) $M = \cup\{q + N : q \in Q\}$;
(2) for $q_1, q_2 \in Q$, $(q_1 + N) \cap (q_2 + N) \neq \emptyset$ if and only if $q_1 = q_2$.

If N is a partitioning subsemimodule of an R-semimodule M, then $M/N_{(Q)} = \{q + N : q \in Q\}$ forms an R-semimodule under the operations $(q_1+N)\oplus(q_2+N) = q_3+N$ and $r\odot(q_1+N) = q_4+N$ where $q_3 \in Q$ is the unique element such that $q_1 + q_2 + N \subseteq q_3 + N$ and $q_4 \in Q$ is the unique element such that $rq_1 + N \subseteq q_4 + N$. This R-semimodule $M/N_{(Q)}$ is called the *quotient semimodule* of M by N (cf. [4]).

Here, we list some results that we need throughout the paper.

Lemma 1.7 ([5], Lemma 2.10)**.** *Let I be a subtractive ideal of a semiring R and* rad I *denote the radical of I. If $a \in I$, $a + b \in$* rad I*, then $b \in$* rad I*.*

Lemma 1.8 ([5], Lemma 1.2)**.** *If N is a subtractive subsemimodule of an R-semimodule M and $m \in M$, then*

(1) *$(N :_R M)$ is a subtractive ideal of R.*
(2) *$(N :_R m) = \{r \in R : rm \in N\}$ is a subtractive ideal of R.*

Lemma 1.9 ([4], Lemma 1.4)**.** *Let N be a subsemimodule of M and $x, y \in M$ such that $x + N \subseteq y + N$. Then for all $z \in M$ and $r \in R$, $x + z + N \subseteq y + z + N$, and $rx + N \subseteq ry + N$.*

Lemma 1.10 ([4], Lemma 3.4)**.** *Let N be a Q-subsemimodule of M. For each $x \in M$, there exists a unique $q \in Q$ such that $x + N \subseteq q + N$. Hence $x = q + a$ for some $a \in N$.*

Theorem 1.11 ([4])**.** *Let N be a Q-subsemimodule of M and let A be a subtractive subsemimodule of M with $N \subseteq A$. Then:*

(1) *N is a $(Q \cap A)$-subsemimodule of A.*
(2) *$A/N_{(Q\cap A)} = \{q + N : q \in Q \cap A\}$ is a subtractive subsemimodule of $M/N_{(Q)}$.*

2. Classical 2-absorbing subsemimodules

In this section, we extend some definitions and results of H. Mostafanasab, Ü. Tekir and K. H. Oral [10] to semimodules over semirings.

Definition 2.1. Following the definition from [10], we define a proper subsemimodule N of an R-semimodule M to be a *classical 2-absorbing subsemimodule* if $abcm \in N$, for any $a, b, c \in R$ and $m \in M$, then $abm \in N$, or $acm \in N$, or $bcm \in N$.

Definition 2.2. A proper subsemimodule N of M is called *classical prime* if $abm \in N$ implies $am \in N$ or $bm \in N$.

Clearly, every classical prime subsemimodule is a classical 2-absorbing subsemimodule. However, in general, the converse is not true.

Example 2.3. Let p be prime. The zero subsemimodule of the $\mathbb{Z}_0^+$-semimodule $\mathbb{Z}_{p^2}$ is classical 2-absorbing: if $abc\overline{x} = 0$ then $p^2 \mid abcx$, so two of a, b, c are multiples of p.

Example 2.4. For distinct primes p, q, the zero subsemimodule of the $\mathbb{Z}_0^+$-semimodule $\mathbb{Z}_p \oplus \mathbb{Z}_q$ is classical 2-absorbing but not classical prime.

Proposition 2.5. *Let N be a proper subtractive subsemimodule of an R-semimodule M.*

(i) *If N is a 2-absorbing subsemimodule of M, then N is a classical 2-absorbing subsemimodule of M.*

(ii) *N is a classical prime subsemimodule of M if and only if N is a 2-absorbing subsemimodule of M and $(N :_R M)$ is a prime ideal of R.*

Proof. (i) Assume N is 2-absorbing. Let $a, b, c \in R$ and $m \in M$ such that $abcm \in N$. Applying the 2-absorbing property to $a(bc)m \in N$, we obtain $am \in N$ or $bcm \in N$ or $abc \in (N :_R M)$.

- If $am \in N$, then $abm = b(am) \in N$.
- If $bcm \in N$, we are done.
- If $abc \in (N :_R M)$, we apply the 2-absorbing property to $(ab)cm \in N$. Then $abm \in N$ or $cm \in N$ or $abc \in (N :_R M)$. If $abm \in N$, done. If $cm \in N$, then $acm = a(cm) \in N$ and $bcm = b(cm) \in N$, so done. The remaining alternative $abc \in (N :_R M)$ is the case already assumed.

Hence N is classical 2-absorbing.

(ii) Suppose N is classical prime. Taking $c = 1$ in the definition of classical 2-absorbing gives that N is 2-absorbing. To see that $(N :_R M)$ is prime, let $a, b \in R$ with $ab \in (N :_R M)$. Then $abm \in N$ for all $m \in M$. Since N is classical prime, for each $m \in M$ we have $am \in N$ or $bm \in N$. Assume that $a \notin (N :_R M)$. Then there exists $m_1 \in M$ with $am_1 \notin N$. For any $m \in M$, if $bm \notin N$, then $am \in N$. Since $ab(m + m_1) \in N$ and N is classical prime, either $a(m + m_1) \in N$ or $b(m + m_1) \in N$. The first alternative, together with $am \in N$ and subtractivity of N, yields $am_1 \in N$, a contradiction. The second alternative, together with $bm_1 \in N$ (which follows from $abm_1 \in N$ and $am_1 \notin N$), yields $bm \in N$ by subtractivity of N. Hence $bm \in N$ for all $m \in M$, so $b \in (N :_R M)$. Thus $(N :_R M)$ is prime.

Conversely, suppose N is 2-absorbing and $(N :_R M)$ is prime. Let $abm \in N$ with $am \notin N$ and $bm \notin N$. By the 2-absorbing property, $ab \in (N :_R M)$. Since $(N :_R M)$ is prime, $a \in (N :_R M)$ or $b \in (N :_R M)$, giving $am \in N$ or $bm \in N$, a contradiction. Hence N is classical prime. □

The following example shows that the converse of Proposition 2.5 (i) is not true.

Example 2.6. Let $R = \mathbb{Z}_0^+$ and $M = \mathbb{Z}_p \oplus \mathbb{Z}_q \oplus \mathbb{Z}_0^+$, where p, q are distinct primes. The zero subsemimodule $N = \{(0, 0, 0)\}$ of an R-semimodule M is classical 2-absorbing subsemimodule, as if $abcm = 0$ in M, then $p \mid abcm$ and $q \mid abcm$, which forces one of abm, acm, bcm to be zero. However, N is not 2-absorbing sunbsemimodule as if we take $a = p$, $b = q$, $m = (1, 1, 0)$; then $abm = 0 \in N$, but $am \neq 0$, $bm \neq 0$, and $ab = pq \notin (N :_R M)$.

Proposition 2.7. *Let M be an R-semimodule and N_1, N_2 be classical prime subsemimodules of M. Then $N_1 \cap N_2$ is a classical 2-absorbing subsemimodule of M.*

Proof. Let $a, b, c \in R$ and $m \in M$ such that $abcm \in N_1 \cap N_2$. We must show that $abm \in N_1 \cap N_2$ or $acm \in N_1 \cap N_2$ or $bcm \in N_1 \cap N_2$. Since $abcm \in N_1$ and N_1 is classical prime, either $abm \in N_1$ or $cm \in N_1$.

- If $abm \in N_1$, then since $abcm \in N_2$ and N_2 is classical prime, either $abm \in N_2$ (in which case $abm \in N_1 \cap N_2$ and we are done) or $cm \in N_2$. If $cm \in N_2$, then $cm \in N_1 \cap N_2$, so $acm = a(cm) \in N_1 \cap N_2$ (since $N_1 \cap N_2$ is a subsemimodule).
- If $cm \in N_1$, then since $abcm \in N_2$ and N_2 is classical prime, either $abm \in N_2$ or $cm \in N_2$. If $cm \in N_2$, then $cm \in N_1 \cap N_2$, so $bcm = b(cm) \in N_1 \cap N_2$. If $abm \in N_2$, then $abm \in N_1 \cap N_2$.

In all cases, at least one of abm, acm, bcm lies in $N_1 \cap N_2$. Hence $N_1 \cap N_2$ is classical 2-absorbing. □

Theorem 2.8. *Let M be an R-semimodule and N, a proper subtractive subsemimodule of M. The following conditions are equivalent:*

(i) *N is classical 2-absorbing;*
(ii) *For every $a, b, c \in R$, $(N :_M abc) = (N :_M ab) \cup (N :_M ac) \cup (N :_M bc)$;*
(iii) *For every $a, b \in R$ and $m \in M$ with $abm \notin N$, $(N :_R abm) = (N :_R am) \cup (N :_R bm)$;*
(iv) *For every $a, b \in R$ and $m \in M$ with $abm \notin N$, $(N :_R abm) = (N :_R am)$ or $(N :_R abm) = (N :_R bm)$;*
(v) *For every $a, b \in R$, every ideal I of R, and $m \in M$ with $abIm \subseteq N$, either $abm \in N$ or $aIm \subseteq N$ or $bIm \subseteq N$;*
(vi) *For every $a \in R$, every ideal I of R, and $m \in M$ with $aIm \nsubseteq N$, $(N :_R aIm) = (N :_R am)$ or $(N :_R aIm) = (N :_R Im)$;*
(vii) *For every $a \in R$, ideals I, J of R, and $m \in M$ with $aIJm \subseteq N$, either $aIm \subseteq N$ or $aJm \subseteq N$ or $IJm \subseteq N$;*
(viii) *For every ideals I, J of R and $m \in M$ with $IJm \nsubseteq N$, $(N :_R IJm) = (N :_R Im)$ or $(N :_R IJm) = (N :_R Jm)$;*
(ix) *For every ideals I, J, K of R and $m \in M$ with $IJKm \subseteq N$, either $IJm \subseteq N$ or $IKm \subseteq N$ or $JKm \subseteq N$;*
(x) *For every $m \in M \setminus N$, $(N :_R m)$ is a 2-absorbing ideal of R.*

Proof. (i) ⇒ (ii): Suppose N is classical 2-absorbing. Let $m \in (N :_M abc)$. Then $abcm \in N$. Hence $abm \in N$ or $acm \in N$ or $bcm \in N$. Therefore $m \in (N :_M ab)$ or $m \in (N :_M ac)$ or $m \in (N :_M bc)$. Consequently, $(N :_M abc) = (N :_M ab) \cup (N :_M ac) \cup (N :_M bc)$.

(ii) ⇒ (iii): Let $abm \notin N$ for some $a, b \in R$ and $m \in M$. Assume $x \in (N :_R abm)$. Then $abxm \in N$, so $m \in (N :_M abx)$. Since $abm \notin N$, $m \notin (N :_M ab)$. By (ii), $m \in (N :_M ax)$ or $m \in (N :_M bx)$, so $x \in (N :_R am)$ or $x \in (N :_R bm)$. Therefore $(N :_R abm) = (N :_R am) \cup (N :_R bm)$.

(iii) ⇒ (iv): By the fact that if an ideal is the union of two subtractive ideals, then it is equal to one of them (Lemma 1.7 and the property of subtractive ideals in a semiring).

(iv) ⇒ (v): Let $abIm \subseteq N$ for some $a, b \in R$, an ideal I of R, and $m \in M$. Then $I \subseteq (N :_R abm)$. If $abm \in N$, we are done. Assume $abm \notin N$. By (iv), $I \subseteq (N :_R am)$ or $I \subseteq (N :_R bm)$, so $aIm \subseteq N$ or $bIm \subseteq N$.

(v) ⇒ (i): This is immediate by taking $I = R$.

(ii) ⇔ (x): By the fact that $(N :_M abc) = (N :_M ab) \cup (N :_M ac) \cup (N :_M bc)$ for all $a, b, c \in R$ if and only if $(N :_R m)$ is a 2-absorbing ideal of R for every $m \in M \setminus N$. This follows from the definition of $(N :_M a) = \{m \in M : am \in N\}$ and the fact that $m \in (N :_M a)$ if and only if $a \in (N :_R m)$.

The implications (v) ⇒ (vi) ⇒ (vii) ⇒ (viii) ⇒ (ix) ⇒ (i) follow by similar reductions to ideals, as in the module case, using the subtractivity of N and the fact that $(N :_R aIm)$ and $(N :_R am)$ are subtractive ideals. Specifically, (vi) is obtained from (v) by setting $I = Rx$ for $x \in I$; (vii) is obtained by applying (vi) to the ideal J; (viii) is obtained by applying (vii) to I and J; (ix) is obtained by applying (viii) to K; and (ix) ⇒ (i) by taking $I = Ra$, $J = Rb$, $K = Rc$. □

Corollary 2.9. *Let R be a semiring and I, a proper ideal of R.*

(i) *I is a classical 2-absorbing subsemimodule of R if and only if I is a 2-absorbing ideal of R.*

(ii) *Every proper ideal of R is 2-absorbing if and only if for every R-semimodule M and every proper subsemimodule N of M, N is a classical 2-absorbing subsemimodule of M.*

Proof. (i) If I is classical 2-absorbing in R, then by Theorem 2.8(x), $(I :_R 1) = I$ is a 2-absorbing ideal of R. The converse follows from Proposition 2.5(i).

(ii) Assume every proper ideal of R is 2-absorbing. Let N be a proper subsemimodule of M. For every $m \in M \setminus N$, $(N :_R m)$ is a proper ideal of R, so it is 2-absorbing. Hence by Theorem 2.8(x), N is classical 2-absorbing. The converse follows from part (i). □

Proposition 2.10. *Let M be an R-semimodule and $\{K_i \mid i \in I\}$ be a chain of classical 2-absorbing subsemimodules of M. Then $\bigcap_{i\in I} K_i$ is a classical 2-absorbing subsemimodule of M.*

Proof. Suppose $abcm \in \bigcap_{i\in I} K_i$ for some $a, b, c \in R$ and $m \in M$. Assume that $abm \notin \bigcap_{i\in I} K_i$ and $acm \notin \bigcap_{i\in I} K_i$. Then there exist $t, l \in I$ such that $abm \notin K_t$ and $acm \notin K_l$. Since the family is a chain, we may assume $K_l \subseteq K_l$ (or vice versa). Without loss of generality, let $K_l \subseteq K_l$. Then $abm \notin K_l$ and $acm \notin K_l$. Since $abcm \in K_l$ and K_l is classical 2-absorbing, $bcm \in K_l$. For any $j \in I$, if $K_j \subseteq K_l$, then $bcm \in K_j$; if $K_l \subseteq K_j$, then since $abm \notin K_l$, it follows that $abm \notin K_j$ (otherwise $abm \in K_l$). Similarly $acm \notin K_j$. Thus $abcm \in K_j$ and K_j is classical 2-absorbing, so $bcm \in K_j$. Hence $bcm \in \bigcap_{i\in I} K_i$. Therefore $\bigcap_{i\in I} K_i$ is classical 2-absorbing. □

Corollary 2.11. *Every classical 2-absorbing subsemimodule of M contains a minimal classical 2-absorbing subsemimodule of M.*

Proof. Let L be a classical 2-absorbing subsemimodule of M. Let us consider the following set

$$\Omega = \{K \mid K \text{ is classical 2-absorbing in } M \text{ and } K \subseteq L\}$$

If $\{K_i : i \in I\}$ is a chain in Ω, then $\bigcap_{i\in I} K_i \in \Omega$ by Proposition 2.10. By Zorn's Lemma, Ω contains a minimal member, which is a minimal classical 2-absorbing subsemimodule of M. □

Proposition 2.12. *Let R be a semiring and N a proper subsemimodule of M. Then N is classical 2-absorbing if and only if N is 3-absorbing and $(N :_R M)$ is a 2-absorbing ideal of R.*

Proof. If N is classical 2-absorbing, then by Definition 1.5, taking $abc \in (N :_R M)$ it is easily seen that N satisfies the 3-absorbing condition verbatim. Also, $(N :_R M)$ is 2-absorbing by Theorem 2.8 (5) with $m \in M \setminus N$.

Conversely, let $abcm \in N$ with $abm, acm, bcm \notin N$. Since N is 3-absorbing, we must have $abc \in (N :_R M)$ (as the other three alternatives of Definition 1.5 are excluded by hypothesis). Since $(N :_R M)$ is 2-absorbing, one of ab, ac, bc lies in $(N :_R M)$, giving $abm \in N$, $acm \in N$ or $bcm \in N$, a contradiction. Hence N is classical 2-absorbing. □

We recall from [6] that a 2-absorbing ideal I satisfies either $\sqrt{I} = P$ with P prime, or $\sqrt{I} = P_1 \cap P_2$ with P_1, P_2 the only distinct minimal primes of I.

Lemma 2.13. *Let R be a commutative semiring with identity and I, a 2-absorbing ideal of R. Suppose that $\sqrt{I} = P$ is a prime ideal of R and $I \neq P$. For each $x \in P \setminus I$, let $(I :_R x) = \{y \in R \mid yx \in I\}$. Then:*

(1) *$(I :_R x)$ is a prime ideal of R containing P.*

(2) *For every $x, y \in P \setminus I$, either $(I :_R y) \subseteq (I :_R x)$ or $(I :_R x) \subseteq (I :_R y)$.*

Proof. (1) We first show that $P \subseteq (I :_R x)$. Since $P = \sqrt{I}$, for every $p \in P$ there exists $n \geq 1$ with $p^n \in I$. We claim that $P^2 \subseteq I$. Let $p, q \in P$, and choose $m, n \geq 1$ such that $p^m, q^n \in I$. Since I is 2-absorbing, a straightforward induction on $m+n$ shows that $pq \in I$; hence $P^2 \subseteq I$. Now, for any $p \in P$ and $x \in P$, we have $px \in P^2 \subseteq I$, so $p \in (I :_R x)$. Thus $P \subseteq (I :_R x)$. To see that $(I :_R x)$ is prime, let $y, z \in R$ with $yz \in (I :_R x)$, i.e., $yzx \in I$. Since I is 2-absorbing, we have $yx \in I$, $zx \in I$, or $yz \in I$. In the first two cases, $y \in (I :_R x)$ or $z \in (I :_R x)$. In the third case, $yz \in I \subseteq P$ and P is prime, so $y \in P \subseteq (I :_R x)$ or $z \in P \subseteq (I :_R x)$. Hence $(I :_R x)$ is prime.

(2) Let $x, y \in P \setminus I$. Suppose, for contradiction, that neither inclusion holds. Then there exist $z \in (I :_R x) \setminus (I :_R y)$ and $w \in (I :_R y) \setminus (I :_R x)$. Thus $zx \in I$ and $wy \in I$, while $zy \notin I$ and $wx \notin I$. Since $z \in (I :_R x)$ and $w \in (I :_R y)$, we have

$$xzw = w(zx) \in I \quad \text{and} \quad yzw = z(wy) \in I.$$

Hence $(x+y)zw = xzw + yzw \in I$. Applying the 2-absorbing property to the product $(x+y)\cdot z \cdot w \in I$, we obtain $(x+y)z \in I$, or $(x+y)w \in I$, or $zw \in I$. If $(x+y)z \in I$, then $xz + yz \in I$. Since $xz \in I$ and I is subtractive, $yz \in I$, a contradiction. If $(x+y)w \in I$, then $xw + yw \in I$; since $yw \in I$ and I is subtractive, $xw \in I$, a contradiction. Finally, if $zw \in I \subseteq P$ and P is prime, then $z \in P$ or $w \in P$. But $z \notin P$ (as $z \in (I :_R x) \setminus (I :_R y)$ and $P \subseteq (I :_R y)$), and $w \notin P$ (as $w \in (I :_R y) \setminus (I :_R x)$ and $P \subseteq (I :_R x)$), a contradiction.

In all cases we reach a contradiction. Hence $(I :_R y) \subseteq (I :_R x)$ or $(I :_R x) \subseteq (I :_R y)$. □

Lemma 2.14. *Let R be a commutative semiring with identity and I a 2-absorbing ideal of R. Suppose that $\sqrt{I} = P_1 \cap P_2$, where P_1 and P_2 are the only nonzero distinct prime ideals of R that are minimal over I. For each $x \in \sqrt{I} \setminus I$, let $(I :_R x) = \{y \in R \mid yx \in I\}$. Then $(I :_R x)$ is a prime ideal of R containing P_1 and P_2. Furthermore, for every $x, y \in \sqrt{I} \setminus I$, either $(I :_R y) \subseteq (I :_R x)$ or $(I :_R x) \subseteq (I :_R y)$.*

Proof. Let $x \in \sqrt{I} \setminus I$. Since $P_1^2 \subseteq I$ and $P_2^2 \subseteq I$ (by adapting the standard induction for 2-absorbing ideals with prime radical), we have $xP_1 \subseteq P_1^2 \subseteq I$ and $xP_2 \subseteq P_2^2 \subseteq I$. Thus $P_1 \subseteq (I :_R x)$ and $P_2 \subseteq (I :_R x)$. To show that $(I :_R x)$ is prime, let $y, z \in R$ with $yz \in (I :_R x)$, i.e., $yzx \in I$. Since $P_1 \subseteq (I :_R x)$ and $P_2 \subseteq (I :_R x)$, we may assume $y, z \notin P_1$ and $y, z \notin P_2$; otherwise $y \in (I :_R x)$ or $z \in (I :_R x)$ follows immediately. Thus $yz \notin P_1 \cap P_2 = \sqrt{I}$, and in particular $yz \notin I$. Since I is 2-absorbing and $yzx \in I$, we must have $yx \in I$ or $zx \in I$. Hence $y \in (I :_R x)$ or $z \in (I :_R x)$, so $(I :_R x)$ is prime. For the comparability, let $x, y \in \sqrt{I} \setminus I$. Suppose, for contradiction, that neither inclusion holds. Then there exist $z \in (I :_R x) \setminus (I :_R y)$ and $w \in (I :_R y) \setminus (I :_R x)$. As in the proof of Lemma 2.13, we obtain $(x+y)zw \in I$. Applying the 2-absorbing property to $(x+y)zw$ yields three cases:

- If $(x+y)z \in I$, then $xz + yz \in I$. Since $xz \in I$ and I is subtractive, $yz \in I$, contradicting $z \notin (I :_R y)$.
- If $(x+y)w \in I$, then $xw + yw \in I$. Since $yw \in I$ and I is subtractive, $xw \in I$, contradicting $w \notin (I :_R x)$.
- If $zw \in I$, then $zw \in \sqrt{I} = P_1 \cap P_2$. Since P_1 and P_2 are prime, and $z, w \notin P_1$ and $z, w \notin P_2$ (as argued above), we reach a contradiction.

Hence either $(I :_R y) \subseteq (I :_R x)$ or $(I :_R x) \subseteq (I :_R y)$. □

Corollary 2.15. *Let N be classical 2-absorbing in M, $m \in M \setminus N$, and $\sqrt{(N :_R m)} = P$ a prime ideal with $(N :_R m) \neq P$. Then for each $x \in \sqrt{(N :_R m)} \setminus (N :_R m)$, $(N :_R xm)$ is a prime ideal containing P, and any two such ideals are comparable by inclusion.*

Proof. Since N is classical 2-absorbing in M and $m \in M \setminus N$, Theorem 2.8 (5) gives that $I := (N :_R m)$ is a 2-absorbing ideal of R. By hypothesis, $\sqrt{I} = P$ is a prime ideal and $I \neq P$. We invoke the Lemma 2.13 for 2-absorbing ideals whose radical is prime.

Now take $x \in \sqrt{(N :_R m)} \setminus (N :_R m) = P \setminus I$. We identify

$$(N :_R xm) = \{r \in R : rxm \in N\} = \{r \in R : rx \in (N :_R m)\} = (I :_R x).$$

Thus, by Lemma 2.13, $(N :_R xm) = (I :_R x)$ is a prime ideal of R containing $P = \sqrt{I}$. Moreover, for any two such elements $x, y \in P \setminus I$, the ideals $(N :_R xm) = (I :_R x)$ and $(N :_R ym) = (I :_R y)$ are comparable by inclusion. This completes the proof. □

Corollary 2.16. *Let N be classical 2-absorbing in M, $m \in M \setminus N$, and $\sqrt{(N :_R m)} = P_1 \cap P_2$ with P_1, P_2 the only nonzero distinct prime ideals minimal over $(N :_R m)$. Then for each $x \in \sqrt{(N :_R m)} \setminus (N :_R m)$, $(N :_R xm)$ is a prime ideal containing P_1 and P_2, and any two such ideals are comparable by inclusion.*

Proof. Since N is classical 2-absorbing in M and $m \in M \setminus N$, Theorem 2.8 (5) gives that $I := (N :_R m)$ is a 2-absorbing ideal of R. By hypothesis, $\sqrt{I} = P_1 \cap P_2$ where P_1, P_2 are the only nonzero distinct prime ideals minimal over I. We invoke the Lemma 2.14 for 2-absorbing ideals whose radical is an intersection of two primes. Now take $x \in \sqrt{(N :_R m)} \setminus (N :_R m) = \sqrt{I} \setminus I$. As in the proof of Corollary 2.15, we identify

$$(N :_R xm) = (I :_R x).$$

By Lemma 2.14, $(N :_R xm) = (I :_R x)$ is a prime ideal of R containing both P_1 and P_2. Moreover, for any two such elements $x, y \in \sqrt{I} \setminus I$, the ideals $(N :_R xm) = (I :_R x)$ and $(N :_R ym) = (I :_R y)$ are comparable by inclusion. This completes the proof. □

3. Classical 2-absorbing subsemimodule in quotient semimodule

In this section N is a Q-subsemimodule of M and P is a subtractive subsemimodule of M with $N \subseteq P$.

Lemma 3.1 ([4]). *For every subtractive A containing N, the subsemimodule N is a $Q \cap A$-subsemimodule of A and $A/N_{(Q\cap A)}$ is a subtractive subsemimodule of $M/N_{(Q)}$.*

Lemma 3.2 ([4]). *Every subtractive subsemimodule of $M/N_{(Q)}$ has the form $P/N_{(Q\cap P)}$ for some subtractive subsemimodule P of M with $N \subseteq P$.*

Lemma 3.3. *For $r \in R$ and $m \in M$ there is a unique $q \in Q$ with $rm \in r \odot (q + N)$.*

Proof. Choose $q, q' \in Q$ with $m + N \subseteq q + N$ and $rm + N \subseteq q' + N$, and let $q'' \in Q$ satisfy $rq + N \subseteq q'' + N$. By Lemma 1.9, $rm + N \subseteq rq + N \subseteq q'' + N$, so $q' = q''$. □

Theorem 3.4. *P is classical 2-absorbing in M if and only if $P/N_{(Q\cap P)}$ is classical 2-absorbing in $M/N_{(Q)}$.*

Proof. By Lemma 3.1, $P/N_{(Q\cap P)}$ is a subtractive subsemimodule of $M/N_{(Q)}$.

($\Rightarrow$) Let $r_1, r_2, r_3 \in R$ and $q + N \in M/N_{(Q)}$ with $r_1 \odot r_2 \odot r_3 \odot (q + N) = q_1 + N \in P/N_{(Q\cap P)}$. Then $r_1r_2r_3q = q_1 + n_1$ with $n_1 \in N \subseteq P$, so $r_1r_2r_3q \in P$. Since P is classical 2-absorbing, one of r_1r_2q, r_1r_3q, r_2r_3q lies in P; say $r_1r_2q \in P$. By Lemma 3.3, $r_1r_2q \in r_1 \odot r_2 \odot (q + N) = q_{12} + N$ with $q_{12} \in Q$, and subtractivity of P gives $q_{12} \in Q \cap P$. Hence $r_1 \odot r_2 \odot (q + N) \in P/N_{(Q\cap P)}$.

($\Leftarrow$) Let $a, b, c \in R$ and $x \in M$ with $abcx \in P$. Choose $q \in Q$ with $x \in q + N$. Then $abcx \in a \odot b \odot c \odot (q + N) = q_1 + N$ with $q_1 \in Q \cap P$, so $a \odot b \odot c \odot (q + N) \in P/N_{(Q\cap P)}$. Since the quotient is classical 2-absorbing, one of $a \odot b \odot (q + N)$, $a \odot c \odot (q + N)$, $b \odot c \odot (q + N)$ lies in $P/N_{(Q\cap P)}$; say the first. Then $abx \in a \odot b \odot (q + N) \subseteq P$. Hence P is classical 2-absorbing in M. □

Corollary 3.5. *If I is a Q-ideal of R and P a subtractive ideal of R with $I \subseteq P$, then P is a 2-absorbing ideal of R if and only if $P/I_{(Q\cap P)}$ is a 2-absorbing ideal of $R/I_{(Q)}$.*

Theorem 3.6. *The following are equivalent:*

(1) P *is classical 2-absorbing in* M*;*
(2) $P/N_{(Q\cap P)}$ *is classical 2-absorbing in* $M/N_{(Q)}$*;*
(3) $(P :_M r^3) = (P :_M r^2)$ *for every* $r \in R$ *with* $r^3 \notin (P :_R M)$*;*
(4) $(P/N_{(Q\cap P)} : r^3) = (P/N_{(Q\cap P)} : r^2)$ *in* $M/N_{(Q)}$ *for every such* r*.*

Proof. (1)⇔(2) is Theorem 3.4. (1)⇔(3) is Theorem 2.8(v) with $a = b = c = r$. (2)⇔(4) is the same characterization applied in the quotient. □

Theorem 3.7. *If* P *is classical 2-absorbing in* M*, then for all* $a, b, c \in R$ *and* $m \in M$*,*

$(P/N_{(Q\cap P)} : abc(m+N)) = (P/N_{(Q\cap P)} : ab(m+N)) \cup (P/N_{(Q\cap P)} : ac(m+N)) \cup (P/N_{(Q\cap P)} : bc(m+N))$,

all annihilators being taken in $M/N_{(Q)}$*.*

Proof. This is the annihilator characterization applied in the quotient $M/N_{(Q)}$, using Theorem 3.4. Concretely, $r \in (P/N_{(Q\cap P)} : abc(m+N)) \Leftrightarrow abcr(m+N) \in P/N_{(Q\cap P)} \Leftrightarrow abcrm \in P$, which by the classical 2-absorbing property of P applied to the element $rm \in M$ is equivalent to $abrm \in P$ or $acrm \in P$ or $bcrm \in P$. □

Corollary 3.8. P *is a classical prime subsemimodule in* M *if and only if* $P/N_{(Q\cap P)}$ *is a classical prime subsemimodule in the quotient semimodule* $M/N_{(Q)}$*.*

Corollary 3.9. *If* $P/N_{(Q\cap P)}$ *is a minimal classical 2-absorbing subsemimodule of* $M/N_{(Q)}$*, then* P *is a minimal classical 2-absorbing subsemimodule of* M*.*

Proof. By Theorem 3.4, we have P is classical 2-absorbing. If $N \subseteq K \subseteq P$ and K is classical 2-absorbing in M, then $K/N_{(Q\cap K)}$ is classical 2-absorbing in $M/N_{(Q)}$ and contained in $P/N_{(Q\cap P)}$; minimality forces equality, hence $K = P$. □

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

डिजिटल बँकिंग आणि किरकोळ बाजार: एक विश्लेषणात्मक अध्ययन

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DOI - 10.5281/zenodo.24339209

सारांश:

भारतीय अर्थव्यवस्थेत डिजिटल बँकिंग आणि डिजिटल पेमेंट पद्धतींचा (UPI, QR Code, Mobile Wallets) वापर वेगाने वाढत आहे. प्रस्तुत संशोधनपर लेखात डिजिटल बँकिंगचा किरकोळ बाजारपेठेवर, किरकोळ व्यापाऱ्यांवर आणि ग्राहकांच्या खरेदीवर झालेल्या परिणामांचा विश्लेषणात्मक अभ्यास करण्यात आला आहे. हा संशोधनपर लेख दुय्यम माहितीवर आधारित असून यासाठी रिझर्व्ह बँक ऑफ इंडिया, NPCI, विविध सरकारी अहवाल आणि प्रकाशित संशोधनपर लेखांचा वापर करण्यात आला आहे. संशोधनातून असे दिसून येते की, डिजिटल बँकिंगमुळे किरकोळ व्यापाऱ्यांच्या विक्रीत वाढ झाली असून व्यवहारातील पारदर्शकता आणि सुलभता वाढली आहे.

मुख्य शब्द: डिजिटल बँकिंग, किरकोळ बाजार, UPI, फिनटेक, ग्राहक व्यवहार, आर्थिक समावेशन.

प्रस्तावना:

भारतीय अर्थव्यवस्थेत किरकोळ बाजार हा अत्यंत महत्त्वाचा आणि रोजगाराच्या दृष्टीने व्यापक असा घटक आहे. आधी किरकोळ व्यापारातील बहुतांश व्यवहार रोख रकमेच्या माध्यमातून पार पडत असत. मात्र, गेल्या काही वर्षांत झालेल्या तंत्रज्ञानाच्या विकासामुळे आणि डिजिटल इंडिया अभियानामुळे भारतीय बँकिंग क्षेत्रात आणि किरकोळ बाजारात क्रांतिकारी बदल घडून आले आहेत. विशेषतः UPI, QR Code, साऊंड-बॉक्स आणि ONDC (Open Network for Digital Commerce) यांसारख्या आधुनिक डिजिटल बँकिंग आणि पेमेंट तंत्रज्ञानाने किरकोळ व्यापाऱ्यांचे आणि ग्राहकांचे खरेदी-विक्रीचे स्वरूप पूर्णपणे बदलून टाकले आहे. आज फक्त मोठे मॉल्स किंवा सुपरमार्केट्सच नव्हे, तर लहान किरकोळ व्यावसायिक, भाजी विक्रेते आणि किराणा व्यावसायिकदेखील डिजिटल बँकिंग सुविधांचा मोठ्या प्रमाणावर वापर करत आहेत. डिजिटल बँकिंगमुळे किरकोळ व्यापाऱ्यांची उधारी व थकबाकीची समस्या कमी होऊन बनावट नोटा आणि डिजिटल फसवणुकीपासून संरक्षण मिळाले आहे. याशिवाय, डिजिटल व्यवहारांच्या नोंदींमुळे लहान व्यापाऱ्यांना बँकिंग प्रणालीतून सहज कर्ज उपलब्ध होणे आणि ONDC मुळे ई-कॉमर्स कंपन्यांशी स्पर्धा करणे शक्य झाले आहे. प्रस्तुत संशोधन हे डिजिटल बँकिंगचा किरकोळ बाजार, व्यापाऱ्यांची कार्यक्षमता आणि

वित्तीय समावेशन यावर झालेल्या सकारात्मक प्रभावाचे विश्लेषणात्मक अध्ययन करते.

गेल्या काही वर्षांत भारतामध्ये तंत्रज्ञानाच्या विकासामुळे वित्तीय क्षेत्रात क्रांती घडून आली आहे. केंद्र सरकारची 'डिजिटल इंडिया' मोहीम आणि नॅशनल पेमेंट्स कॉर्पोरेशन ऑफ इंडिया (NPCI) द्वारे विकसित करण्यात आलेले UPI यामुळे डिजिटल बँकिंग सर्वसामान्यांपर्यंत पोहोचले आहे. आधी किरकोळ बाजारात बहुतांश व्यवहार हे रोख स्वरूपात होत असत. मात्र आता डिजिटल बँकिंग व QR Code चा वापर केला जात आहे. या बदलामुळे किरकोळ व्यापारी आणि ग्राहक यांच्यातील व्यवहार अधिक जलद व सोपे झाले आहेत.

साहित्याचे पुनरावलोकन:

१) **Ungratwar et al. (2025) यांच्या** "Mapping the digital banking landscape: a multi-dimensional exploration of fintech, digital payments, and e-wallets, with insights into current scenarios and future research" गेल्या २० वर्षांत डिजिटल बँकिंगमध्ये प्रचंड प्रगती झाली असली तरी या विषयावर अजूनही सखोल अभ्यासाची गरज होती, आणि हीच उणीव भरून काढण्यासाठी १९८३ ते २०२० दरम्यानच्या १,९५९ रिसर्च पेपर्सचा आधुनिक तंत्रज्ञानाच्या मदतीने अभ्यास करून ATM, इंटरनेट बँकिंग, मोबाईल बँकिंग, P2P फायनान्स, क्रिप्टोकरन्सी, डिजिटल पेमेंट्स आणि फिनटेक हे ७ महत्त्वाचे भाग समोर आणले आहेत. या अभ्यासातून स्मार्टफोन नसलेल्या लोकांपर्यंत डिजिटल पेमेंट्स पोहोचवणे, बँकिंगमधील फसवणूक व धोके कमी करणे, फिनटेकची शाश्वतता आणि क्रिप्टोकरन्सीचे व्यापारीकरण यांसारख्या मुद्द्यांवर भविष्यात अधिक संशोधन करण्याची गरज अधोरेखित झाली आहे; तसेच UPI, ई-वॉलेट्स आणि मोबाईल बँकिंग यांसारख्या विषयांवर भविष्यातील संशोधनासाठी हे संशोधन महत्वाचे आहे.

२) **MS Farooq (2025)** यांच्या "AI in Fintech: An Evaluation of Financial Payment Systems" तंत्रज्ञानाच्या वाढत्या वापरामुळे आज भारतात UPI आणि डिजिटल पेमेंट्स खूप लोकप्रिय झाले आहेत, ज्यामुळे आर्थिक व्यवहार पूर्वीपेक्षा अधिक सोपे आणि जलद बनले आहेत. जरी डिजिटल व्यवहार मोठ्या प्रमाणात वाढले असले, तरी त्या तुलनेत फसवणुकीचे प्रमाण खूप कमी आहे, म्हणूनच काही आव्हाने असूनही भारतातील डिजिटल पेमेंट पद्धतींचे भविष्य चांगले आहे.

३) **Yadava et al. (2026)** यांच्या "Digital Banking Experience and Retail Customer Loyalty in Emerging Indian Cities: An Integrative Review with Implications for Ayodhya" हा संशोधन निबंध रिटेल ग्राहकांच्या निष्ठेवर डिजिटल बँकिंग सेवांच्या पडणाऱ्या सखोल प्रभावाचा अभ्यास करतो, ज्यामध्ये तीन मुख्य घटकांवर लक्ष केंद्रित केले आहे. सेवा गुणवत्ता, व्यवहार सुरक्षा आणि वैयक्तिकृत सेवा. डिजिटल बँकिंग जसजशी विकसित होत आहे, तसतसे हे घटक ग्राहकांच्या निष्ठेवर कसा प्रभाव पाडतात हे समजून घेणे वित्तीय क्षेत्रात स्पर्धात्मक टिकून राहण्यासाठी अत्यंत महत्त्वाचे आहेत. ग्राहकांच्या डिजिटल बँकिंग प्लॅटफॉर्मबाबतच्या संकल्पना आणि अनुभवांची सखोल माहिती मिळवण्यासाठी ४०० रिटेल बँकिंग ग्राहकांचे सर्वेक्षण करण्यात आले. ॲनोव्हासह वर्णनात्मक आणि अनुमानात्मक सांख्यिकी पद्धतींचा वापर करून, डिजिटल बँकिंगच्या वैशिष्ट्यांचा आणि ग्राहक निष्ठेचा परस्परसंबंधांचा अभ्यास करण्यात आला.

४) **M. Bhatt et al. (2023)** यांच्या "A Study of Customer Perception toward Digital Banking

Payments" या संशोधनपर लेखात त्यांच्या मते डिजिटल नवोपक्रम आणि माहिती तंत्रज्ञानामुळे पारंपारिक बँकिंगकडून कागदविरहित डिजिटल बँकिंगकडे होणारा बदल सातत्याने सुरू असून यामुळे बँकिंग व्यवसायाचा विकास जलद गतीने झाला आहे. या पार्श्वभूमीवर, हे वर्णनात्मक संशोधन बँकांनी दिलेल्या डिजिटल पेमेंट प्रणालीचा ग्राहकांवरील प्रभाव आणि त्यांचा दृष्टिकोन यावर आधारित आहे, ज्यामध्ये ग्राहक पेमेंट कसे करतात, खरेदीसाठी पैसे कसे देतात, ऑनलाइन व्यवहारात कोणत्या समस्या येतात आणि मिळालेल्या सेवांबद्दल ते किती समाधानी आहेत याचा ५०० ग्राहकांच्या नमुन्यावरून आणि प्रश्नावलीद्वारे गोळा केलेल्या माहितीवर ANOVA पद्धतीने संशोधन करण्यात आले आहे.

५) **AS Virdi & A. Mer (2023)** यांच्या "Fintech and Banking: An Indian Perspective" या पुस्तकात त्यांच्या मते या संशोधनात भारतीय बँकांसाठी फिनटेकच्या संधी व आव्हानांचा आढावा घेतला आहे. आज Google Pay, PhonePe, निओ बँक्स आणि इतर ॲप्समुळे नवीन कंपन्यांना मोठी संधी मिळाली आहे. बँकांपेक्षा या फिनटेक कंपन्यांवर कमी नियम असतात. त्यामुळे, बँकेत पैसे जमा ठेवण्याव्यतिरिक्त बाकी सर्व आर्थिक सेवांमध्ये या कंपन्या आज पारंपरिक बँकिंग व्यवस्थेसमोर मोठे आव्हान निर्माण करत आहेत.

फायदे:

1. व्यापाऱ्यांच्या रोख व्यवहारांऐवजी खात्यात थेट पैसे जमा होऊन उधारी व थकबाकीचे व्यवस्थापन सोपे होते.
2. किरकोळ व्यावसायिकांचा औपचारिक बँकिंगशी संपर्क वाढून त्यांना शासकीय योजना व सुलभ कर्ज मिळण्यास मदत होते.
3. ओएनडीसी मुळे लहान दुकानदारांना मोठ्या ई-कॉमर्स कंपन्यांशी (उदा. ॲमेझॉन/फ्लिपकार्ट) थेट स्पर्धा करण्याचे बळ मिळते.
4. साऊंड-बॉक्स आणि सुरक्षित ॲप्समुळे बनावट पेमेंट स्क्रीनशॉट व ऑनलाईन फसवणुकीपासून व्यापाऱ्यांचे संरक्षण होते.
5. कॅशबॅक आणि रिवॉर्ड्समुळे ग्राहकांची आर्थिक बचत होऊन त्यांची ऑनलाईन खरेदी करण्याची वारंवारता वाढते.

उद्दिष्टे:

1. डिजिटल बँकिंग व ऑनलाईन पेमेंट व्यवस्थेमुळे किरकोळ व्यापाऱ्यांच्या उधारी आणि थकबाकीच्या समस्येत झालेल्या घट विश्लेषित करणे.
2. लहान किरकोळ व्यावसायिक आणि डिजिटल बँकिंग सेवांमुळे झालेल्या वित्तीय समावेशनाचा आढावा घेणे.
3. ओएनडीसी (ONDC : Open Network for Digital Commerce) आणि डिजिटल बँकिंग प्रणालीच्या एकत्रीकरणामुळे स्थानिक किरकोळ व्यापाऱ्यांच्या स्पर्धात्मक क्षमतेतील वाढीचे विश्लेषण करणे.
4. डिजिटल बँकिंगमधील साऊंड-बॉक्स तंत्रज्ञानामुळे व्यापाऱ्यांच्या सुरक्षेत आणि डिजिटल फसवणूक रोखण्यात झालेल्या सुधारांचा शोध घेणे.
5. डिजिटल बँकिंग ॲप्सद्वारे मिळणाऱ्या कॅशबॅक आणि लॉयल्टी रिवॉर्ड्सचा (Loyalty Reward Points) ग्राहकांच्या पुनरावृत्ती खरेदीवर होणाऱ्या प्रभावाचा अभ्यास करणे.

गृहितके:

1. डिजिटल बँकिंग व पेमेंट पद्धतींमुळे किरकोळ व्यापाऱ्यांची उधारी आणि थकबाकीचे प्रमाण लक्षणीयरीत्या कमी झाले आहे.
2. डिजिटल बँकिंग सुविधांमुळे किरकोळ व्यापाऱ्यांचा औपचारिक बँकिंग क्षेत्रातील सहभाग वाढला आहे.
3. ओएनडीसी आणि डिजिटल बँकिंगच्या सोयीमुळे स्थानिक किरकोळ व्यापाऱ्यांना ई-कॉमर्स कंपन्यांशी स्पर्धा करणे अधिक सोपे झाले आहे.
4. साऊंड-बॉक्स तंत्रज्ञानाचा वापर वाढल्यामुळे किरकोळ व्यापाऱ्यांमधील बनावट स्क्रीनशॉट व डिजिटल फसवणुकीची भीती कमी झाली आहे.
5. डिजिटल बँकिंगद्वारे मिळणाऱ्या लॉयल्टी रिवॉर्ड्स आणि कॅशबॅकच्या प्रलोभनांमुळे ग्राहक सातत्याने डिजिटल पद्धतीने खरेदी करण्यास प्राधान्य देतात.

संशोधन पद्धती:

प्रस्तुत संशोधनपर लेख हा विश्लेषणात्मक आणि वर्णनात्मक स्वरूपाचा आहे. या संशोधनासाठी आवश्यक असणारी संपूर्ण माहिती ही दुय्यम स्रोतांतून संकलित करण्यात आली आहे. यामध्ये, रिझर्व्ह बँक ऑफ इंडिया (RBI) आणि NPCI चे अधिकृत अहवाल. विविध राष्ट्रीय व आंतरराष्ट्रीय संशोधन नियतकालिके, वृत्तपत्रे, प्रसिद्ध लेख आणि फिनटेक क्षेत्रातील अहवाल यांचा समावेश आहे.

माहितीचे विश्लेषण:

१) गृहीतक (Hypothesis 1): डिजिटल बँकिंग व पेमेंट पद्धतींमुळे किरकोळ व्यापाऱ्यांची उधारी आणि थकबाकीचे प्रमाण लक्षणीयरीत्या कमी झाले आहे.

तक्ता क्र. १ : डिजिटल बँकिंग व पेमेंट पद्धतींमुळे किरकोळ व्यापाऱ्यांची उधारी आणि थकबाकीचे प्रमाण लक्षणीयरीत्या कमी झाले आहे दर्शवणारा तक्ता

निकष	पारंपरिक cash युग	आधुनिक डिजिटल बँकिंग युग (२०२६)
एकूण डिजिटल व्यवहार वाढ	मूळ पातळी	११ पटीने वाढ
लहान व्यापाऱ्यांद्वारे UPI चा स्वीकार	कमी	९४% लहान व्यापारी सक्रिय
एकूण व्यवहारांमध्ये UPI चा वाटा	मर्यादित	जवळपास ८०% वाटा
व्यापाऱ्यांच्या विक्रीत/नफ्यात वाढ	अनिश्चित आणि संथ	५७% व्यापाऱ्यांच्या विक्रीत वाढ

Note. ही आकडेवारी वित्त मंत्रालयाच्या Socio-Economic Impact Analysis (2026) अधिकृत अहवालावर आधारित आहे.

माहितीचे संक्षिप्त विश्लेषण व निष्कर्ष:

वित्त मंत्रालयाच्या २०२६ च्या अहवालानुसार देशातील ९४% लहान किरकोळ व्यापाऱ्यांनी UPI स्वीकारले आहे. एकूण व्यवहारांमध्ये UPI चा वाटा जवळपास ८०% झाल्यामुळे आणि ५७% ग्राहकांनी रोख रकमेऐवजी डिजिटल पेमेंटला पसंती दिल्यामुळे किरकोळ बाजारातील पारंपारिक उधारीची पद्धत जवळपास संपुष्टात आली आहे. ग्राहकांकडे पैसे नसणे किंवा सुट्ट्या पैशांवरून

होणारी तात्पुरती उधारी आता जागीच डिजिटल पेमेंटद्वारे वसूल होते. ५७% व्यापाऱ्यांनी डिजिटल पेमेंटमुळे त्यांच्या विक्रीत वाढ झाल्याचे नोंदवले आहे. आरबीआयच्या पेमेंट रिपोर्टनुसार, डिजिटल फूटप्रिंटमुळे पैसा थेट बँक खात्यात जमा होत असल्याने थकबाकी (Bad Debts) निर्माण होण्याचा धोका नष्ट झाला आहे. RBI (२०२६)

व्यापारी वापरासाठी युपीआय क्यूआर (QR) कोड्स ९.३ कोटींवरून ६५.८ कोटींवर पोहोचले आहेत. इकोसिस्टम मजबूत: थर्ड-पार्टी ॲप्स १६ वरून ३८ झाले आहेत, तर युपीआयवर कार्यरत बँका २१६ वरून ६६१ (मार्च २०२५ पर्यंत) झाल्या आहेत. लोकांच्या सवयींत बदल: नोटांचा वापर आणि एटीएममधून पैसे काढणे कमी झाले असून, डिजिटल पेमेंट्सवर अवलंबित्व वाढले आहे.

या अधिकृत सांख्यिकीय डेटाच्या आधारे प्रथम गृहीतक स्वीकारण्यात येत आहे.

२) गृहीतक (Hypothesis 2): डिजिटल बँकिंग सुविधांमुळे लहान किरकोळ व्यापाऱ्यांचा औपचारिक बँकिंग क्षेत्रातील सहभाग वाढला आहे.

तक्ता क्र. २: डिजिटल बँकिंग सुविधांमुळे लहान किरकोळ व्यापाऱ्यांचा औपचारिक बँकिंग क्षेत्रातील सहभाग वाढला आहे दर्शवणारा तक्ता

निकष	पारंपरिक युग	आधुनिक डिजिटल बँकिंग युग (२०२६)
वित्तीय समावेशन निर्देशांक (RBI FI-Index)	६७.० (मार्च २०२५)	७०.० (मार्च २०२६)
व्यापारी QR कोड नेटवर्क	९.३ कोटी (२०२१)	जवळपास ६५.८ कोटींपेक्षा जास्त
औपचारिक सूक्ष्म-कर्ज मंजुरी (PM SVANidhi)	कमी / सावकार	१ कोटीपेक्षा जास्त किरकोळ व्यापारी जोडले
बँकिंग सुविधांची भौगोलिक उपलब्धता	मर्यादित	९९.९२% गावांमध्ये ५ किमी अंतरात सुविधा RBI (2026)

Note. ही आकडेवारी रिझर्व्ह बँक ऑफ इंडियाच्या (RBI, 2026) फायनान्शियल इनक्लुजन रिपोर्ट आणि पीआयबी (PIB, 2026) च्या अधिकृत प्रसिद्धीपत्रकावर आधारित आहे.

माहितीचे संक्षिप्त विश्लेषण व निष्कर्ष:

रिझर्व्ह बँकेचा वित्तीय समावेशन निर्देशांक (FI-Index) ७०.० वर पोहोचणे हे सिद्ध करते की तळागाळातील नागरिकांचा बँकिंग क्षेत्रातील सहभाग वेगाने वाढला आहे RBI (2026). किरकोळ व्यापाऱ्यांकडे QR कोडचे जाळे ६५.८ कोटींवर गेल्यामुळे त्यांचे रोजचे उत्पन्न थेट बँकेत जमा होत आहे. पूर्वी बँक खात्याअभावी किरकोळ व्यापारी कर्ज घेण्यासाठी इतरांवर अवलंबून असत. मात्र, डिजिटल व्यवहार आणि पीएम स्वनिधी (१ जून २०२०) सारख्या डिजिटल लिंक्ड योजनांमुळे १ कोटीहून अधिक किरकोळ व्यापाऱ्यांना औपचारिक बँकिंग प्रणालीद्वारे थेट विनातारण कर्ज मिळाले आहे RBI (2026).

या अधिकृत सांख्यिकीय डेटावरून सिद्ध होते की डिजिटल बँकिंगमुळे किरकोळ व्यापाऱ्यांचा औपचारिक

बँकिंगमधील सहभाग वाढला आहे. त्यामुळे दुसरे गृहीतक स्वीकारण्यात येत आहे.

३) गृहीतक (Hypothesis 3): ओएनडीसी (ONDC) आणि डिजिटल बँकिंगच्या सोयीमुळे स्थानिक किरकोळ व्यापाऱ्यांना ई-कॉमर्स कंपन्यांशी स्पर्धा करणे अधिक सोपे झाले आहे.

तक्ता क्र. ३ : ओएनडीसी (ONDC) आणि डिजिटल बँकिंगच्या सोयीमुळे स्थानिक किरकोळ व्यापाऱ्यांना ई-कॉमर्स कंपन्यांशी स्पर्धा करणे अधिक सोपे झाले आहे दर्शवणारा तक्ता

निकष	**पारंपरिक ई-कॉमर्स युग**	**आधुनिक ONDC व डिजिटल युग (२०२६)**
एकूण संचित व्यवहार (Cumulative Transactions)	०.२ दशलक्ष (FY23)	५०० दशलक्ष (जुलाई २०२६ पर्यंत)
सक्रिय किरकोळ व्यापारी	मोजकेच मोठे ब्रँड्स	२,००,००० पेक्षा जास्त किरकोळ व्यापारी
कमिशनचा दर	२५% ते ३५% (अवाजवी)	५% ते १०% (अत्यंत कमी)
ग्राहकांपर्यंत पोहोच	केवळ एकाच ॲपपुरती मर्यादित	१,२००+ शहरे व सर्व खरेदीदार ॲप्सवर आहेत.

स्त्रोत : ही आकडेवारी केंद्रीय वाणिज्य आणि उद्योग मंत्रालयाच्या DPIIT (August 2026) च्या संसदेतील अधिकृत अहवालावर आणि ONDC च्या अधिकृत प्रकाशनावर आधारित आहे.

माहितीचे संक्षिप्त विश्लेषण व निष्कर्ष:

पारंपरिक ई-कॉमर्स कंपन्यांच्या (उदा. Amazon, Flipkart) मक्तेदारीला मोडून काढण्यासाठी सरकारने ONDC ची निर्मिती केली. DPIIT (Department for Promotion of Industry and Internal Trade) च्या ऑगस्ट २०२६ च्या अहवालानुसार, ONDC ने ५०० दशलक्ष व्यवहारांचा टप्पा ओलांडला असून त्यावर २ लाखांहून अधिक स्थानिक किरकोळ व्यापारी सक्रिय आहेत. यामुळे स्थानिक दुकानांना मोठ्या कंपन्यांप्रमाणेच डिजिटल पोहोच मिळाली आहे. .मोठ्या कंपन्या लहान व्यापाऱ्यांकडून २५% ते ३५% कमिशन घेत असत, जे ONDC च्या खुल्या नेटवर्कमुळे ५% ते १०% वर आले आहे. यामुळे स्थानिक व्यापाऱ्यांना किंमतींच्या बाबतीत मोठ्या ई-कॉमर्स कंपन्यांशी स्पर्धा करणे शक्य झाले आहे. तसेच, पेमेंट गेटवे आणि डिजिटल बँकिंगमुळे व्यापाऱ्यांचे सेटलमेंट २४ तासांत थेट बँक खात्यात होते.

या अधिकृत सांख्यिकीय डेटावरून हे सिद्ध होते की ONDC आणि डिजिटल बँकिंगमुळे स्थानिक व्यापाऱ्यांची स्पर्धात्मक क्षमता वाढली आहे. त्यामुळे तिसरे गृहीतक स्वीकारण्यात येत आहे.

४) गृहीतक (Hypothesis 4): साऊंड-बॉक्स तंत्रज्ञानाचा वापर वाढल्यामुळे किरकोळ व्यापाऱ्यांमधील बनावट स्क्रीनशॉट व डिजिटल फसवणुकीची भीती कमी झाली आहे.

तक्ता क्र. ४ : साऊंड-बॉक्स तंत्रज्ञानाचा वापर वाढल्यामुळे किरकोळ व्यापाऱ्यांमधील बनावट स्क्रीनशॉट व डिजिटल फसवणुकीची भीती कमी झाली आहे दर्शवणारा तक्ता

निकष	**साऊंड-बॉक्स पूर्व युग (फक्त QR)**	**आधुनिक साऊंड-बॉक्स युग (२०२६)**
साऊंड-बॉक्स उपयोजन	कमी (२०२० पूर्वी)	२ कोटींहून अधिक (५ कोटींचे लक्ष्य)
झटपट आवाज पुष्टीकरण (Real-time Audio)	शून्य (केवळ SMS वर अवलंबून)	१००% व्यवहारांवर तात्काळ ऑडिओ अलर्ट
बनावट स्क्रीनशॉट फसवणूक	उच्च जोखीम	थेट खात्यात पैसे आल्याशिवाय आवाज नाही
मर्चंट क्युरेशन टॅम्परिंग (QR Sticker Tampering)	ओळखणे कठीण (फसवणुकीची भीती)	बनावट QR वर साऊंड-बॉक्सद्वारे आवाज येत नाही.

स्त्रोत: ही आकडेवारी नॅशनल पेमेंट्स कॉर्पोरेशन ऑफ इंडिया (NPCI), पीडब्ल्यूसी (PwC India Report) आणि फिनटेक बाजार अहवालांवर आधारित आहे.

माहितीचे संक्षिप्त विश्लेषण व निष्कर्ष:

साऊंड-बॉक्स बाजारात येण्यापूर्वी ग्राहक बनावट पेमेंट ॲप्सद्वारे 'बनावट स्क्रीनशॉट' दाखवून किंवा 'नेटवर्क एरर'चे कारण सांगून किरकोळ व्यापाऱ्यांची फसवणूक करत असत. NPCI आणि फिनटेक कंपन्यांच्या डेटानुसार, देशात २ कोटींहून अधिक सक्रिय साऊंड-बॉक्स कार्यरत आहेत. साऊंड-बॉक्स थेट बँकेच्या SMS आणि PSP (Payment Service Provider) पेमेंट्स प्रवाहाला ट्रॅक करतो आणि खरोखर व्यवहार झाल्यावरच आवाज करतो, ज्यामुळे स्क्रीनशॉट फसवणुकीची भीती पूर्णपणे संपली आहे. बाजारात गर्दीच्या वेळी व्यापाऱ्यांना फोन उघडून सारखा SMS तपासण्याची गरज उरलेली नाही. याशिवाय, मूळ QR कोडवर दुसरे बनावट QR चे स्टिकर चिकटवून होणाऱ्या फसवणुकीतही, साऊंड-बॉक्सचा आवाज न आल्यामुळे व्यापाऱ्याला तात्काळ चोरी समजून येते. यामुळे लहान दुकानदारांचा डिजिटल व्यवहारांवरील विश्वास वाढला आहे.

या अधिकृत डेटा आणि तांत्रिक वास्तविकतेच्या आधारे चौथे गृहीतक स्वीकारण्यात येत आहे.

५) गृहीतक (Hypothesis 5): डिजिटल बँकिंगद्वारे मिळणाऱ्या लॉयल्टी रिवॉर्ड्स आणि कॅशबॅकच्या प्रलोभनांमुळे ग्राहक सातत्याने ऑनलाईन / डिजिटल पद्धतीने खरेदी करण्यास प्राधान्य देतात.

तक्ता क्र. ५: डिजिटल बँकिंगद्वारे मिळणाऱ्या लॉयल्टी रिवॉर्ड्स आणि कॅशबॅकच्या प्रलोभनांमुळे ग्राहक सातत्याने ऑनलाईन / डिजिटल पद्धतीने खरेदी करण्यास प्राधान्य देतात दर्शवणारा तक्ता

ग्राहक निकष	पारंपरिक खरेदी पद्धत	आधुनिक डिजिटल बँकिंग युग (२०२६)
कॅशबॅकमुळे ॲप/पेमेंट निवड	कमी (०%)	५२% ग्राहकांची मुख्य प्रेरणा
सातत्याने होणारे दैनंदिन डिजिटल व्यवहार	मर्यादित	६५% युजर्सचे दिवसातून अनेकदा व्यवहार
डिजिटल पेमेंटला मिळणारे प्रोत्साहन	शून्य	७५% ग्राहक कॅशबॅकमुळे प्रोत्साहित
कॅशबॅक मार्केटचा आकार	$३.४५ अब्ज (२०२५)	$११.२२ अब्ज (२०२६ पर्यंत वाढ)

स्त्रोत: ही आकडेवारी वित्त मंत्रालयाच्या Socio-Economic Impact Analysis (February 2026) अधिकृत अहवालावर आणि भारतीय डिजिटल पेमेंट्स ग्राहक व्यवहार सर्वेक्षणावर (PwC/IRJ) आधारित आहे.

माहितीचे संक्षिप्त विश्लेषण व निष्कर्ष:

वित्त मंत्रालयाच्या २०२६ च्या अहवालानुसार, ५२% ग्राहकांनी डिजिटल पेमेंट वापरण्यामागे 'कॅशबॅक इन्सेंटीव्ह' हे मुख्य कारण असल्याचे सांगितले आहे. ग्राहकांना मिळणारे झटपट रिवॉर्ड्स त्यांच्यात 'इन्स्टंट ग्रॅटीफिकेशन' (जागेवरच मिळणारा आनंद) निर्माण करतात, ज्यामुळे ६५% युजर्स आता दिवसातून अनेक वेळा रोख रकमेऐवजी डिजिटल पद्धतीनेच व्यवहार करत आहेत. सांख्यिकीय संशोधनानुसार, ७५% ग्राहक मान्य करतात की लॉयल्टी रिवॉर्ड्स आणि कॅशबॅकमुळे ते सातत्याने डिजिटल पद्धतीकडे वळतात. भारतातील कॅशबॅक मार्केटचा आकार २०२६ मध्ये ११.२२ अब्ज डॉलर्सवर पोहोचणे हे सिद्ध करते की कंपन्या ग्राहकांना आपल्या प्लॅटफॉर्मवर टिकवून ठेवण्यासाठी या प्रलोभनांचा यशस्वी वापर करत आहेत. यामुळे ग्राहकांना डिजिटल खरेदीची एक 'सवय' लागलेली आहे.

या अधिकृत सांख्यिकीय निष्कर्षांवरून हे सिद्ध होते की रिवॉर्ड्स आणि कॅशबॅकच्या प्रलोभनांमुळे ग्राहकांचे डिजिटल खरेदीचे प्राधान्य सातत्याने वाढत आहे. त्यामुळे पाचवे गृहीतक स्वीकारण्यात येत आहे.

उपाययोजना:

1. ग्रामीण व निमशहरी भागातील लहान किरकोळ व्यापाऱ्यांसाठी बँक आणि प्रशासनाने विशेष डिजिटल साक्षरता व मार्गदर्शन शिबिरे आयोजित करावीत.
2. जरी चोवीस तास हेल्पलाईनची शिफारस केली जात असली, तरी प्रत्यक्षात कॉल्स न स्वीकारले जाणे आणि प्रतिसाद न मिळणे हे व्यापारी व ग्राहकांसाठी मोठे आव्हान आहे. त्यामुळे केवळ हेल्पलाईन उभारणे पुरेसे नसून तिची प्रत्यक्ष कार्यक्षमता सुधारणे आवश्यक आहे.
3. लहान शहरातील किरकोळ दुकानांमध्ये अखंडित व्यवहारांसाठी उच्च क्षमतेचे इंटरनेट नेटवर्क व डिजिटल इन्फ्रास्ट्रक्चर उपलब्ध करून द्यावे.
4. स्थानिक व्यापाऱ्यांना ONDC नेटवर्कवर सहज समाविष्ट करून घेण्यासाठी सोप्या ॲप्स आणि प्रादेशिक भाषेतील प्रशिक्षण सुविधा द्याव्यात.
5. डिजिटल व्यवहारांचा वापर वाढवणाऱ्या लहान व्यापाऱ्यांना आणि किरकोळ व्यावसायिकांना

डिजिटल व्यवहार शुल्कात सवलत व विशेष आर्थिक सवलती द्याव्यात.

मर्यादा:

1. प्रस्तुत संशोधन हे प्रामुख्याने RBI, NPCI आणि सरकारी अहवालांच्या दुय्यम माहितीवर आधारित आहे.
2. हा शोधनिबंध मुख्यत्वे भारतातील शहरी व निमशहरी भागातील डिजिटल बँकिंगच्या प्रभावापुरता मर्यादित आहे.
3. हे अध्ययन डिजिटल बँकिंगच्या अलीकडील काही वर्षांतील आकडेवारीवर केंद्रित आहे.
4. इंटरनेट कनेक्टिव्हिटी, सर्व्हर डाऊन होणे यांसारख्या बाह्य तांत्रिक अडचणींचा व्यापाऱ्यांवर होणारा तात्कालिक परिणाम या अभ्यासात पूर्णपणे मोजता आलेला नाही.
5. या अध्ययनात प्राथमिक सर्वेक्षण न केल्यामुळे व्यापाऱ्यांच्या वैयक्तिक व प्रत्यक्ष अनुभवांचे सांख्यिकीय संकलन समाविष्ट नाही.
6. पीएम स्वनिधी (PM SVANidhi) किंवा इतर बँकिंग ॲप्सद्वारे कर्ज मिळतात, पण त्यासाठी अजूनही कागदपत्रे, सिबिल स्कोर आणि मोठी मंजुरी प्रक्रिया लागते. किरकोळ व्यावसायिकाने दररोज केलेले ५०-१०० रुपयांचे UPI व्यवहार पाहून कोणत्याही मानवी हस्तक्षेपाशिवाय किंवा कागदपत्रांशिवाय काही मिनिटांत ऑटो-अन्प्रूव्हड कर्ज मिळण्याची यंत्रणा अजूनही सर्व लहान व्यापाऱ्यांपर्यंत पोहोचलेली नाही.
7. सामान्य UPI (A/c to A/c) मोफत आहे, पण जर ग्राहकाने 'क्रेडिट कार्ड' वापरून किंवा POS मशीनद्वारे पेमेंट केले, तर व्यापाऱ्याला १.५% ते २% पर्यंत MDR शुल्क भरावे लागते. सूक्ष्म व लहान व्यापाऱ्यांना अशा सर्वच प्रकारच्या डिजिटल पेमेंटवर हे शुल्क पूर्णपणे माफ करण्यात यावे.
8. खात्यातून पैसे कट झाले किंवा साऊंड-बॉक्स चालत नसेल, तर तक्रार नोंदवून पैसे परत मिळण्यासाठी ३ ते ७ दिवस वाट पाहावी लागते. २४ तासांच्या आत आपोआप रिफंड (Auto-Refund) मिळणे आणि कस्टमर केअर प्रतिनिधीशी थेट संवाद होणे अजूनही कठीण आहे.

निष्कर्ष:

प्रस्तुत संशोधनातून असे स्पष्ट होते की, डिजिटल बँकिंग आणि अत्याधुनिक पेमेंट तंत्रज्ञानाने भारतातील किरकोळ बाजारात एक क्रांतिकारी आणि सकारात्मक बदल घडवून आणला आहे. वित्त मंत्रालय, RBI आणि DPIIT च्या २०२६ मधील अधिकृत डेटानुसार, देशातील ९४% लहान व्यापाऱ्यांनी UPI चा स्वीकार केल्यामुळे आणि एकूण व्यवहारांमध्ये UPI चा वाटा जवळपास ८०% वर पोहोचल्यामुळे किरकोळ बाजारातील पारंपारिक उधारीची पद्धत संपुष्टात येऊन व्यापाऱ्यांचा कॅश-फ्लो अधिक मजबूत झाला आहे. तसेच, वित्तीय समावेशन निर्देशांक (FI-Index) ७०.० वर पोहोचणे आणि 'पीएम स्वनिधी' योजनेद्वारे १ कोटींहून अधिक किरकोळ व्यापाऱ्यांना विनातारण कर्ज मिळणे हे तळागाळातील घटकांचे औपचारिक बँकिंगशी जोडले जाणे सिद्ध करते. ONDC पद्धतीमुळे लहान व्यापाऱ्यांचे प्लॅटफॉर्म कमिशन २५%-३५% वरून ५%-१०% वर आले असून, २ लाखांहून अधिक सक्रिय दुकानदारांना मोठ्या ई-कॉमर्स कंपन्यांशी स्पर्धा करण्याचे समान व्यासपीठ मिळाले आहे. याशिवाय, २ कोटींहून अधिक साऊंड-बॉक्स उपयोजित झाल्यामुळे बनावट स्क्रीनशॉटद्वारे होणारी डिजिटल

फसवणूक पूर्णपणे रोखली गेली आहे. तसेच ५२% ग्राहक कॅशबॅक व लॉयल्टी रिवॉर्ड्समुळे डिजिटल बँकिंगचा वापर करत असल्याने ग्राहकांच्या खरेदीत 'डिजिटल सवय' निर्माण झाली आहे. या सांख्यिकीय निष्कर्षांच्या आधारे संशोधनातील गृहीतके स्वीकारण्यात आली आहेत, ज्यावरून डिजिटल बँकिंग हे किरकोळ बाजाराचे सबलीकरण करणारे आणि आर्थिक सुरक्षितता देणारे मुख्य साधन ठरले आहे.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Influence of Financial Influencers on the Investment Decisions of Youth in Mumbai City

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DOI - 10.5281/zenodo.24339232

Abstract:

Young adults now often learn about savings, investments, and financial products through social media. Financial influencers, or finfluencers, share money concepts using short videos, posts, and easy-to-understand formats. While this content can help people understand finances better, it can also push people to make investment choices based on what's popular, what seems urgent, or incomplete facts. This paper looks at how financial influencers might affect investment decisions of young people in Mumbai City. It focuses on how credible and trustworthy these influencers seem, how well young people understand digital finance, and how they tend to behave. The research uses a descriptive and exploratory method based on existing studies, industry reports, and rules from regulators. The discussion uses ideas from behavioral finance, including herd behaviour, fear of missing out, and overconfidence, to create a framework for future local studies. Evidence from India shows that sharing information clearly, checking sources, and separating financial education from investment advice are important. The paper suggests that influencer content should be a starting point for learning, not a replacement for making your own decisions. It ends by discussing what this means for young investors, schools, people who create financial content, and regulators. The proposed relationships require empirical testing among a clearly defined sample of young adults in Mumbai City.

Keywords: Financial Influencers; Investment Decisions; Youth Investors; Digital Financial Literacy.

Introduction:

Social media has changed how individuals discover and interpret financial information. Alongside banks, financial advisers, newspapers and formal investor-education resources, young adults now get investment-related content through Instagram, YouTube and other digital platforms. Financial influencers—often described as finfluencers—explain financial concepts, discuss market developments and share personal-finance narratives. Their accessible language and short-form presentation can help audiences approach topics that may otherwise appear complex.

Mumbai City is a good place to study this change. As a major business and financial hub, it gives young adults lots of chances to learn about financial services, find jobs and discover investment information. However, just because people can access content does not mean they can tell if it is correct, risky or right for them. A confident speaker, many followers or a popular post might look like proof of real knowledge.

Financial influencer content can help when it explains basic concepts, encourages saving, or directs audiences to reliable resources. Concerns arise when content makes unsupported return claims, omits important risks, blurs education with promotion or encourages urgent

action. Social-media formats may also amplify popular opinions, potentially contributing to herding behaviour or fear of missing out (FOMO).

Behavioural finance provides a useful lens for considering these issues. Investors may use mental shortcuts and respond to social cues rather than evaluating every alternative systematically. Kahneman and Tversky's (1979) prospect theory demonstrates that decisions under risk can depart from conventional models of rational choice. Barber and Odean (2008) also show that attention can influence which securities individual investors buy. In a digital environment, attention-grabbing content may therefore affect which opportunities young investors investigate, although attention alone does not establish that a recommendation causes a purchase.

This study examines how financial influencers might affect the way young people in Mumbai make investment choices. It focuses on the perceived trustworthiness of these influencers, the extent of people's trust in them, young people's understanding of digital finance, and their typical behaviour. The paper separates what research has already established from ideas that still need to be tested in Mumbai.

Review of Literature:

1. Behavioural finance and investment decisions:

Behavioural finance recognises that financial decisions are influenced not only by expected returns and risk, but also by psychological processes and limits to judgement. Prospect theory proposes that people evaluate outcomes relative to a reference point and may respond differently to gains and losses (Kahneman & Tversky, 1979). This is relevant to online investment content that emphasises potential gains, highlights dramatic losses or presents an opportunity as one that must not be missed.

Barber and Odean (2008) examined attention and the buying behaviour of individual and institutional investors. Their work supports the importance of attention in the investment process. In social media, repeated mentions, trending topics and high-engagement posts may bring particular securities or products to a viewer's attention. However, visibility and popularity are not reliable substitutes for assessing risk or suitability.

2. Financial influencers, trust and credibility:

Finfluencers communicate financial topics through a blend of explanation, personal experience and entertainment. Their content may lower the perceived barrier to learning about budgeting, investing and financial products. At the same time, followers may find it difficult to distinguish educational information from promotion or personalised recommendations.

The CFA Institute's report The Finfluencer Appeal: Investing in the Age of social media (2024) examined young investors' engagement with financial influencers. Subsequent CFA Institute research focused on India, including Clicks and Credibility: Understanding Finfluencers' Role in Investment Decisions (2025) and Clicks and Credibility 2.0 (2026). These reports make the Indian finfluencer environment a relevant subject for investor education and policy discussion. Their samples and methods should be considered when interpreting findings; they should not automatically be treated as representative of all young investors in Mumbai.

Perceived credibility may be shaped by the clarity of an explanation, visible qualifications, consistency, transparency and the way a creator handles uncertainty. However, being trusted is not the same as being skilled. The number of followers and likes shows how

engaged people are with someone's content, but it does not show whether their financial guidance is accurate or if an investment suits your needs.

3. Herding, FOMO and overconfidence:

Herding behaviour occurs when people follow the apparent choices or opinions of others rather than relying entirely on independent assessment. A widely circulated investment narrative may create an impression that an opportunity is safe or widely accepted. FOMO can add urgency when viewers believe others are earning returns and that delay will mean missing out. Overconfidence may arise when simplified content gives viewers an inflated sense of their ability to understand complex investments. Confirmation bias may also lead users to favour content that supports an existing view while ignoring contrary evidence.

These concepts are plausible mechanisms through which social-media content may relate to investment choices. Their presence, frequency and effects among youth in Mumbai City must be tested with suitable data; they should not be assumed to apply to every viewer.

4. Research gap:

Published research and industry reports says that financial influencers, investor trust and online financial communication, but national-level findings do not particularly explain how young adults in a specific city use such content. A local study could check the relationship between exposure frequency, perceived credibility, financial literacy and self-reported investment decisions. It could also investigate whether digital financial literacy is associated with more critical evaluation of online recommendations. The contribution of the present paper is to organise these issues into a focused framework for Mumbai City.

Objectives of the Study:

1. To examine the role of financial influencers as a source of investment among youth in Mumbai City.
2. To explore the relationship between perceived influencer credibility and young people's investment decisions.
3. To examine the relevance of herding behaviour, FOMO and overconfidence in responses to online financial content.
4. To consider the role of digital financial literacy in evaluating financial influencer content.
5. To identify measures that may support informed and responsible investment decision-making among young people.

Research Methodology:

1. Research Design and Data Sources:

The study adopts a descriptive and exploratory secondary-data approach. It draws from academic studies on how people make financial decisions, public reports from the CFA Institute about financial influencers, and educational materials from India's Securities and Exchange Board (SEBI). The study examines these sources to find common patterns and create research ideas that apply to young people in Mumbai. It does not try to measure how common these behaviours are among local youth.

2. Analytical Framework:

The framework considers five central constructs: exposure to financial influencer content, perceived credibility, trust, digital financial literacy and investment decision-making. Herding behaviour, FOMO, overconfidence and confirmation bias are considered possible behavioural mechanisms. The proposed relationships are conceptual and have not been statistically tested in this paper.

3. Scope and Limitations:

The paper focuses on the potential influence of financial influencers on investment decisions among youth in Mumbai City, particularly young adults who use social media to obtain financial information. It is based on secondary sources and conceptual analysis; it does not report a completed primary survey or original statistical findings. The sources reviewed use different populations and research designs, so their findings cannot be directly generalised to youth in Mumbai City. Social-media content changes over time, and examples of creators or posts must be verified at the time of any future content analysis.

4. Proposed Approach for Future Empirical Research:

A future local study could use a structured questionnaire with a clearly defined age range, sampling frame and sample size. Items could measure frequency of exposure, reliance on influencer content, trust, financial literacy, investment experience and self-reported decision practices. A separate content analysis could code a specified sample of public Instagram posts for educational content, specific investment recommendations, risk warnings and sponsorship or affiliation disclosures. Descriptive statistics, reliability analysis, correlation and regression could be used where appropriate to the data and research questions. Any results should be reported only after data collection and analysis.

Research Hypotheses:

Based on the literature reviewed, the following hypotheses are proposed for future empirical testing:

H1: Greater exposure to financial influencer content may be associated with greater consideration of investment opportunities discussed online.

H2: Perceived credibility may be associated with the extent to which young investors use influencer content when evaluating investments.

H3: Herding behaviour and FOMO may help explain responses to popular or urgent investment narratives.

H4: Digital financial literacy may be associated with more critical evaluation of financial influencer content.

H5: Clear disclosure of commercial relationships and investment risks may help viewers evaluate financial content more effectively.

These hypotheses are proposed for future empirical testing and have not been statistically tested in this secondary-data-based paper.

Findings of the Study:

1. Accessibility and Reach of Financial Content:

The reviewed literature and industry reports indicate that social media has become a visible channel for financial information, particularly for younger audiences. Short-form content can make basic concepts easier to approach, but accessibility does not guarantee completeness or suitability.

2. Credibility and Disclosure Remain Central Concerns:

The CFA Institute's India-focused reports identify credibility, registration and disclosure as important issues in the finfluencer environment. These sources support treating transparency as a central consideration, while their samples should not be generalised to all creators or all young investors in Mumbai.

3. Behavioural Mechanisms Are Plausible but Locally Untested:

Behavioural finance literature provides a basis for examining herding, FOMO and overconfidence in response to popular investment narratives. The secondary sources reviewed do not establish how prevalent these behaviours are

among youth in Mumbai City, nor do they demonstrate that influencer exposure causes specific investment outcomes.

4. Digital Financial Literacy Is a Practical Protective Capability:

The reviewed evidence supports the importance of evaluating sources, understanding risk and distinguishing education from promotion. Whether digital financial literacy statistically moderates the relationship between influencer exposure and investment decisions in Mumbai requires primary data.

5. Financial Influencers as a Source of Information:

Financial influencers can make financial concepts more approachable by using everyday language, visual examples and short explanations. For young adults who are beginning to explore investments, such material may provide an initial route into financial learning. Nevertheless, a short video is unlikely to cover every consideration relevant to a complex financial decision. Viewers need to distinguish a general explanation from a recommendation to buy or sell a specific security.

CFA Institute reports on finfluencers in India provide a useful basis for examining concerns around credibility, disclosures and investment-related communication. Their findings should be interpreted in relation to their stated samples and methods rather than as a complete account of all creators or users. For Mumbai's youth, a key question for future research is whether viewers verify claims independently or rely mainly on familiarity, popularity and ease of understanding.

6. Credibility and Investment Choices:

A viewer may perceive a creator as credible because of qualifications, experience, clear explanations or transparent communication. However, online popularity alone does not establish financial expertise. An influencer may explain a concept effectively without being qualified or authorised to provide every type of investment advice. Young investors should therefore verify claims against independent sources, review relevant product documents and consider risks before acting.

SEBI's regulatory framework addresses certain associations between regulated entities and persons providing securities-related advice or recommendations without required registration or permission, subject to the applicable provisions and exceptions. This context makes it important to distinguish financial education, promotion and regulated advice. The precise regulatory status of a creator should be checked against current official records rather than inferred from a social-media profile.

7. Behavioural Tendencies in a Social-Media Setting:

Repeated exposure to a popular investment idea may make it seem more credible than it is. This is consistent with the logic of herding, but popularity alone does not prove that an individual has followed the crowd. Similarly, FOMO may encourage rushed action when posts emphasise rapid gains or suggest that an opportunity is about to disappear. Overconfidence may arise when a simplified explanation is mistaken for sufficient knowledge to evaluate an investment independently.

These are explanatory possibilities, not established outcomes for all young viewers. A local survey would need to assess whether such tendencies are associated with exposure to financial influencer content and whether they relate to self-reported investment choices. It should also consider other factors, including investment experience, financial circumstances, risk tolerance and independent sources of advice.

8. Digital Financial Literacy and Responsible Decisions:

Digital financial literacy includes the ability to locate information and evaluate its

reliability, identify promotional content, understand uncertainty and recognise potential conflicts of interest. A financially literate viewer should ask whether a claim is supported, whether the risks are explained, whether commercial affiliations are disclosed and whether the information applies to their own circumstances.

Colleges and universities can support this capability through practical financial education. Activities may include checking the source of an investment claim, comparing product information, identifying misleading return presentations and discussing behavioural biases. Such initiatives can help students use social media as a learning resource without treating it as a substitute for independent judgement.

9. Illustrative Accounts for a Future Instagram Content Analysis:

A future content analysis could consider public financial-education content from creators such as CA Rachana Ranade (@ca_rachanaranade), Pranjal Kamra (@pranjalkamra), Ankur Warikoo and Sharan Hegde. These are illustrative candidates only, not endorsements or conclusions about the accuracy of their advice, regulatory status or impact on investment outcomes. Official account identity, content availability and registration status should be verified at the time of research. A transparent design would specify the observation period, selection criteria and number of posts, then code content for educational explanations, specific investment recommendations, risk disclosures, sponsorship disclosures and references to qualifications. This would avoid relying on isolated examples or subjective impressions.

Recommendations:

Young investors should treat influencer content as a starting point for learning, not as an automatic basis for buying or selling. They should verify sources, understand the risks, compare independent information and consider their own financial objectives. Financial influencers should distinguish educational content from promotion and recommendations, and disclose relevant commercial relationships clearly. Educational institutions can incorporate digital financial literacy and behavioural finance into student learning. Regulators and investor-education bodies can continue to clarify applicable rules and promote accessible guidance on identifying misleading claims. Researchers should combine local survey evidence with transparent content analysis to understand how online financial communication is received by Mumbai's youth.

Conclusion:

Financial influencers are a visible part of the digital financial information environment. Their content can make investment concepts accessible and encourage young people to take an interest in financial planning. However, accessibility and popularity should not be confused with reliability, suitability or professional authorisation. For youth in Mumbai City, the important question is how financial content is evaluated and whether viewers distinguish educational material from promotion or unsupported claims.

Behavioural finance provides a useful framework for studying the possible roles of herding, FOMO, overconfidence and confirmation bias. The secondary evidence also highlights the importance of disclosure and investor education. Nevertheless, the specific relationship between influencer exposure and investment decisions among Mumbai's youth remains to be established through local empirical research. Independent evaluation, awareness of risk and digital financial literacy can help young people engage with online financial content more thoughtfully.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

One Pot Synthesis of Some Novel Dipyrano-Pyridine Derivatives From 1-(2,6-Dichloro-4-(Trifluoromethyl) Phenyl) Piperidine-2,6-Dione

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DOI - 10.5281/zenodo.24339263

Abstract:

In current study we have victoriously revealed the several inventive derivatives of pyrano-pyridine derivatives. These compounds were developed from 4-Amino 3,5 Dichlorobenzotrifluoride and Glutaric anhydride and substituted benzaldehyde. Greener chemical synthesis using PbO nanoparticles as a catalyst represents a significant advancement in sustainable chemistry by eliminating hazardous organic solvents and toxic reagents like piperidine. The novel synthons have been successfully developed in the current context. This environmentally friendly method achieves high product yields while adhering to the core principles of green path. PbO nanoparticles function as an efficient catalyst.

All newly described molecules were analyzed by various spectral analysis tools such as FT-IR, ^{1}H-NMR, ^{13}C-NMR, and mass. These compounds were tested for their anti-inflammatory properties.

Keywords: pyrano-pyridine, cyclic imide, malononitrile, PbO nanoparticals.

Introduction:

Numerous broad aspects of heterocyclic chemistry are recognized as fields of mainstream significance that affect practically all aspects of modern organic chemistry, medicinal chemistry, and biochemistry[1].An Imide is considered as a functional group in synthetic chemistry having two acyl substituent's that are attached to the nitrogen which is found in both form chain and cyclic[2].

Cyclic imides were prepared from primary amine and cyclic anhydrides which emerged as an important class of organic substrates for agricultural, biological and chemical applications[3].Among the cyclic imides specifically glutarimide derivatives are described as they are observed in the metabolism of a brain[4] while some N-aryl succinimides were acts as an anti-muscarinic and nephrotoxic[5]. Glutaric and succinic are extensively utilized cyclic imides in the field of innovative drug designing both acts as pioneers for various drugs, pesticides[6], herbicides[7], polymer[8], and natural product equivalents[9]. These are also the key role in numerous natural product frames such as Julocrotine, lamprolobine, and migastatin, etc.

One of the most often used nuclei in the field of drug development is pyridine-based heterocycles. This is mainly because of their substantial therapeutic properties against a spectrum of ailments, which led to the development of various medicinal medications[10].According to several studies; pyridine moiety in biologically active molecules improves cellular mobility, metabolic stability, biochemical strength, and protein-binding problems.

As per the literature review which exhibits that 4H-pyran-nucleated heterocyclic compounds are known to be a rich source of physiologically extraordinary molecules with a variety of biological and pharmacological features[11-13]. In addition to their medicinal

significance, they have also been remarked for their incredible applications in agrochemical industries due to their magnificent insecticidal and pesticidal properties[14-15]

As we know that in today's main stream research, the researchers are trying to developing modern synthetic strategies with complimenting and exploration of novel methodologies in the domain of heterocyclic compounds. In addition to the traditional methods, plenty of eco-friendly methodologies have been described in literature within side the current instances permitting stepped forward to get complex heterocycles moieties from convenient precursors and under milder reaction conditions.

As we discussed earlier in order to maintain synthetic interest, eco-friendly technical enhancements were required for the initial reaction conditions. It is possible to synthesize dipyrano derivatives with the assistance of PbO nanoparticles by reacting cyclic imide with malononitrile in the presence of a substituted aromatic aldehyde. In conventional synthesis techniques of dipyrano have used a basic catalyst such as piperidine or triethylamine in an organic solvent such as ethanol, DMF, or acetic acid[16-21] and microwave irradiation also be used to make them[22].Long reaction times, non-renewable solvents, toxic chemicals, poor yield, and complex set-up are all disadvantages of these techniques. PbO nanoparticles were used to perform a solvent-free synthesis of pyranopyran derivatives which is an efficient catalyst at room temperature. PbO nanoparticles have been shown to be a highly efficient, renewable, and environmentally acceptable heterogeneous catalyst. The Procedure, which is simple to set up, fast reaction times, solvent-free, and avoids hazards chemicals. N-phenyl succinimides with substituted aromatic aldehyde and malononitrile yielded a new class of pyrano-pyridine (6a-e).

Pyrano-pyridines are the remarkable genre of heterocyclic scaffolds where pyridine ring fused with pyran nucleus having rich therapeutic properties. Consequently, the pharmacokinetic and pharmacodynamic properties of molecules are also greatly improved[23].

In present work we have used 2, 6 dichloro 4-trifluro methyl aniline for synthesizing novel pyrano-pyridine derivatives via cyclic imide 1-(2, 6-dichloro-4-trifluoromethyl-phenyl)-piperidine-2, 6-Dione (4a) with various substituted benzaldehyde. Literature survey shows that2, 6 dichloro 4-fluromethyl aniline is selectively utilized for synthesis of pesticide such as Fipronil[24-25]. An overview of this amine shows that the addition of trifluoro methyl on thebenzene ring significantly utilized in the agrochemical and pharmaceutical industries[26-29]

In continuation of prior study we have designed a novel 1-(2,6-dichloro-4-(trifluoromethyl)phenyl)piperidine-2,6-dione (4a) (cyclic glutaric imide) from 4-Amino 3,5 Dichlorobenzotrifluoride and Glutaric anhydride[30-31]. While compound 4a was further utilized to design a new series inventive substituted pyrano-pyridine derivatives (6a-e) using numerous aromatic aldehyde derivatives and PbO nanoparticles by the most convenient synthetic technique. There are multifarious synthetic operations have been reported in literature including traditional as well as modern.

We have followed these methods and redesigned in most facile way for synthesis of these newly described molecules. It provides pretty yield in short reaction time with low economic cost. It was also observed in literature that pyrano-pyridine derivatives are most magnificent class of heterocyclic compounds and specifically classified for their multi medicinal features including cancer.

However, the genre of 2,8-diamino-4,6-bis(substituted-phenyl)-10-(substituted-phenyl)-tetrahydrodi pyrano-pyridine-3,7-dicarbonitrile derivatives have been infrequently disclosed in literature. Taking advantage of such seldom work over this specific class of compounds we have victoriously developed this class of compounds.

Material and Methods:

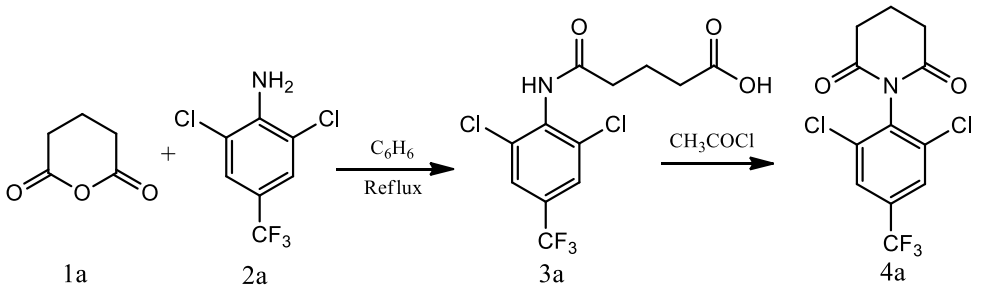
Chemical reagents and solvents were utilized for the developing of all new compounds was pure. Melting points of all synthetically designed compounds were determined by the open capillary method and were found uncorrected. The reaction was monitored by TLC which was accomplished by using pre-coated silica gel aluminum plates with a mixture of hexane, ethyl acetate as solvent. FTIR spectra are recorded on Perkin-Elmer spectrum. H^1NMR and ^{13}C-NMR spectra are recorded on Bruker (Advance HD III) 500 MHz spectrometer with DMSO-d^6 solvent and TMS was used as internal reference (chemical shift in δ ppm). However, mass spectra were recorded on Bruker (Impact HD) mass spectrometer using dlc-ms 600mz method.

Experimental:

1. General method for the synthesis of cyclic imide using glutaric anhydride:

Synthesis of 1-(2,6-dichloro-4-(trifluoromethyl)phenyl)piperidine-2,6-dione (4a):

Glutaric anhydride (0.01mol) was dissolved in benzene (20ml) and transferred to a round bottom flask. Then 2,6-dichloro-4-trifluoromethyl aniline (0.01mol) was dissolved in 5 ml benzene and added to it vigorously. The 4-((2, 6-dichloro-4- (trifluoromethyl) phenyl) amino)-4-oxopentanoic acid was formed. This acid underwent cyclization by using (0.09mol) of acetyl chloride under refluxed condition for one hour at 60-70ºC. The reaction was simultaneously monitored by TLC by using pre-coated silica gel aluminum plates with a mixture of n-hexane and ethyl acetate (8:2) as a solvent phase. The crude product (4a) was obtained and recrystallized from methanol (Scheme-1).



Scheme-1 Synthesis of 1-(2, 6-dichloro-4-trifluoromethyl-phenyl)-piperidine -2,6-Dione

1-(2, 6-Dichloro-4-triflouromethyl-phenyl)-piperidine-2, 6-Dione (4a):

Molecular Formula: $C_{12}H_8Cl_2F_3NO_2$, **Molecular Weight (g/mol):** 326, **Melting Point (ºC):** 70-72, **Physical Appearance:** Off white solid, **Percentage Yield (%):** 72

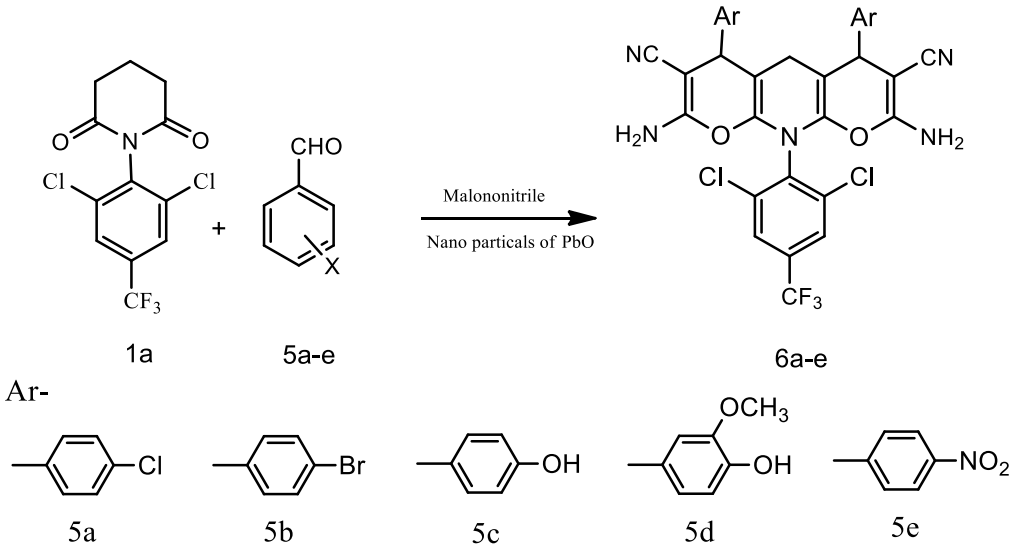
FT-IR (KBr) cm^{-1}: 3088 (C-H stretching), 2870 (C-H stretching of Ar-H), 1737 (C=O stretching), 1575 and 1531 (ArC=C), 1037 (C-F stretching), 886 (Cl stretching)

H^1-NMR (500 MHz, DMSO-d^6 δ ppm): 2.5 (s, 4H), 7.7 (s, 2H, Ar-H).

2. General procedure for the synthesis of Dipyrano-pyridine using cyclic imide (3a) and aromatic aldehydes:

Synthesis of Dipyrano-pyridinederivatives of 1-(2, 6-dichloro-4-trifluoromethyl-phenyl)-piperidine-2,6-dione(6a-e):

Mixture of N-phenyl glutarimidederivatives (0.01mole), aromatic aldehydes (0.02mole), malononitrile (0.02mole) and 100 mg PbO nanoparticles were ground for half hour at a room temperature with a mortar and pestle. The reaction was monitored by thin layer chromatography (TLC). After completion of reaction, the product was washed with distilled water. The novel developed compounds were dried and recrystallized from ethanol to furnished pure compounds with maximum yield. **(**Scheme 2)



Scheme-1.1 Synthesis of Dipyrano-pyridine derivatives of 1-(2,6-dichloro-4-(trifluoromethyl)phenyl)piperidine-2,6-dione.

i) 2,8-diamino-4,6-bis(4-chlorophenyl)-10-(2,6-dichloro-4-(trifluoromethyl)phenyl)-4,5,6,10-tetrahydrodipyrano[2,3-b:3',2'-e]pyridine-3,7-dicarbonitrile (6a)

Molecular Formula: $C_{32}H_{18}Cl_4F_3N_5O_2$, **Physical Appearance:** White solid, **Nature of compound:** Crystalline, **Percentage Yield (%):** 64, **Melting Point (ºC):** 166-168, **Molecular Weight (g/mol):** 703

FT-IR (KBr) cm^{-1}: 3180 (N-H stretching) 3093 (C=C-H stretching), 2928 (C-H stretching), 1673 (N-H bending), 1578 and 1528 (Ar-C=C), 1282 (C-N), 1153 (C-F stretching), 935 and 851 (C-Cl stretching), 1153 (C-F stretching), 684 (N-H Wagging)

^{1}H-NMR (500 MHz, DMSO-d^6, δ ppm): 8.32 (s, 2H, N-H),8.00 (s, 2H, Ar-H, *J* = 2.3 Hz), 7.67 (dd, 4H, Ar-H, *J* = 7.5 Hz), 7.17 (dd, 4H, Ar-H, *J*= 7.5 Hz), 4.48 (s, 2H), 3.33 (s, 2H)

^{13}C-NMR (125 MHz, DMSO-d$_6$, δ ppm): 127-131 (d, 10C, Ar-C), 162 (s, 2C, N-C-O), 139 (s, 2C, Ar-C), 132 (s, 4C, Ar-C), 83 (s, 2C, Ar-C), 151 (s, 3C, Ar-C), 114 (s, 2C, CN), 76 (s, 2C, Ar-C), 34 (s, 2C), 26 (s, 1C), 121 (s, 1C, F-C)

ii) 2,8-diamino-4,6-bis(4-bromophenyl)-10-(2,6-dichloro-4-(trifluoromethyl)phenyl)-4,5,6,10-tetrahydrodipyrano[2,3-b:3',2'-e]pyridine-3,7-dicarbonitrile (6b):

Molecular Formula: $C_{32}H_{18}Br_2Cl_2F_3N_5O_2$ **Physical Appearance:** White solid, **Nature of**

compound: Crystalline, **Percentage Yield (%):** 68, **Melting Point (ºC):**152-154, **Molecular Weight (g/mol):** 792

^{13}C-NMR (125 MHz, DMSO-d_6, δ ppm): 126-130 (d, 10C, Ar-C), 159 (s, 2C, N-C-O), 141 (s, 2C, Ar-C), 124-129 (s, 4C, Ar-C), 86 (s, 2C, Ar-C), 149 (s, 3C, Ar-C), 119 (s, 2C, CN), 75 (s, 2C, Ar-C), 35 (s, 2C), 22 (s, 1C), 123 (s, 1C, F-C).

iii) 2,8-diamino-10-(2,6-dichloro-4-(trifluoromethyl)phenyl)-4,6-bis(4-hydroxyphenyl)-4,5,6,10-tetrahydrodipyrano[2,3-b:3',2'-e]pyridine-3,7-dicarbonitrile (6c):

Molecular Formula: $C_{32}H_{20}Cl_2F_3N_5O_4$, **Physical Appearance:** Off-white solid, **Nature of compound:** Crystalline, **Percentage Yield (%):** 65, **Melting Point (ºC):** 124-126, **Molecular Weight (g/mol):** 666

FT-IR (KBr) cm^{-1}: 3342 (N-H stretching), 3172 (Ar-O-H stretching broad), 3021 (C=C-H stretching), 2981 (C-H stretching), 2227 (C-N stretching Nitrile), 1668 (N-H bending), 1578, 1517, and 1444 (Ar-C=C), 1388 (C-N stretching), 1287 (C-O Stretching), 1159 (C-F stretching), 885 and 823 (C-Cl stretching), 695 (N-H wagging) .

^{1}H-NMR (500 MHz, DMSO-d_6, δ ppm): 8.49 (s, 2H, N-H),7.99 (s, 2H, Ar-H, *J* = 2.3 Hz), 7.60 (dd, 4H, Ar-H, *J* = 7.5 Hz), 7.45 (dd, 4H, Ar-H, *J*= 7.5 Hz), 8.88 (s, 2H, O-H), 4.55 (s, 2H), 3.58 (s, 2H).

iv) 2,8-diamino-10-(2,6-dichloro-4-(trifluoromethyl)phenyl)-4,6-bis(4-hydroxy-3-methoxyphenyl)-4,5,6,10-tetrahydrodipyrano[2,3-b:3',2'-e]pyridine-3,7-dicarbonitrile (6d):

Molecular Formula: $C_{34}H_{24}Cl_2F_3N_5O_6$, Physical Appearance: Faint brown solid, Nature of compound: Crystalline, Percentage Yield (%): 70, Melting Point (ºC):178-180, Molecular Weight (g/mol): 726

FT-IR (KBr) cm^{-1}: 3412 (N-H stretching), 3186 (Ar-O-H stretching), 3021 (C=C-H stretching), 2842 (C-H stretching), 2221 (C-N stretching Nitrile), 1662 (N-H bending), 1567, 1505, and 1433 (Ar-C=C), 1388 (C-N stretching), 1293 (C-O Stretching), 1153 (C-F stretching), 885 (C-Cl stretching), 695 (N-H wagging)

HRMS (ESI): Cal: 726 (exact mass) Obs: m/z: 724.95 [M+H]

v) 2,8-diamino-10-(2,6-dichloro-4-(trifluoromethyl)phenyl)-4,6-bis(4-nitrophenyl)-4,5,6,10-tetrahydrodipyrano[2,3-b:3',2'-e]pyridine-3,7-dicarbonitrile (6e):

Molecular Formula: $C_{32}H_{18}Cl_2F_3N_7O_6$, **Physical Appearance:** Yellow solid

Nature of compound: Crystalline, **Percentage Yield (%):** 68, **Melting Point (ºC):**146-148

Molecular Weight (g/mol): 724

FT-IR (KBr) cm^{-1}: 3252 (N-H stretching), 3032 (C=C-H stretching), 2852 (C-H stretching), 2221 (C-N stretching Nitrile), 1672 (N-H bending), 1572 (N-O asymmetric stretching), 1483 (Ar-C=C), 1405 (N-O symmetric stretching), 1287 (C-N stretching), 1209 (C-O Stretching), 1120 (C-F stretching), 885 (C-Cl stretching), 706 (N-H wagging)

^{1}H-NMR (500 MHz, DMSO-d_6, δ ppm): 8.51 (s, 2H, N-H), 8.30 (dd, 4H, Ar-H, *J* = 7.5 Hz), 8.00 (s, 2H, Ar-H, *J* = 2.3 Hz), 7.70 (dd, 4H, Ar-H, *J* = 7.5 Hz), 5.10 (s, 2H), 3.65 (s, 2H).

Biological Studies:

1. Anti-inflammatory activity:

The series of all synthesized novel compounds (6a-e) were investigated for their anti-inflammatory activity.

Procedure of anti-inflammatory activity evaluation in vitro:

The human red blood cell (HRBC) membrane stabilization assay was specifically used to screen the anti-inflammatory activity of synthetically design compounds in vitro. Fresh blood sample (approximately 3 ml) was obtained intravenously from physically fit and healthy person who had not any history for NSAID consumption before 10-12 days of study. Blood sample was settled in heparin tubes to avoid blood coagulation. Thereafter blood was blended with equal ratio of non-contaminated Alsever solution (2% dextrose, 0.8% sodium citrate, 0.5% citric acid and 0.42% sodium chloride in water). The blood mixture was centrifuged at 2500-3000 rpm for 15-20 min and packed cells were isolated. The separated packed cells was cleaned by isosaline suspension (0.85%, pH 7.2) carefully and reconstructed into a 10% v/v HRBC suspension in isosaline solution. In addition HRBC suspension was utilized for the evaluation of anti-inflammatory activity. 1 ml Test sample (400 µg/ml) and 1ml reference drug in hyposaline liquid (0.25% NaCl) was individually blended by 2 ml of hyposaline solution (0.36%), 1 ml of phosphate buffer suspension (0.15 M, pH 7.4), and 0.5 ml of HRBC suspension. 2 ml of distilled water was used as the control in place of hyposaline solution. Eventually all test mixture was placed in incubator at 37ºC for 30 min for incubation and centrifuged at 2500-300 rpm for 20 min. Thereafter the supernatant liquid was extracted and the haemoglobin part of supernatant solution was investigated by spectrophotometer at specific wavelength (560 nm). Percentage haemolysis was observed by considering the haemolysis produced in the control as 100%. All the tests were analyzed in triplicate manner. The HRBC membrane stabilization percentage or protection was measured by using the following formula[23-24].

$$\% \text{ Protection} = \frac{\text{Absorbance of control} - \text{Absorbance of test}}{\text{Absorbanceofcontrol}} \text{ x100}$$

Result and Discussion:

We have synthesized series of (6a-e) molecules from cyclic imide (4a) as shown in (Scheme-1.0) this imide was treated to various benzaldehydes (5a-e), with malononitrile under the catalyst (PbOnanoparticals) to afford pyranopyrrole derivatives (6a-e).

We have used PbO nanoparticles as a catalyst which replaces use of hazardous piperidine and costly solvents along with providing high practical yield and purity. This method is one of classified eco-friendly method which is conveniently utilized over traditional method to save the time and human efforts. All these newly developed compounds were characterized by elemental and spectral analysis techniques such as FT-IR, ^{1}H-NMR, ^{13}C-NMR, HRMS (ESI) these compounds were also investigated for their anti-inflammatory properties victoriously.

i) Biological Activity:

Screening of anti-inflammatory activity in vitro: An innovative series of molecules (6a-e) was screened for their anti-inflammatory properties in vitro by HRBC membrane stabilization assay. The blood sample was obtained from physically good human client. Blood sample was blended with Alsever reagent and kept at low temperature for 24 h. The sample was centrifuged and transparent part was removed. However remaining packed cells were purified by non-contaminated saline suspension. It was re-designed to 10 % HRBC suspension using isosaline solution. Simultaneously test sample of synthetic compounds and reference drug was prepared (400µg/ml) in hyposaline liquid (0.25% NaCl). To the appropriate amount of test sample and reference drug sample

phosphate buffer (1ml), hyposaline (2 ml) and HRBC (0.5 ml) suspensions were added separately. The blended mixture was incubated, centrifuged and investigated by a spectrophotometer at selective wave length. Distilled water was used as control instead saline suspension. The tests were analyzed in triplicate format.

ii) Results:

An innovative cyclic imide (4a) was synthesized using a simple method. Compound (4a) was derivatized and further transformed into a most path breaking series of pyrano-pyridine derivatives (6a-e). The % protection or HRBC membrane stabilization was observed as per the formula that described above**.** Whole readings were accurately measured and tabulated in the Table-1.

Table-1: Anti-inflammatory activity of novel compounds (6a-e):

Sr. No.	Compound	T1	T2	T3	Mean	% activity
1	6a	0.335	0.351	0.347	0.344	28.33
2	6b	0.368	0.374	0.366	0.369	23.12
3	6c	0.299	0.286	0.311	0.298	37.91
4	6d	0.327	0.347	0.358	0.344	28.33
5	6e	0.392	0.375	0.387	0.384	20.47
	Standard	0.125	0.149	0.103	0.125	73.95
	Ctrl	0.484	0.477	0.479	0.48	0.00

Pyran fused compounds are recognized as a fertile source of biologically outstanding molecules however investigation on pyrano-pyridine nucleus is rarely described in literature. Taking into account the enormous biological applications of these pyran fused compounds and constrained studies over this precise sort of compound (Pyrano-pyridine), we have endeavored to synthesize a bunch of new derivatives of pyrano-pyridine derivatives (6a-e). These molecules (6a-e) were effectively analyzed by spectroscopic techniques and evaluated for their anti-inflammatory properties. It was also concluded that almost all compounds were found to be anti-inflammatory agents while compound 6c and 6d exhibited satisfactorily anti-inflammatory effects however most of them observed as moderate anti-inflammatory compounds.

Conclusion:

A novel series of pyrano-pyridine (6a-e) was successfully synthesized under milder conditions from cyclic imide (4a), substituted aromatic aldehyde and malononitrile using green approach. We have employed a solvent-free catalyst PbO nanoparticle that provide high yield in short time and also replaces use of harmful reaction conditions. This newly reformed method also avoids use of piperidine as a catalyst.

Acknowledgement:

We are thankful to Savitribai Phule Pune University for providing facilities for spectral analysis. The authors are also grateful to the Department of Chemistry, SSVPS's L K Dr. P. R. Ghogrey Science College, Dhule (M. S), India for providing research laboratory and anti-inflammatory screening facilities**.**

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Accelerated Fixed-Point Approximation of Nonlocal Caputo-Type Fractional Differential Equations via a New Iteration Process

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DOI - 10.5281/zenodo.24339279

Abstract:

In this paper, we employ the accelerated three-step New Iteration Process (NIP) to investigate the existence and uniqueness of the solution to a nonlocal fractional initial value problem of Caputo type, in which the classical initial condition is replaced by a nonlocal (Byszewski-type) condition. We also deal with the strong convergence, T-stability, and rate of-convergence properties of NIP relative to the Picard, Mann, Ishikawa, and S-iteration processes, together with data-dependence results describing the sensitivity of the solution to perturbations of the governing function, the nonlocal functional, and the initial data.

Finally, we illustrate all of our conclusions using a concrete example and compare the rate of convergence of NIP with the other iterative approaches.

Keywords: Fractional Differential Equations; Nonlocal Initial Condition; Caputo Derivative; Fixed-Point Theory; New Iteration Process; Contraction Mappings; Mild Solution; Iterative Schemes; Rate of Convergence; Stability; Data Dependence.

MSC (2020):47H09; 47H10; 34A08; 34K37; 54H25.

1 Introduction

We consider the following nonlocal fractional initial value problem in the sense of Caputo of the type

$$({}^{c}D^{\alpha}u)(t) = f(t, u(t)), \qquad t \in J = (0, 1],\ 0 < \alpha < 1, \tag{A}$$

with the given nonlocal initial condition

$$u(0) + g(u) = u_0, \tag{B}$$

where $f : [0, 1] \times \mathbb{R} \to \mathbb{R}$ is continuous, $u_0 \in \mathbb{R}$ is a given constant, and $g : X \to \mathbb{R}$ is a nonlocal functional depending on the trajectory of u rather than on its value at a single point. The space $X = C[0, 1]$ will be specified later.

The nonlocal fractional-order initial value problem (A)-(B) constitutes an appropriate mathematical model for processes in which the initial state cannot be measured directly but must instead be inferred from later observations of the trajectory. Such conditions arise naturally in problems of viscoelasticity, anomalous diffusion, and control systems, and they generalize the classical pointwise condition $u(0) = u_0$ to allow feedback from the entire solution history. As a result, the reduction of (A)-(B) to a fixed-point equation, and the identification of the correct contraction constant governing that equation, requires a dedicated investigation distinct from the classical (local) theory.

In 1922, Banach studied the existence of a unique fixed point for contraction mappings on complete metric spaces, and showed that the associated Picard iteration converges to that fixed point from any starting point. While the Picard iteration always converges under a contraction hypothesis, its rate of convergence can be slow, which motivated a long line of accelerated iterative schemes. In 1953, Mann introduced a one-parameter iterative scheme for approximating fixed points more robustly than Picard iteration. In 1974, Ishikawa proposed a two-step generalization of Mann's scheme. In 2000, Noor introduced a three-step iterative scheme for variational inequalities. In 2007, Agarwal, O'Regan and Sahu introduced the S-iteration process and showed that, for certain classes of operators, it converges faster than both Mann and Ishikawa iteration. In 1991, Byszewski established existence and uniqueness theorems for a semilinear evolution equation subject to a nonlocal Cauchy condition of the type appearing in (B), initiating a substantial body of work on nonlocal problems for integer- and fractional-order evolution equations. Recently, Filali, Alshaban, Albalawi, Alamrani, Alatawi and Khan introduced a new three-step iterative scheme — the New Iteration Process (NIP) — which uses two evaluations of T^2 per step and attains a smaller effective contraction factor (q^2, rather than q) than the classical schemes listed above; they established its strong convergence, T-stability, a rate comparison against Picard, Mann, Ishikawa and S-iteration, and a data-dependence estimate, and applied the scheme to a two-point Caputo-type fractional boundary value problem reformulated via a Green's function as a fixed-point equation.(see [[1], [2],[3],[4], [5], [6], [8],[7, 9, 10, 11, 12, 13, 14]).

Independently of the choice of iterative scheme, two further qualitative properties are of practical importance: stability (also called T-stability), in the sense of Ostrowski [15]and of Harder and Hicks[16], which quantifies robustness of the scheme to round-off and computational errors, and *data dependence*, which quantifies the sensitivity of the fixed point to perturbations of the operator itself [17, 18, 19, 20].

The three-step iteration method has become an important tool in fixed-point theory and nonlinear analysis owing to its improved convergence characteristics. In contrast to methods that primarily address existence, three-step schemes such as NIP additionally provide an explicit, and typically much smaller, contraction factor per iteration, which translates into a demonstrably faster rate of convergence for contractive operators arising from integral reformulations of fractional differential equations. Owing to these advantages, we employ NIP in the present work.(see [21])

Because the boundary value problem originally treated by Filali et al. and the nonlocal initial value problem (A)-(B) considered here lead to structurally different solution operators — a Green's function integral operator versus a Volterra integral operator carrying an additional nonlocal term — the reduction to a fixed-point equation, the identification of the correct Lipschitz/contraction constant, and the resulting existence–uniqueness and convergence statement are new. In this context, we study the nonlocal Caputo-type fractional initial value problem (A)-(B) using the New Iteration Process, with the main purpose of establishing the existence, uniqueness, convergence, stability, and data-dependence properties of its solution. [22, 23, 24, 27]Concretely, we:

(i) recall, with complete and fully expanded proofs written directly via the Riemann–Liouville fractional integration operator, the abstract NIP theorems of Filali et al.[21] (Section 3)[[1], [2]].;

(ii) reduce the nonlocal Caputo initial value problem to a Volterra fixed-point equation and identify explicit conditions on f and g under which the associated solution operator is a contraction (Section 4, Proposition 4.3);

(iii) state and prove an existence–uniqueness and NIP-convergence theorem for the nonlocal

problem, together with an explicit data-dependence estimate under perturbations of f, g, or u_0 (Theorem 4.4, Corollary 4.5);

(iv) validate the theory numerically, comparing NIP against Picard, Mann, Ishikawa, and S-iteration on a concrete nonlocal Caputo problem, using a product-trapezoidal discretization of the underlying Abel-type kernel [25, 26] (Section 5).

2 Preliminaries

Throughout, $X = C[0,1]$ is the Banach space of all real-valued continuous functions defined on $[0,1]$, equipped with the supremum norm $\|u\|_\infty = \max_{t\in[0,1]} |u(t)|$.

Definition 2.1 ([1])**.** A mapping $T : X \to X$ is a *contraction* if there exists $q \in [0,1)$ such that

$$\|Tu - Tv\|_\infty \le q\|u - v\|_\infty, \qquad \text{for all } u, v \in X.$$

Theorem 2.2 (Banach contraction principle [1])**.** *If $T : X \to X$ is a contraction, then T has a unique fixed point $u^* \in X$, and the Picard iteration $w_{m+1} = Tw_m$ converges to u^* for every $w_0 \in X$.*

Definition 2.3 (Rate of convergence, [21])**.** Let $\{u_m\}$ and $\{v_m\}$ be sequences in X converging to the same limit u^*, and suppose there are real sequences $\{\zeta_m\}, \{\eta_m\}$ with $\|u_m - u^*\|_\infty \le \zeta_m$ and $\|v_m - u^*\|_\infty \le \eta_m$ for all m. Then $\{u_m\}$ *converges faster* than $\{v_m\}$ if $\lim_{m\to\infty} \zeta_m/\eta_m = 0$.

Definition 2.4 (T-stability, [21])**.** Let $F_m : X \to X$ define an iteration $w_{m+1} = F_m(w_m)$ converging to a fixed point u^* of T. The iteration is *T-stable* if for every sequence $\{x_m\} \subset X$,

$$\lim_{m\to\infty} \|x_m - F_m(x_m)\|_\infty = 0 \iff \lim_{m\to\infty} x_m = u^*.$$

For control sequences $\{\zeta_m\}, \{\kappa_m\}, \{\eta_m\} \subset (0,1)$ and $w_0 \in X$, we recall the classical iterative schemes:

- *Picard iteration* [2]: $w_{m+1} = Tw_m$.
- *Mann iteration* [3]: $w_{m+1} = (1-\zeta_m)w_m + \zeta_m Tw_m$.
- *Ishikawa iteration* [4]: $v_m = (1-\kappa_m)w_m + \kappa_m Tw_m$, $w_{m+1} = (1-\zeta_m)w_m + \zeta_m Tv_m$.
- *S-iteration* [6]: $v_m = (1-\kappa_m)w_m + \kappa_m Tw_m$, $w_{m+1} = (1-\zeta_m)Tw_m + \zeta_m Tv_m$.

Definition 2.5 (Caputo fractional derivative and Riemann–Liouville integral, [22, 23, 24])**.** For $\alpha > 0$ and $u \in C[0,1]$, the Riemann–Liouville fractional integral of order α is defined by

$$(I^\alpha u)(t) = \frac{1}{\Gamma(\alpha)} \int_0^t (t-s)^{\alpha-1} u(s)\, ds, \qquad t \in [0,1],$$

where $\Gamma(\cdot)$ is the Euler Gamma function. For $0 < \alpha < 1$, the Caputo fractional derivative of u is defined as

$$({}^cD^\alpha u)(t) = (I^{1-\alpha} u')(t) = \frac{1}{\Gamma(1-\alpha)} \int_0^t (t-s)^{-\alpha} u'(s)\, ds, \qquad t \in (0,1].$$

Definition 2.6 (Nonlocal initial condition, cf. [27])**.** A *nonlocal (Byszewski-type) initial condition* for $u(0)$ is a relation $u(0) + g(u) = u_0$, in which $g : X \to \mathbb{R}$ is a given functional depending on the trajectory of u, rather than the classical pointwise condition $u(0) = u_0$.

Definition 2.7. Let $X = C[0,1]$. A continuous function $u \in X$ is defined as a mild solution to the nonlocal Caputo fractional initial value problem (A)-(B) if $u(t)$ satisfies the corresponding Volterra integral equation:

$$u(t) = u_0 - g(u) + \frac{1}{\Gamma(\alpha)} \int_0^t (t-s)^{\alpha-1} f(s, u(s)) ds, \quad \text{for all } t \in [0,1]. \tag{C}$$

3 The New Iteration Process and Its Abstract Theory

We recall the NIP scheme of Filali et al. [21] [[1], [2]].

Definition 3.1 (New Iteration Process, [21])**.** Let $T : X \to X$, $\{\zeta_m\}, \{\kappa_m\} \subset (0,1)$, and $w_0 \in X$[[1], [2]].. Define, for $m \geq 0$,

$$\begin{cases} u_m = (1-\zeta_m)w_m + \zeta_m T^2 w_m, \\ v_m = (1-\kappa_m)Tw_m + \kappa_m T^2 u_m, \\ w_{m+1} = Tv_m. \end{cases} \tag{NIP}$$

Theorem 3.2 (Strong convergence via Fractional Integration; cf. [21], Theorem 2)**.** *Let $T : X \to X$ be defined by the Volterra integral operator*

$$(Tu)(t) = u_0 - g(u) + \frac{1}{\Gamma(\alpha)} \int_0^t (t-s)^{\alpha-1} f(s, u(s))\, ds, \qquad t \in [0,1]. \tag{1}$$

Assume T is a contraction on X with constant $q = L_g + \frac{L_f}{\Gamma(\alpha+1)} < 1$ and unique solution $u^* \in X$. Let $\{w_m\}$ be generated by (NIP) *for an arbitrary starting function $w_0 \in X$. Then $\{w_m\}$ converges strongly to u^* in $C[0,1]$, and for every $m \geq 0$,*

$$\|w_{m+1} - u^*\|_\infty \leq r_m \|w_m - u^*\|_\infty, \tag{2}$$

where $r_m := q^2(1-\kappa_m) + \kappa_m q^3\big(1 - \zeta_m(1-q^2)\big) \leq q^2$. In particular,

$$\|w_m - u^*\|_\infty \leq q^{2m} \|w_0 - u^*\|_\infty \longrightarrow 0 \quad \text{as } m \to \infty.$$

Proof. **Step 0 (Integral Contractive Bound for T and T^2).** For any $x, y \in X$ and $t \in [0,1]$, evaluating the operator difference directly gives

$$\begin{aligned} |(Tx)(t) - (Ty)(t)| &= \left| -\big[g(x) - g(y)\big] + \frac{1}{\Gamma(\alpha)} \int_0^t (t-s)^{\alpha-1} \big[f(s, x(s)) - f(s, y(s))\big] ds \right| \\ &\leq |g(x) - g(y)| + \frac{1}{\Gamma(\alpha)} \int_0^t (t-s)^{\alpha-1} |f(s, x(s)) - f(s, y(s))|\, ds \\ &\leq L_g \|x - y\|_\infty + \frac{L_f}{\Gamma(\alpha)} \|x - y\|_\infty \int_0^t (t-s)^{\alpha-1}\, ds \\ &= \left(L_g + \frac{L_f t^\alpha}{\alpha \Gamma(\alpha)} \right) \|x - y\|_\infty \\ &\leq \left(L_g + \frac{L_f}{\Gamma(\alpha+1)} \right) \|x - y\|_\infty = q \|x - y\|_\infty, \end{aligned}$$

using $\int_0^t (t-s)^{\alpha-1} ds = t^\alpha/\alpha$, $\Gamma(\alpha+1) = \alpha\Gamma(\alpha)$, $t \leq 1$. Taking $\sup_{t \in [0,1]}$,

$$\|Tx - Ty\|_\infty \leq q \|x - y\|_\infty, \qquad x, y \in X. \tag{3}$$

Applying (3) to the pair (Tx, Ty), and then writing out $T^2x = T(Tx)$, $T^2y = T(Ty)$ explicitly via (1),

$$|(T^2x)(t) - (T^2y)(t)| \leq |g(Tx) - g(Ty)| + \frac{1}{\Gamma(\alpha)} \int_0^t (t-s)^{\alpha-1} |f(s, (Tx)(s)) - f(s, (Ty)(s))|\, ds \leq q \|Tx$$

by the identical chain of estimates applied to $(Tx, Ty) \in X \times X$; combined with (3),

$$\left\|T^2x - T^2y\right\|_\infty \leq q \|Tx - Ty\|_\infty \leq q^2 \|x - y\|_\infty, \qquad x, y \in X. \tag{4}$$

Since $Tu^* = u^*$, applying T again gives $T^2u^* = u^*$.

Step 1 (estimate for $u_m - u^*$). Since $u^* = (1-\zeta_m)u^* + \zeta_m u^* = (1-\zeta_m)u^* + \zeta_m T^2u^*$, subtracting from the definition of u_m,

$$u_m(t) - u^*(t) = (1-\zeta_m)\big[w_m(t) - u^*(t)\big] + \zeta_m\big[(T^2w_m)(t) - (T^2u^*)(t)\big].$$

By the triangle inequality and (4) with $(x,y) = (w_m, u^*)$,

$$\|u_m - u^*\|_\infty \le (1-\zeta_m)\|w_m - u^*\|_\infty + \zeta_m q^2 \|w_m - u^*\|_\infty = q_u \|w_m - u^*\|_\infty, \qquad q_u = 1-\zeta_m(1-q^2) \in [q^2, \tag{5}$$

Step 2 (estimate for $v_m - u^*$). Since $u^* = (1-\kappa_m)Tu^* + \kappa_m T^2u^*$ (as $Tu^* = T^2u^* = u^*$), subtracting from the definition of v_m,

$$v_m(t) - u^*(t) = (1-\kappa_m)\big[(Tw_m)(t) - (Tu^*)(t)\big] + \kappa_m\big[(T^2u_m)(t) - (T^2u^*)(t)\big].$$

By (3) with $(x,y) = (w_m, u^*)$ and (4) with $(x,y) = (u_m, u^*)$,

$$\|v_m - u^*\|_\infty \le (1-\kappa_m)q\|w_m - u^*\|_\infty + \kappa_m q^2 \|u_m - u^*\|_\infty.$$

Substituting (5),

$$\|v_m - u^*\|_\infty \le \Big[(1-\kappa_m)q + \kappa_m q^2 q_u\Big] \|w_m - u^*\|_\infty = \theta_m \|w_m - u^*\|_\infty. \tag{6}$$

The intermediate parameter θ_m and the sub-step contraction factor q_u are defined respectively as $\theta_m = (1-\kappa_m)q + \kappa_m q^2 q_u$, where $q_u = 1-\zeta_m(1-q^2)$

Step 3 (estimate for $w_{m+1} - u^*$). Since $Tu^* = u^*$, and directly evaluating $(Tv_m)(t) - (Tu^*)(t)$ via (1),

$$|(Tv_m)(t) - (Tu^*)(t)| \le |g(v_m) - g(u^*)| + \frac{1}{\Gamma(\alpha)}\int_0^t (t-s)^{\alpha-1}|f(s,v_m(s)) - f(s,u^*(s))|\,ds \le q\|v_m - u^*\|_\infty,$$

by the same chain as (3), so, using (6),

$$\|w_{m+1} - u^*\|_\infty \le q\|v_m - u^*\|_\infty \le q\theta_m \|w_m - u^*\|_\infty = r_m \|w_m - u^*\|_\infty, \tag{7}$$

where $r_m = q\theta_m = q^2(1-\kappa_m) + \kappa_m q^3 q_u$, which is exactly (2) (recalling $q_u = 1-\zeta_m(1-q^2)$). Since $q_u \le 1$,

$$r_m = q^2(1-\kappa_m) + \kappa_m q^3 q_u \le q^2(1-\kappa_m) + \kappa_m q^3 \le q^2(1-\kappa_m) + \kappa_m q^2 = q^2,$$

using $q < 1 \Rightarrow q^3 \le q^2$. Hence $r_m \le q^2 < 1$ for every $m \ge 0$.

Step 4 (explicit unrolling: $q^2, q^4, q^6, q^8, \ldots$, then formal induction). We now make the geometric decay fully explicit rather than invoking induction in one line, since this is where the acceleration of NIP relative to Picard-type schemes (which only attain a single power of q per step) becomes visible term by term.

At $m = 0$: by (7), $\|w_1 - u^*\|_\infty \le r_0 \|w_0 - u^*\|_\infty \le q^2 \|w_0 - u^*\|_\infty$.

At $m = 1$: applying (7) again, now with w_1 in place of w_0,

$$\|w_2 - u^*\|_\infty \le r_1 \|w_1 - u^*\|_\infty \le q^2 \|w_1 - u^*\|_\infty \le q^2\big(q^2 \|w_0 - u^*\|_\infty\big) = q^4 \|w_0 - u^*\|_\infty.$$

At $m = 2$:

$$\|w_3 - u^*\|_\infty \le r_2 \|w_2 - u^*\|_\infty \le q^2 \|w_2 - u^*\|_\infty \le q^2\big(q^4 \|w_0 - u^*\|_\infty\big) = q^6 \|w_0 - u^*\|_\infty.$$

At $m = 3$:

$$\|w_4 - u^*\|_\infty \le r_3 \|w_3 - u^*\|_\infty \le q^2 \|w_3 - u^*\|_\infty \le q^2\big(q^6 \|w_0 - u^*\|_\infty\big) = q^8 \|w_0 - u^*\|_\infty .$$

At $m = 4$: by exactly the same one-step application of (7),

$$\|w_5 - u^*\|_\infty \le q^2 \|w_4 - u^*\|_\infty \le q^2\big(q^8 \|w_0 - u^*\|_\infty\big) = q^{10} \|w_0 - u^*\|_\infty .$$

The pattern is now unmistakable: each application of (7) multiplies the previous bound by an additional factor of q^2, so that after m applications the exponent of q has grown by $2m$. We record this as a formal claim and prove it by mathematical induction on m, which is the rigorous justification for the pattern observed above.

Claim. $\|w_m - u^*\|_\infty \le q^{2m} \|w_0 - u^*\|_\infty$ for every $m \ge 0$.

Base case ($m = 0$): $\|w_0 - u^*\|_\infty \le q^0 \|w_0 - u^*\|_\infty = \|w_0 - u^*\|_\infty$, trivially true with equality.

Inductive step: Suppose the claim holds for some $m \ge 0$, i.e. $\|w_m - u^*\|_\infty \le q^{2m} \|w_0 - u^*\|_\infty$. By (7) and $r_m \le q^2$,

$$\|w_{m+1} - u^*\|_\infty \le r_m \|w_m - u^*\|_\infty \le q^2 \cdot \|w_m - u^*\|_\infty \le q^2 \cdot q^{2m} \|w_0 - u^*\|_\infty = q^{2(m+1)} \|w_0 - u^*\|_\infty .$$

By mathematical induction,

$$\|w_m - u^*\|_\infty \le q^{2m} \|w_0 - u^*\|_\infty .$$

Because $q \in (0, 1)$, $q^{2m} \to 0$ as $m \to \infty$, This proves strong convergence.

Theorem 3.3 (T-stability via Volterra Integration; cf. [21], Theorem 3)**.** *Under the hypotheses of Theorem 3.2, the iteration* (NIP)*, represented by the operator composition $w_{m+1} = F_m(w_m)$ with*

$$F_m(w) = u_0 - g(v_m(w)) + \frac{1}{\Gamma(\alpha)} \int_0^t (t - s)^{\alpha-1} f(s, v_m(w)(s))\, ds,$$

where $v_m(w) = (1 - \kappa_m)Tw + \kappa_m T^2((1 - \zeta_m)w + \zeta_m T^2 w)$, is T-stable in $C[0, 1]$.

Proof. **Step 1 (Integral Lipschitz Bound for F_m).** For any functions $x, y \in C[0, 1]$, applying the integral operator bounds from Step 0–3 of Theorem 3.2 gives

$$\begin{aligned} |(F_m(x))(t) - (F_m(y))(t)| &\le |g(v_m(x)) - g(v_m(y))| \\ &\quad + \frac{1}{\Gamma(\alpha)} \int_0^t (t - s)^{\alpha-1} |f(s, v_m(x)(s)) - f(s, v_m(y)(s))|\, ds \\ &\le q\|v_m(x) - v_m(y)\|_\infty \le r_m \|x - y\|_\infty \le q^2 \|x - y\|_\infty . \end{aligned}$$

Taking supremum over $t \in [0, 1]$ gives $\|F_m(x) - F_m(y)\|_\infty \le r_m \|x - y\|_\infty$. Also, $F_m(u^*) = u^*$.

Step 2 ($\Longrightarrow$). Let $\{x_m\} \subset C[0, 1]$ be a sequence such that $\lim_{m\to\infty} \|x_m - F_m(x_m)\|_\infty = 0$. By the triangle inequality,

$$\begin{aligned} \|x_m - u^*\|_\infty &\le \|x_m - F_m(x_m)\|_\infty + \|F_m(x_m) - F_m(u^*)\|_\infty \\ &\le \|x_m - F_m(x_m)\|_\infty + r_m \|x_m - u^*\|_\infty . \end{aligned}$$

Rearranging yields $\|x_m - u^*\|_\infty \le \frac{1}{1-q^2} \|x_m - F_m(x_m)\|_\infty$. Taking $m \to \infty$ gives $x_m \to u^*$.

Step 3 ($\Longleftarrow$). Conversely, if $x_m \to u^*$,

$$\|x_m - F_m(x_m)\|_\infty \le \|x_m - u^*\|_\infty + \|F_m(u^*) - F_m(x_m)\|_\infty \le (1 + q^2)\|x_m - u^*\|_\infty \longrightarrow 0$$

as $m \to \infty$, proving T-stability. □

Theorem 3.4 (Rate Comparison; cf. [21], Theorem 4)**.** *Let $T : C[0,1] \to C[0,1]$ be the Volterra integral operator* (1) *with contraction constant $q \in (0,1)$ and solution u^*. Let $\{\zeta_m\}, \{\kappa_m\} \subset (0,1)$ be sequences bounded away from* 0 *and* 1*. there is $\delta \in (0, \frac{1}{2})$ such that*

$$\delta \le \zeta_m, \kappa_m \le 1 - \delta, \qquad \forall m \ge 0.$$

Then the NIP sequence $\{w_m\}$ converges to u^* faster (2.3)*than the Picard, Mann, Ishikawa, and S-iteration sequences generated by T from the same w_0.*

Proof. By Theorem 3.2, $\|w_m - u^*\|_\infty \le Aq^{2m}$, $A = \|w_0 - u^*\|_\infty$. We derive, from the defining recursions of Section 2 and the contraction bound (3), an explicit one-step (and hence, by induction exactly as in Step 4 of Theorem 3.2 proof, an explicit m-step) bound for each classical scheme, then compare exponents.

Picard. $p_{m+1} = Tp_m$, so by (3), $\|p_{m+1} - u^*\|_\infty \le q \|p_m - u^*\|_\infty$; by induction (base case trivial, inductive step identical in structure to Theorem 3.2 Step 4 but with a single power of q per step), so by induction

$$\|p_m - u^*\|_\infty \le B\, q^m, \qquad B = \|p_0 - u^*\|_\infty.$$

Hence the comparison ratio is

$$\frac{\|w_m - u^*\|_\infty}{\|p_m - u^*\|_\infty} \le \frac{A}{B} \left(\frac{q^2}{q}\right)^m = \frac{A}{B}\, q^m \;\longrightarrow\; 0,$$

since $q \in (0,1)$. Therefore $\{w_m\}$ converges faster than the Picard sequence $\{p_m\}$.

Mann. $m_{m+1} = (1 - \zeta_m)m_m + \zeta_m T m_m$. Since $u^* = (1 - \zeta_m)u^* + \zeta_m T u^*$,

$$m_{m+1}(t) - u^*(t) = (1 - \zeta_m)\big[m_m(t) - u^*(t)\big] + \zeta_m\big[(Tm_m)(t) - (Tu^*)(t)\big],$$

so, by (3), $\|m_{m+1} - u^*\|_\infty \le (1 - \zeta_m)\|m_m - u^*\|_\infty + \zeta_m q \|m_m - u^*\|_\infty = c_m \|m_m - u^*\|_\infty$, $c = 1 - \zeta_m(1 - q)$;

$$c_m \le c^* = 1 - \delta(1 - q) \qquad \forall m,$$

so by induction

$$\|m_m - u^*\|_\infty \le C\,(c^*)^m, \qquad C = \|m_0 - u^*\|_\infty.$$

Moreover

$$c^* - q = (1 - q)(1 - \delta) > 0 \implies c^* > q > q^2.$$

Hence the comparison ratio is

$$\frac{\|w_m - u^*\|_\infty}{\|m_m - u^*\|_\infty} \le \frac{A}{C} \left(\frac{q^2}{c^*}\right)^m = \frac{A}{C} \left(\frac{q^2}{1 - \delta(1 - q)}\right)^m \;\longrightarrow\; 0,$$

because $0 < q^2/c^* < 1$. Therefore $\{w_m\}$ converges faster than the Mann sequence $\{m_m\}$.

S-iteration. $v_m = (1 - \kappa_m)w_m + \kappa_m T w_m$, $w_{m+1} = (1 - \zeta_m)Tw_m + \zeta_m T v_m$. As above, $\|v_m - u^*\|_\infty \le (1 - \kappa_m)\|w_m - u^*\|_\infty + \kappa_m q \|w_m - u^*\|_\infty = [1 - \kappa_m(1 - q)]\|w_m - u^*\|_\infty$. Since $u^* = (1 - \zeta_m)Tu^* + \zeta_m T u^*$ (as $Tu^* = u^*$),

$$w_{m+1}(t) - u^*(t) = (1 - \zeta_m)\big[(Tw_m)(t) - (Tu^*)(t)\big] + \zeta_m\big[(Tv_m)(t) - (Tu^*)(t)\big],$$

so, by (3) applied twice,

$$\begin{aligned} ||w_{m+1} - u^*||_\infty &\le (1 - \zeta_m)q||w_m - u^*||_\infty + \zeta_m q||v_m - u^*||_\infty \\ &\le q\Big[(1 - \zeta_m) + \zeta_m\big(1 - \kappa_m(1 - q)\big)\Big]||w_m - u^*||_\infty \end{aligned}$$

$$\|w_{m+1} - u^*\|_\infty \le q\big[1 - \zeta_m\kappa_m(1-q)\big]\,\|w_m - u^*\|_\infty = s_m\|w_m - u^*\|_\infty.$$

Since s_m is decreasing in $\zeta_m\kappa_m \ge \delta^2$,

$$s_m \le s^* = q\big[1 - \delta^2(1-q)\big] \qquad \forall m,$$

so by induction

$$\|s_m - u^*\|_\infty \le D\,(s^*)^m, \qquad D = \|s_0 - u^*\|_\infty.$$

Moreover

$$s^* - q^2 = q(1-q)(1-\delta^2) > 0 \implies s^* > q^2.$$

Hence the comparison ratio is

$$\frac{\|w_m - u^*\|_\infty}{\|s_m - u^*\|_\infty} \le \frac{A}{D}\left(\frac{q^2}{s^*}\right)^m = \frac{A}{D}\left(\frac{q}{1-\delta^2(1-q)}\right)^m \longrightarrow 0,$$

because $0 < q^2/s^* < 1$. Therefore $\{w_m\}$ converges faster than the S-iteration sequence $\{s_m\}$.

Ishikawa. With $v_m = (1-\kappa_m)x_m + \kappa_m T x_m$ and $x_{m+1} = (1-\zeta_m)x_m + \zeta_m T v_m$, (3) gives

$$\|v_m - u^*\|_\infty \le \big[1 - \kappa_m(1-q)\big]\,\|x_m - u^*\|_\infty,$$

and since $u^* = (1-\zeta_m)u^* + \zeta_m T u^*$,

$$\|x_{m+1} - u^*\|_\infty \le \big[1 - \zeta_m(1-q)(1+q\kappa_m)\big]\,\|x_m - u^*\|_\infty = r_{I,m}\|x_m - u^*\|_\infty.$$

Since $\zeta_m(1+q\kappa_m)$ is increasing in both ζ_m and κ_m, it attains its minimum at $\zeta_m = \kappa_m = \delta$, so

$$r_{I,m} \le r_I^* = 1 - \delta(1-q)(1+q\delta) \qquad \forall m,$$

hence by induction

$$\|x_m - u^*\|_\infty \le E\,(r_I^*)^m, \qquad E = \|x_0 - u^*\|_\infty.$$

Moreover, since $\delta < 1$ and $q\delta < 1$ imply $\delta(1+q\delta) < 1+q$,

$$r_I^* - q^2 = (1-q)\big[(1+q) - \delta(1+q\delta)\big] > 0 \implies r_I^* > q^2.$$

Hence the comparison ratio is

$$\frac{\|w_m - u^*\|_\infty}{\|x_m - u^*\|_\infty} \le \frac{A}{E}\left(\frac{q^2}{r_I^*}\right)^m = \frac{A}{E}\left(\frac{q^2}{1-\delta(1-q)(1+q\delta)}\right)^m \longrightarrow 0,$$

because $0 < q^2/r_I^* < 1$. Therefore $\{w_m\}$ converges faster than the Ishikawa sequence $\{x_m\}$.

Conclusion. For each classical scheme with one-step factor $\rho \in \{q, c^*, s^*, r_I^*\}$, we have shown $\rho > q^2$ pointwise for every m; since ζ_m, κ_m are bounded away from $0, 1$, ρ is in fact bounded away from q^2 by a fixed gap independent of m (each of c, s, r_I is a continuous, monotone function of $\zeta_m, \kappa_m \in [\delta, 1-\delta]$, attaining its infimum over this compact range at a value still $> q^2$). Hence there is $\rho_{\min} > q^2$ with $\rho \ge \rho_{\min}$ for every m and every scheme, and

$$\lim_{m\to\infty} \frac{Aq^{2m}}{A\rho^m} \le \lim_{m\to\infty}\left(\frac{q^2}{\rho_{\min}}\right)^m = 0,$$

since $q^2/\rho_{\min} < 1$. By Definition 2.3, $\{w_m\}$ converges faster than each of the four classical schemes. □

Remark 3.5. In the constant-parameter case $\zeta_m \equiv \zeta$, $\kappa_m \equiv \kappa$ (so that δ may be taken equal to $\min(\zeta, \kappa) = \max(\zeta, \kappa)$), the ratios above reduce exactly to those implicit in [21]Theorem 4 : q, q^2/c, q/s, q^2/r_I, with $c = 1 - \zeta(1-q)$, $s = q\big[1 - \zeta\kappa(1-q)\big]$, $r_I = 1 - \zeta(1-q)(1+q\kappa)$.

Theorem 3.6 (Data Dependence via Fractional Integration; cf. [21], Theorem 5)**.** *Let* $T, \widetilde{T} : C[0,1] \to C[0,1]$ *be two fractional integral operators defined by*

$$(Tu)(t) = u_0 - g(u) + \frac{1}{\Gamma(\alpha)} \int_0^t (t-s)^{\alpha-1} f(s, u(s))\, ds,$$

$$(\widetilde{T}u)(t) = \widetilde{u}_0 - \widetilde{g}(u) + \frac{1}{\Gamma(\alpha)} \int_0^t (t-s)^{\alpha-1} \widetilde{f}(s, u(s))\, ds,$$

with identical Lipschitz constant $q \in (0,1)$ *and unique solutions* $u^*, \widetilde{u}^*$*. If* $\sup_{x \in X} \|Tx - \widetilde{T}x\|_\infty \leq \varepsilon$*, then*

$$\|u^* - \widetilde{u}^*\|_\infty \leq \frac{\varepsilon}{1-q}. \tag{8}$$

Moreover, NIP sequences $\{w_m\}, \{\widetilde{w}_m\}$ *generated by* T *and* $\widetilde{T}$ *with* $w_0 = \widetilde{w}_0$ *satisfy*

$$\|w_m - \widetilde{w}_m\|_\infty \leq q^{2m} \|w_0 - \widetilde{w}_0\|_\infty + \frac{C(q)\varepsilon}{1-q^2}, \qquad C(q) = 1 + q + q^2 + q^3 + q^4. \tag{9}$$

Proof. **Bound (8).** Since $Tu^* = u^*$, $\widetilde{T}\widetilde{u}^* = \widetilde{u}^*$,

$$\|u^* - \widetilde{u}^*\|_\infty = \left\|Tu^* - \widetilde{T}\widetilde{u}^*\right\|_\infty \leq \|Tu^* - T\widetilde{u}^*\|_\infty + \left\|T\widetilde{u}^* - \widetilde{T}\widetilde{u}^*\right\|_\infty \leq q\, \|u^* - \widetilde{u}^*\|_\infty + \varepsilon,$$

using (3) for T and the hypothesis $\left\|Tx - \widetilde{T}x\right\|_\infty \leq \varepsilon$ at $x = \widetilde{u}^*$. Rearranging, $(1-q)\, \|u^* - \widetilde{u}^*\|_\infty \leq \varepsilon$, giving (8).

Bound (9). Write $e_m = \|w_m - \widetilde{w}_m\|_\infty$.

Step A *($u_m - \widetilde{u}_m$).* Subtracting the two versions of the first NIP sub-step,

$$u_m(t) - \widetilde{u}_m(t) = (1 - \zeta_m)\big[w_m(t) - \widetilde{w}_m(t)\big] + \zeta_m\big[(T^2 w_m)(t) - (\widetilde{T}^2 \widetilde{w}_m)(t)\big].$$

Insert and subtract $(T^2 \widetilde{w}_m)(t)$:

$$(T^2 w_m)(t) - (\widetilde{T}^2 \widetilde{w}_m)(t) = \big[(T^2 w_m)(t) - (T^2 \widetilde{w}_m)(t)\big] + \big[(T^2 \widetilde{w}_m)(t) - (\widetilde{T}^2 \widetilde{w}_m)(t)\big].$$

By (4), the first term has norm $\leq q^2 e_m$. For the second, write $T^2 \widetilde{w}_m = T(T\widetilde{w}_m)$, $\widetilde{T}^2 \widetilde{w}_m = \widetilde{T}(\widetilde{T}\widetilde{w}_m)$, insert/subtract $\widetilde{T}(T\widetilde{w}_m)$:

$$(T^2 \widetilde{w}_m)(t) - (\widetilde{T}^2 \widetilde{w}_m)(t) = \big[T(T\widetilde{w}_m)(t) - \widetilde{T}(T\widetilde{w}_m)(t)\big] + \big[\widetilde{T}(T\widetilde{w}_m)(t) - \widetilde{T}(\widetilde{T}\widetilde{w}_m)(t)\big].$$

The first piece has norm $\leq \varepsilon$ by hypothesis (evaluated at $x = T\widetilde{w}_m$). The second, by (3) for $\widetilde{T}$ and the hypothesis again (at $x = \widetilde{w}_m$),

$$\left\|\widetilde{T}(T\widetilde{w}_m) - \widetilde{T}(\widetilde{T}\widetilde{w}_m)\right\|_\infty \leq q\, \left\|T\widetilde{w}_m - \widetilde{T}\widetilde{w}_m\right\|_\infty \leq q\varepsilon.$$

Combining, $\left\|T^2 \widetilde{w}_m - \widetilde{T}^2 \widetilde{w}_m\right\|_\infty \leq \varepsilon + q\varepsilon = (1+q)\varepsilon$, and so

$$\|u_m - \widetilde{u}_m\|_\infty \leq (1-\zeta_m) e_m + \zeta_m\big[q^2 e_m + (1+q)\varepsilon\big] = q_u e_m + \zeta_m(1+q)\varepsilon, \qquad q_u = 1 - \zeta_m(1-q^2). \tag{10}$$

Step B *($v_m - \widetilde{v}_m$).*

$$v_m(t) - \widetilde{v}_m(t) = (1 - \kappa_m)\big[(Tw_m)(t) - (\widetilde{T}\widetilde{w}_m)(t)\big] + \kappa_m\big[(T^2 u_m)(t) - (\widetilde{T}^2 \widetilde{u}_m)(t)\big].$$

For the first bracket, insert/subtract $(T\widetilde{w}_m)(t)$ by (3) and the hypothesis, $\left\|Tw_m - \widetilde{T}\widetilde{w}_m\right\|_\infty \le qe_m + \varepsilon$. For the second, insert/subtract $(T^2\widetilde{u}_m)(t)$ exactly as in Step A:

$$\left\|T^2u_m - \widetilde{T}^2\widetilde{u}_m\right\|_\infty \le q^2\left\|u_m - \widetilde{u}_m\right\|_\infty + (1+q)\varepsilon \le q^2\big[q_ue_m + \zeta_m(1+q)\varepsilon\big] + (1+q)\varepsilon,$$

using (10). Combining both brackets,

$$\begin{aligned}\left\|v_m - \widetilde{v}_m\right\|_\infty &\le (1-\kappa_m)\big[qe_m + \varepsilon\big] + \kappa_m\Big\{q^2q_ue_m + \big[q^2\zeta_m(1+q) + (1+q)\big]\varepsilon\Big\} \\ &= \underbrace{\big[(1-\kappa_m)q + \kappa_mq^2q_u\big]}_{=\theta_m}e_m + \underbrace{\Big[1 + \kappa_mq + \kappa_mq^2\zeta_m(1+q)\Big]}_{=C_v}\varepsilon, \qquad (11)\end{aligned}$$

using $(1-\kappa_m) + \kappa_m(1+q) = 1 + \kappa_mq$.

Step C *$(w_{m+1} - \widetilde{w}_{m+1})$.*

$w_{m+1}(t) - \widetilde{w}_{m+1}(t) = (Tv_m)(t) - (\widetilde{T}\widetilde{v}_m)(t) = \big[(Tv_m)(t) - (T\widetilde{v}_m)(t)\big] + \big[(T\widetilde{v}_m)(t) - (\widetilde{T}\widetilde{v}_m)(t)\big]$,

so, by (3) and the hypothesis, and then (12),

$$e_{m+1} \le q\left\|v_m - \widetilde{v}_m\right\|_\infty + \varepsilon \le q\theta_me_m + qC_v\varepsilon + \varepsilon.$$

Note $q\theta_m = q\big[(1-\kappa_m)q + \kappa_mq^2q_u\big] = q^2\big[(1-\kappa_m) + \kappa_mqq_u\big] = r_m$ Theorem 3.2. Setting

$$C = qC_v + 1 = q\Big[1 + \kappa_mq + \kappa_mq^2\zeta_m(1+q)\Big] + 1 = 1 + q + \kappa_mq^2 + \kappa_mq^3\zeta_m(1+q),$$

we obtain

$$e_{m+1} \le r_me_m + C\varepsilon \le q^2e_m + C\varepsilon, \qquad (12)$$

using $r_m \le q^2$. Bounding $\kappa_m, \zeta_m \le 1$, $C \le 1 + q + q^2 + q^3(1+q) = 1 + q + q^2 + q^3 + q^4 = C(q)$, matching the statement.

Step D [Exactly as in Theorem 3.2] Step 4,] we use (12) explicitly:

$$\begin{aligned}e_1 &\le q^2e_0 + C(q)\varepsilon, \\ e_2 \le q^2e_1 + C(q)\varepsilon &\le q^2\big[q^2e_0 + C(q)\varepsilon\big] + C(q)\varepsilon = q^4e_0 + \big[q^2+1\big]C(q)\varepsilon, \\ e_3 &\le q^2e_2 + C(q)\varepsilon \le q^6e_0 + \big[q^4 + q^2 + 1\big]C(q)\varepsilon,\end{aligned}$$

and, by an induction identical in structure to Theorem 3.2 (base case trivial; inductive step multiplies by q^2 and adds one further term $C(q)\varepsilon$),

$$e_m \le q^{2m}e_0 + C(q)\varepsilon\sum_{j=0}^{m-1}q^{2j} = q^{2m}e_0 + C(q)\varepsilon\cdot\frac{1-q^{2m}}{1-q^2} \le q^{2m}e_0 + \frac{C(q)\varepsilon}{1-q^2},$$

which is (4). □

4 Application to a Nonlocal Caputo Fractional Initial Value Problem

Let $X = C[0,1]$ equipped with the supremum norm $\|u\|_\infty = \max_{t\in[0,1]}|u(t)|$. We consider the nonlocal Caputo fractional initial value problem

$$\begin{aligned}{}^cD^\alpha u(t) &= f(t,u(t)), \qquad t \in J = (0,1], \quad 0 < \alpha < 1, \qquad (13)\\ u(0) + g(u) &= u_0, \qquad (14)\end{aligned}$$

where $f : [0,1]\times\mathbb{R} \to \mathbb{R}$ is continuous, $u_0 \in \mathbb{R}$ is a given constant, and $g : X \to \mathbb{R}$ is a nonlocal functional[3].

Definition 4.1. Let $X = C[0,1]$. A continuous function $u \in X$ is defined as a mild solution to the nonlocal Caputo fractional initial value problem (13)-(14) if $u(t)$ satisfies the corresponding Volterra integral equation:

$$u(t) = u_0 - g(u) + \frac{1}{\Gamma(\alpha)} \int_0^t (t-s)^{\alpha-1} f(s, u(s)) ds, \quad \text{for all } t \in [0,1]. \tag{15}$$

Lemma 4.2 (Equivalent Integral Equation)**.** *Let $u \in C[0,1]$ such that $I^{1-\alpha}u \in C^1[0,1]$. Then $u(t)$ is a Mild solution of* (13)-(14) *if and only if $u(t)$ satisfies the Volterra integral equation* (15)

Proof. ($\Longrightarrow$) Let $u(t)$ satisfy the differential equation (13) with condition (14). Applying the Riemann–Liouville fractional integral operator I^α to both sides of (13),

$$I^\alpha \left({}^cD^\alpha u\right)(t) = I^\alpha \left(f(\cdot, u(\cdot))\right)(t).$$

By the standard fundamental relation connecting the Caputo fractional derivative and integral for $0 < \alpha < 1$, we obtain By (2.5) ${}^cD^\alpha u(t) = (I^{1-\alpha}u')(t)$. Hence

$$I^\alpha \big({}^cD^\alpha u\big)(t) = I^\alpha \big(I^{1-\alpha}u'\big)(t).$$

$$u(t) - u(0) = \frac{1}{\Gamma(\alpha)} \int_0^t (t-s)^{\alpha-1} f(s, u(s))\, ds.$$

Substituting the nonlocal initial condition $u(0) = u_0 - g(u)$ yields

$$u(t) = u_0 - g(u) + \frac{1}{\Gamma(\alpha)} \int_0^t (t-s)^{\alpha-1} f(s, u(s))\, ds,$$

which is precisely equation (15).

($\Longleftarrow$) Conversely, suppose $u \in C[0,1]$ satisfies (15). Evaluating (15) at $t = 0$ gives

$$u(0) = u_0 - g(u) + \frac{1}{\Gamma(\alpha)} \int_0^0 (0-s)^{\alpha-1} f(s, u(s))\, ds = u_0 - g(u),$$

which proves $u(0) + g(u) = u_0$. Next, applying the Caputo operator ${}^cD^\alpha$ to both sides of (15), noting that ${}^cD^\alpha(u_0 - g(u)) = 0$ for constant terms and ${}^cD^\alpha I^\alpha f(t, u(t)) = f(t, u(t))$, we recover

$${}^cD^\alpha u(t) = f(t, u(t)).$$

Hence, $u(t)$ is a solution of (13)–(14). □

Define the operator $T : X \to X$ associated with equation (15) by

$$(Tu)(t) = u_0 - g(u) + \frac{1}{\Gamma(\alpha)} \int_0^t (t-s)^{\alpha-1} f(s, u(s))\, ds. \tag{16}$$

Proposition 4.3 (Contraction Property of T)**.** *Assume that the following conditions hold:*

(H1) There exists $L_f > 0$ such that

$$|f(t,u) - f(t,v)| \le L_f |u - v|, \qquad \forall t \in [0,1],\ u, v \in \mathbb{R}.$$

(H2) There exists $L_g > 0$ such that

$$|g(u) - g(v)| \le L_g \|u - v\|_\infty, \qquad \forall u, v \in X.$$

(H3) The constant q defined by

$$q = L_g + \frac{L_f}{\Gamma(\alpha+1)} < 1.$$

Then T defined in (16) *is a contraction on X with contraction constant q.*

Proof. Let $u, v \in X$ and $t \in [0,1]$. Using the operator definition (16), we write

$$\begin{aligned}|(Tu)(t) - (Tv)(t)| &= \left| -[g(u) - g(v)] + \frac{1}{\Gamma(\alpha)} \int_0^t (t-s)^{\alpha-1} \big[f(s,u(s)) - f(s,v(s)) \big]\, ds \right| \\ &\leq |g(u) - g(v)| + \frac{1}{\Gamma(\alpha)} \int_0^t (t-s)^{\alpha-1} \big| f(s,u(s)) - f(s,v(s)) \big|\, ds.\end{aligned}$$

Applying conditions (H1) and (H2), we get

$$\begin{aligned}|(Tu)(t) - (Tv)(t)| &\leq L_g \|u - v\|_\infty + \frac{L_f}{\Gamma(\alpha)} \int_0^t (t-s)^{\alpha-1} |u(s) - v(s)|\, ds \\ &\leq L_g \|u - v\|_\infty + \frac{L_f}{\Gamma(\alpha)} \|u - v\|_\infty \int_0^t (t-s)^{\alpha-1}\, ds.\end{aligned}$$

Evaluating the fractional integral directly,

$$\int_0^t (t-s)^{\alpha-1}\, ds = \frac{t^\alpha}{\alpha} \leq \frac{1}{\alpha}, \qquad \forall t \in [0,1].$$

Recalling $\Gamma(\alpha+1) = \alpha\Gamma(\alpha)$, it follows that

$$|(Tu)(t) - (Tv)(t)| \leq L_g \|u - v\|_\infty + \frac{L_f}{\alpha\Gamma(\alpha)} \|u - v\|_\infty = \left(L_g + \frac{L_f}{\Gamma(\alpha+1)} \right) \|u - v\|_\infty.$$

Taking the supremum over $t \in [0,1]$, we obtain $\|Tu - Tv\|_\infty \leq q \|u - v\|_\infty$. Since $q < 1$ by (H3), T is a strict contraction on X. □

Theorem 4.4 (Main Existence and NIP Convergence)**.** *Under hypotheses (H1)-(H3), problem* (13)-(14) *has a unique solution $u^* \in C[0,1]$. Moreover, for any initial guess $w_0 \in C[0,1]$, the sequence $\{w_m\}_{m=0}^\infty$ generated by the New Iteration Process (NIP) converges strongly to u^* with the error bound*

$$\|w_m - u^*\|_\infty \leq q^{2m} \|w_0 - u^*\|_\infty,$$

and the scheme is T-stable.

Proof. **Step 1 (Existence and Uniqueness via Banach Contraction Principle).** By Proposition 4.3, the operator $T : X \to X$ defined by (16) is a strict contraction on the complete metric space (Banach space) $X = C[0,1]$ under hypothesis (H3) ($q < 1$). Therefore, by the Banach Contraction Principle (Theorem 2.2), T possesses a unique fixed point $u^* \in X$, satisfying $Tu^* = u^*$. Through Lemma 4.2, finding a fixed point of T is completely equivalent to solving the nonlocal fractional initial value problem (13)-(14). Thus, $u^* \in C[0,1]$ is the unique solution to the nonlocal Caputo-type problem.

Step 2 (Strong Convergence of the New Iteration Process). To establish the strong convergence of the New Iteration Process (NIP) sequence $\{w_m\}_{m=0}^\infty$ generated from an arbitrary initial guess $w_0 \in C[0,1]$, we invoke the abstract convergence machinery established in Theorem 3.2 for Volterra integral operators. Specifically, the recursive error estimate between the NIP iterate w_{m+1} and the unique solution u^* satisfies:

$$\|w_{m+1} - u^*\|_\infty \leq r_m \|w_m - u^*\|_\infty,$$

where $r_m = q^2(1-\kappa_m) + \kappa_m q^3\big(1-\zeta_m(1-q^2)\big) \le q^2 < 1$. Unrolling this inequality recursively across m steps via mathematical induction yields the global error bound:

$$\|w_m - u^*\|_\infty \le q^{2m}\|w_0 - u^*\|_\infty.$$

Since $q \in (0,1)$, it follows that $q^{2m} \to 0$ as $m \to \infty$, which proves that the sequence $\{w_m\}$ converges strongly to the unique solution u^* in the supremum norm topology of $C[0,1]$.

Step 3 (T-Stability of the NIP Scheme). To show that the NIP scheme is T-stable in the sense of Definition 2.4, we represent the overall NIP multi-step procedure as a composite operator sequence $w_{m+1} = F_m(w_m)$, where:

$$F_m(w) = u_0 - g(v_m(w)) + \frac{1}{\Gamma(\alpha)}\int_0^t (t-s)^{\alpha-1} f(s, v_m(w)(s))\, ds,$$

with $v_m(w) = (1-\kappa_m)Tw + \kappa_m T^2((1-\zeta_m)w + \zeta_m T^2 w)$. By the integral Lipschitz bounds proven in Theorem 3.3, F_m satisfies $\|F_m(x) - F_m(y)\|_\infty \le r_m\|x-y\|_\infty \le q^2\|x-y\|_\infty$ for all $x, y \in C[0,1]$, and $F_m(u^*) = u^*$.

Let $\{x_m\} \subset C[0,1]$ be an arbitrary sequence such that $\lim_{m\to\infty}\|x_m - F_m(x_m)\|_\infty = 0$. By the triangle inequality:

$$\|x_m - u^*\|_\infty \le \|x_m - F_m(x_m)\|_\infty + \|F_m(x_m) - F_m(u^*)\|_\infty \le \|x_m - F_m(x_m)\|_\infty + q^2\|x_m - u^*\|_\infty.$$

Rearranging terms gives:

$$\|x_m - u^*\|_\infty \le \frac{1}{1-q^2}\|x_m - F_m(x_m)\|_\infty.$$

Taking the limit as $m \to \infty$ on both sides yields $\lim_{m\to\infty}\|x_m - u^*\|_\infty = 0$ (i.e., $x_m \to u^*$). Conversely, if $x_m \to u^*$, then:

$$\|x_m - F_m(x_m)\|_\infty \le \|x_m - u^*\|_\infty + \|F_m(u^*) - F_m(x_m)\|_\infty \le (1+q^2)\|x_m - u^*\|_\infty \longrightarrow 0 \quad \text{as } m \to \infty.$$

This confirms the equivalence condition required for T-stability, completing the proof. □

Corollary 4.5 (Data Dependence for the Nonlocal Problem). *Let (f, g, u_0) and $(\widetilde{f}, \widetilde{g}, \widetilde{u}_0)$ both satisfy (H1)-(H3) with the same constants L_f, L_g, q, and suppose*

$$\sup_{t\in[0,1], v\in\mathbb{R}} |f(t,v) - \widetilde{f}(t,v)| \le \varepsilon_f, \qquad \sup_{u\in X} |g(u) - \widetilde{g}(u)| \le \varepsilon_g, \qquad |u_0 - \widetilde{u}_0| \le \varepsilon_0.$$

Let $T, \widetilde{T}$ be the corresponding operators (16)*, and set $\varepsilon = \varepsilon_0 + \varepsilon_g + \varepsilon_f/\Gamma(\alpha+1)$. Then the respective unique solutions $u^*, \widetilde{u}^*$ satisfy $\|u^* - \widetilde{u}^*\|_\infty \le \frac{\varepsilon}{1-q}$, and NIP sequences $\{w_m\}, \{\widetilde{w}_m\}$ started from w_0 satisfy*

$$\|w_m - \widetilde{w}_m\|_\infty \le q^{2m}\|w_0 - \widetilde{w}_0\|_\infty + \frac{C(q)\varepsilon}{1-q^2}, \qquad C(q) = 1 + q + q^2 + q^3 + q^4.$$

Proof. For any $u \in X$ and $t \in [0,1]$, using definition (16),

$$|(Tu)(t) - (\widetilde{T}u)(t)| \le |u_0 - \widetilde{u}_0| + |g(u) - \widetilde{g}(u)| + \frac{1}{\Gamma(\alpha)}\int_0^t (t-s)^{\alpha-1}|f(s,u(s)) - \widetilde{f}(s,u(s))|\, ds$$

$$\le \varepsilon_0 + \varepsilon_g + \frac{\varepsilon_f}{\Gamma(\alpha)}\int_0^t (t-s)^{\alpha-1} ds \le \varepsilon_0 + \varepsilon_g + \frac{\varepsilon_f}{\Gamma(\alpha+1)} = \varepsilon.$$

Taking supremum over $u \in X$ gives $\sup_{u\in X}\|Tu - \widetilde{T}u\|_\infty \le \varepsilon$. The result follows directly by applying Theorem 3.6. □

5 Numerical Experiments

We illustrate Theorem 4.4 on the concrete problem

$$^{c}D^{0.7}u(t) = -0.3\sin u(t) + t, \qquad t \in (0,1], \qquad u(0) + 0.1\,u(0.5) = 0.2. \tag{17}$$

Here $\alpha = 0.7$, $f(t,u) = -0.3\sin u + t$ satisfies (H1) with $L_f = 0.3$, and $g(u) = 0.1\,u(0.5)$ satisfies (H2) with $L_g = 0.1$. Since $\Gamma(1.7) \approx 0.90864$,

$$q = L_g + \frac{L_f}{\Gamma(1.7)} = 0.1 + \frac{0.3}{0.90864} \approx 0.4302 < 1,$$

so (H3) holds and Theorem 4.4 applies: problem (17) has a unique solution u^*, and NIP converges to it with rate $q^{2m} \approx (0.185)^m$.

5.1 Discretization

We discretize the Volterra integral (16) for the concrete problem (17) i.e. $\alpha = 0.7$, $u_0 = 0.2$, $f(t,u) = -0.3\sin u + t$, $g(u) = 0.1\,u(0.5)$. Throughout, numerical values are shown at five representative grid points $t = 0,\ 0.25,\ 0.5,\ 0.75,\ 1$. The Volterra integral (16) was discretized on the uniform grid $t_i = i/N$, $i = 0,\dots,N$, $N = 200$, so that each function u is represented by the vector $\mathbf{u} = (u_0, u_1, \dots, u_{200})$, $u_i \approx u(t_i)$. The fractional integral is evaluated at every grid point by using the product-trapezoidal quadrature of Diethelm [25, 26] for the Abel-type kernel:

$$(I^{\alpha} f(\cdot, u(\cdot)))(t_i) \;\approx\; \frac{h^{\alpha}}{\Gamma(\alpha+2)} \sum_{j=0}^{i} a_{i,j}\, f(t_j, u_j), \tag{18}$$

$$a_{i,j} = \begin{cases} i^{\alpha+1} - (i-\alpha)(i+1)^{\alpha}, & j = 0, \\ (i-j+2)^{\alpha+1} + (i-j)^{\alpha+1} - 2(i-j+1)^{\alpha+1}, & 1 \le j \le i-1, \\ 1, & j = i. \end{cases} \tag{19}$$

Applying this at every $i = 0,\dots,200$ turns the abstract operator T into an explicit map $\mathbb{R}^{201} \to \mathbb{R}^{201}$, denoted T_h below . All five schemes use $\zeta_m \equiv 0.7$, $\kappa_m \equiv 0.8$ and the constant start $w_0 \equiv 0.1$. The reference solution u^* is obtained by iterating NIP 80 times.

5.2 Results

As predicted by Theorem 3.4, NIP reaches machine precision by $m \approx 8$, whereas Picard, Mann and Ishikawa require roughly 20–25 iterations for comparable accuracy.

6 Conclusions

We showed that NIP applies directly to a nonlocal Caputo-type fractional initial value problem, establishing existence, uniqueness, convergence, and data dependence under the explicit contraction constant $q = L_g + L_f/\Gamma(\alpha+1)$. Numerical experiments confirm NIP converges significantly faster than classical schemes.

Table 1: Sup-norm error $\|w_m - u^*\|_\infty$ for problem (17).

m	Picard	Mann	Ishikawa	S-Iteration	NIP
0	5.769×10^{-1}	5.769×10^{-1}	5.769×10^{-1}	5.769×10^{-1}	5.769×10^{-1}
1	1.136×10^{-1}	9.356×10^{-2}	1.709×10^{-1}	3.626×10^{-2}	3.146×10^{-3}
2	2.226×10^{-2}	1.670×10^{-2}	5.057×10^{-2}	2.211×10^{-3}	2.184×10^{-5}
3	5.092×10^{-3}	3.151×10^{-3}	1.496×10^{-2}	1.477×10^{-4}	1.708×10^{-7}
4	1.214×10^{-3}	6.088×10^{-4}	4.426×10^{-3}	1.044×10^{-5}	1.354×10^{-9}
5	2.945×10^{-4}	1.169×10^{-4}	1.309×10^{-3}	7.604×10^{-7}	1.074×10^{-11}
6	7.175×10^{-5}	3.079×10^{-5}	3.875×10^{-4}	5.600×10^{-8}	8.504×10^{-14}
7	1.750×10^{-5}	1.000×10^{-5}	1.147×10^{-4}	4.138×10^{-9}	7.772×10^{-16}
8	4.267×10^{-6}	3.249×10^{-6}	3.395×10^{-5}	3.061×10^{-10}	1.110×10^{-16}
9	1.041×10^{-6}	1.041×10^{-6}	1.005×10^{-5}	2.265×10^{-11}	0
10	2.538×10^{-7}	3.294×10^{-7}	2.977×10^{-6}	1.676×10^{-12}	0
11	6.191×10^{-8}	1.032×10^{-7}	8.816×10^{-7}	1.241×10^{-13}	0
12	1.510×10^{-8}	3.207×10^{-8}	2.612×10^{-7}	9.215×10^{-15}	0
13	3.683×10^{-9}	9.886×10^{-9}	7.738×10^{-8}	6.661×10^{-16}	0
14	8.982×10^{-10}	3.026×10^{-9}	2.293×10^{-8}	1.110×10^{-16}	0
15	2.191×10^{-10}	9.205×10^{-10}	6.796×10^{-9}	1.110×10^{-16}	0
16	5.343×10^{-11}	2.784×10^{-10}	2.015×10^{-9}	5.551×10^{-17}	0
17	1.303×10^{-11}	8.376×10^{-11}	5.973×10^{-10}	5.551×10^{-17}	0
18	3.178×10^{-12}	2.508×10^{-11}	1.771×10^{-10}	5.551×10^{-17}	0
19	7.753×10^{-13}	7.478×10^{-12}	5.253×10^{-11}	5.551×10^{-17}	0
20	1.892×10^{-13}	2.221×10^{-12}	1.558×10^{-11}	5.551×10^{-17}	0

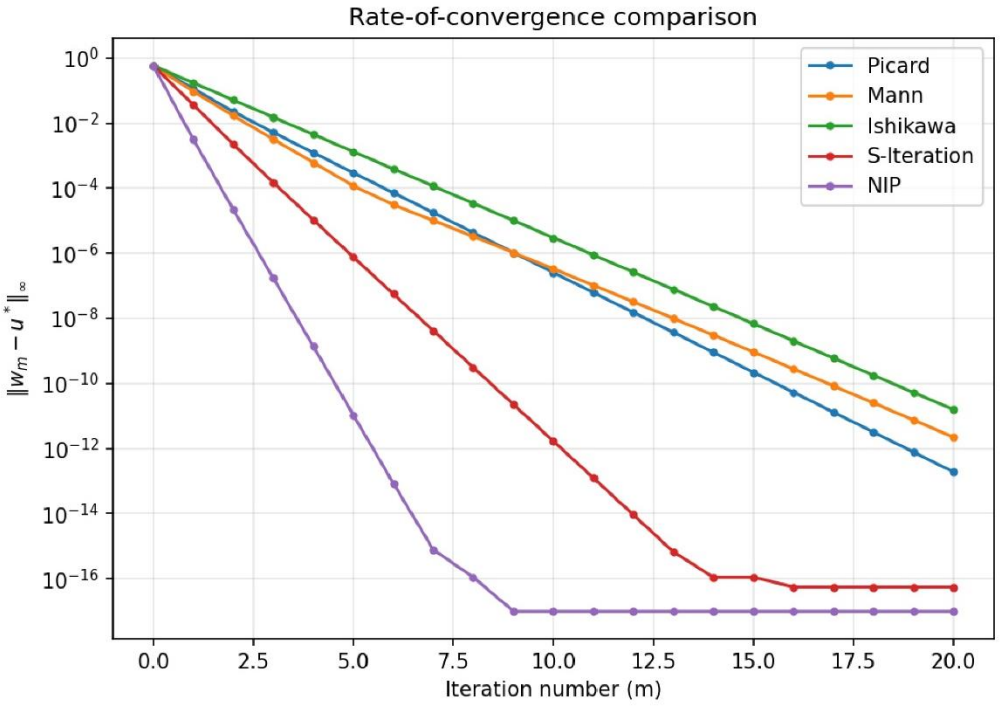

Figure 1: Rate-of-convergence comparison for problem (17).

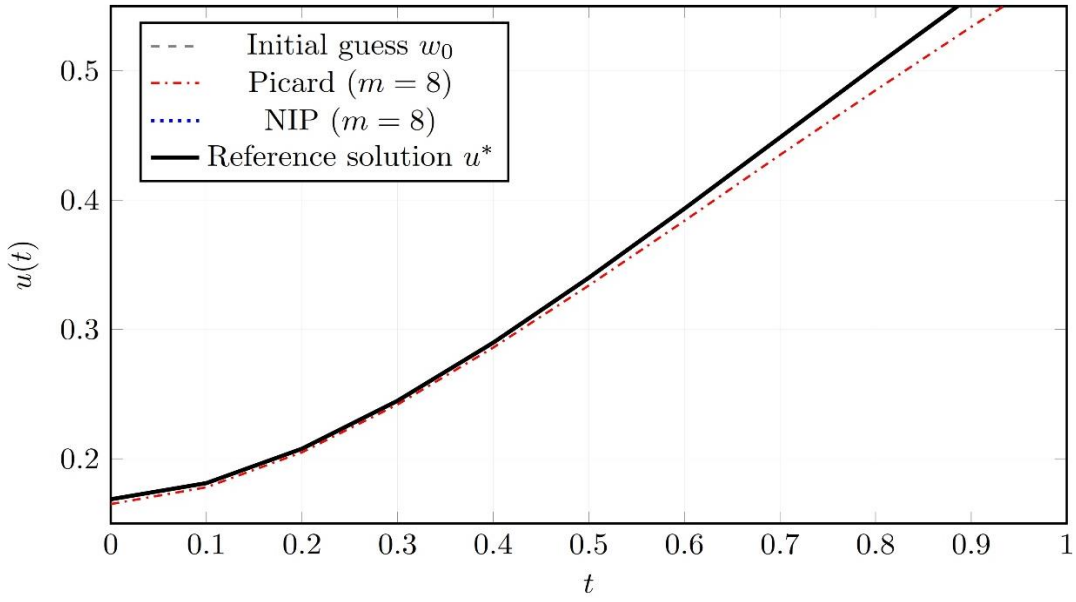

Figure 2: Recovered solution u^* of (17).

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Use of AI and Digital Humanities in English Language and Literature: A Study Through the Perspective of Digital Humanism

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Abstract:

The ways of teaching English language and literature are changing with the introduction of AI and digital humanities. AI and digital humanities challenge the earlier human-centric approach in teaching English language and literature. The paper studies three works of Tripathi et al., Yadav, and Ashok through the perspective of digital humanism, with reference to the book Introduction to Digital Humanism (Werthner et al.). These works support the earlier human-centric approach but they lack common theoretical framework. To study the subject this paper uses a qualitative method and comparative close reading method. The paper examines the subject under four themes: broadening participation and accessibility; human role in creative expression and interpreting meaning; ethics; and responsibilities of teachers and institutions. For the analysis of the subject, Digital Humanism provides the theoretical framework. The three works agree that technology should assist humans and not replace them. However, they differ in the evidence they provide to support this claim. The paper therefore examines the role of AI and digital humanities in English studies and shows where claims are supported by evidence and where they are only demonstrated.

Keywords: Digital Humanities; Digital Humanism; AI; English Studies; English Language and Literature Teaching; Creative Expression; Ethics and Responsibility

Introduction:

Traditionally, the study of English language and literature was based on close reading and interpretation of the text, with the element of imaginative creativity added to it. The introduction of AI and digital humanities has changed the traditional experience of the study of English language and literature making it more personal and free from the judgement of right and wrong. This reduces the fear of language practice(Yadav 63). The new system helps to revise text and generate drafts (Yadav 62-63). Literary texts get new meaning and new routes through annotation platforms, corpora and digital archives (Ashok c551; Tripathi et al. 400, 402–03). This new experience of technology raises concerns such as who really benefits from the privileges of the change, who is excluded or marginalized, who should be held responsible and accountable. The new experience also raises concern regarding the role and position of human efforts in writing, reading and Interpreting English studies.

The paper studies three recent works by Tripathi et al., Yadav and Ashok that address these concerns. The work of Tripathi et al. gives a review of AI and digital humanities in a structured and integrative way in English literature education (398–401). Yadav presents an essay on AI in language teaching, writing,

creativity and ethics (61–64). In another work, Ashok offers his view that English language teaching can become more learner-centred with the use of digital humanities (c550–51). The three works agree that technology should be treated as an aid or support to teaching and it should not replace teachers, close reading or human judgement (Tripathi et al. 409; Yadav 64; Ashok c552).

However, the three works lack a common theoretical framework to prove their claim. The present paper focuses on what each work thinks about the learner and technology, whether the ethical concerns align with the digital humanist position and to what extent; also where it falls short. To address these questions, the paper rests on the book *Introduction to Digital Humanism* edited by Werthner et al. The paper aims to examine how these four texts can be put to one common framework. The paper also aims to study the role of digital humanism in the debate on AI and digital humanities in English studies.

Digital Humanism: A Common Theoretical Framework:

Digital humanism is different from digital humanities. Both terms imply different meanings so, these should not be confused and cannot be used interchangeably. Digital humanism focuses on the kind of society digital technology should serve (Nida-Rumelin and Staudacher 17-18) . It is related to the ethical position technology has in a society. Ashok states that digital humanities is the use of computing to study the questions of humanities through corpus linguistics, text mining, digital archives and annotation platforms (c551). Digital humanities, on the contrary, does not deal with the ethical side of technology, it is a scholarly field.

The book *Introduction to Digital Humanism* talks about digital humanism as an interdisciplinary approach that follows the 2019 Vienna Manifesto (Werthner 123). The book states that digital humanism studies and influences the interplay of technology and humankind (Werthner 123). Digital humanism has an ethical aspect, where it gives respect to universal human rights (Werthner 123,129). The book does not limit itself to students alone, it also suits the needs of teachers and policy makers as well.

Based on the book this paper uses three criterias:

a) Technology should not displace teachers, instead it should aid the experience of learners (Werthner 126,128).
b) No one should be excluded from the benefits digital technology provides, not even the marginalized (Werthner 124,126) .
c) The responsibility and accountability should be on the shoulders of designers, institutions and policy makers (Werthner 124, 127).

Research Method Used:

A comparative close reading of three works is done, which are: Tripathi et al., Yadav and Ashok. The paper applies a qualitative and conceptual study. Each work talks about the learner, the benefits and risks it offers, evidence and recommendations. The findings from the three works are given under four themes. The book, Introduction to Digital Humanism, provides the theoretical framework and does not provide the evidence about classrooms. The works studied for this research paper are a small set of texts. The paper aims to find out the research gap in the three texts and formulate a research paper covering this gap. But the limitation here is, the findings cannot be applied to the whole field of AI and digital humanities. Rather, the findings are exploratory.

The Four Themes:

1. Broadening Participation and Accessibility:

Tripathi et al. give importance to participation or inclusion. AI-assisted tools like speech recognition, digital annotation and text-to-speech can make learning easy for learners with dyslexia, sensory impairments and communication difficulties (401–03). This technology development's outcome depends on several factors like support of the teacher, accessible design and reliable infrastructure (405). There are learners from low- and middle-income settings who need special education but lack access to devices and connectivity (405). In a short essay, Ashok also talks about the same concern regarding government schools and rural institutions (c551–52). Yadav, in another short essay, praises AI for providing access to English to all by speaking practice (63) but does not raise the question about who lacks access to its benefits or who are excluded from receiving the benefits. Tripathi et al. talk about this theme of broadening participation and accessibility in the strongest way, Ashok is biased or partial in treatment and Yadav only assumes access. This unevenness is important in English studies because audiobooks, captioned resources and multimodal activities help only those who can reach them (Tripathi et al. 405). In other words, technology benefits only those who have access to it. Those who are excluded are bereft of all the privileges of technology. Thus, broadening participation and accessibility depend on both resource availability and the design of digital tools.

2. Human Role in Creative Expression and Interpreting Meaning:

The three works by Tripathi et al., Ashok and Yadav claim that AI should support humans. Yadav argues strongly that AI cannot provide originality and depth to the argument; it can only fix superficial errors (63). Yadav further adds that creative expression needs emotional and ethical awareness along with lived experience, which AI cannot authentically produce; it can only imitate (63). Yadav goes a step ahead by warning that, with over-dependence on AI, students may avoid thinking and writing, leading to a loss of the skills that English studies aims to develop (64). Tripathi et al. talk in a similar way about interpretation, highlighting the importance of teachers in interpreting meanings. They argue that computational patterns may support reading, but teachers must explain and correct them (402). They also argue that greater engagement does not necessarily mean greater understanding (405). Ashok argues that learners are producers of knowledge and not passive recipients (c550–51). These claims do not contradict each other. The human role depends on how AI is used. Tripathi et al. talk about practices that protect the human role: transparent use of tools, learner reflection and teacher-guided revision (406). If seen from the perspective of digital humanism, it is a question of ultimate control. AI can produce texts and patterns, but the question is whether teachers and learners remain in a position to interpret them and to control the narrative set by AI (Nida-Rumelin and Staudacher 27).

3. Ethics:

Ethical perspective is dealt with in detail in the work of Tripathi et al. The work warns against the stereotypes and misrepresentation of disability that AI-generated content may produce (405). The work also fears that the data of learners can be reused without prior consent or information (406). There is also a possibility that AI-generated content may contain errors, including invented information, and learners may accept these unknowingly and unquestioningly (406). Yadav also voices the reality that AI tools reflect the culture, language and ideology of those who assemble the data they are trained on, and in this process there is a fear that other voices are excluded; Yadav also raises the concern of

plagiarism (64). In a short essay, Ashok mentions in brief copyright, responsible AI use and privacy (c552). The ethical aspect is also seen in digital humanism, which focuses on human rights and human direction of technology (Werthner 123–24). This aspect is also seen in the work of Tripathi et al., where the work talks about the involvement of different groups in the society like learners, teachers and specialists in the design from the beginning (409).

4. Responsibilities of Teachers and Institutions:

The work of Tripathi et al. cites UNESCO's caution that technology choices should not be driven by commercial pressure but should be based on learners' needs (407–08). The work calls for sustained professional development in areas like accessibility, ethics and digital competence (407). The work provides a multi-level framework that links together various parties involved such as learners, teachers, institutions, policy and technology design (408). The work also ties teacher judgement to assessment, recommending oral explanation, reflective commentary and process evidence so that AI-generated responses do not hide what a learner actually understands (407). Ashok agrees that limited training makes the use of technology inconsistent and superficial, and calls for investment in infrastructure, teacher training, curriculum redesign and interdisciplinary collaboration (c552). Yadav, in another essay, says little about institutions or policy but calls for critical and responsible engagement by the discipline (64). This theme corresponds to the digital humanist view that responsibility is shared: the Vienna Manifesto gives roles to regulators, universities and education (Werthner124), and the book's framework includes education and political intervention among the activities needed (Werthner129).

The Findings:

The three works agree in principle, but there is no common evidence for the claim that they make. The evidence in the work of Tripathi et al. does not come mainly from English literature classrooms; much of it comes from inclusive education and assistive technology in general, so findings must be transferred with care (405, 409). Yadav does not cite evidence for the claim that AI helps jobless learners gain confidence and employment (62). Even Ashok does not give any data to prove the claim that educational benefits outweigh the limitations (c552).

When these findings are looked at through the lens of digital humanism, a few things are noticed:

A) Digital humanism shifts the question from whether a tool really works for the one it serves and under whose control. Also, there is another question, with what protection of rights the tool work (Werthner 123–24, 129).

B) The choice of technology, whether AI or digital humanities, is not neutral, because choices about data, design and procurement shape who benefits. Tripathi et al. express this concern in their discussion of bias (405) and commercial pressure (407–08).

The book does not deal specifically with English education, as it is a general textbook. The paper is therefore exploratory in nature, and applying the book's framework here is an interpretive step.

Conclusion:

The three works agree on a common point: AI and digital humanities should assist human effort and not replace it. However, they differ in the evidence they provide. This paper provides a common theoretical framework for this

claim by taking as its base the book *Introduction to Digital Humanism: A Textbook* (Werthner et al.). The points discussed under the themes come from the three works and not from the book. The book is a general textbook, hence it does not talk about the themes directly. The book only provides the framework.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Financial Literacy and Investment Behaviour: A Review of Secondary Evidence with Special Reference to College Teachers in India

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DOI - 10.5281/zenodo.24339332

Abstract:

Financial literacy is increasingly important as individuals navigate a wider range of saving and investment products. College teachers, despite having regular employment, must make decisions about household budgets, children's education, insurance, taxation, housing, and retirement. This paper reviews selected secondary evidence on the relationship between financial literacy and investment behaviour, with particular reference to college teachers in India. It synthesises research on financial knowledge, attitudes, behaviour, financial planning, risk perception, and investment participation. The literature indicates that financial literacy is associated with financial planning and can support more informed evaluation of risk, return, inflation, diversification, and investment costs. However, investment behaviour is not determined by knowledge alone; income, family obligations, age, financial goals, risk tolerance, and access to reliable information also matter. Research on college teachers in Arunachal Pradesh provides a relevant professional-group example, while national evidence from the Securities and Exchange Board of India illustrates the difference between awareness of securities products and actual participation.

Keywords: Financial Literacy, Investment Behaviour, College Teachers, Financial Planning, Secondary Data, India.

Introduction:

Financial decisions increasingly require individuals to compare products that differ in risk, return, liquidity, taxation, cost, and investment horizon. Traditional avenues such as savings accounts, fixed deposits, gold, and real estate continue to coexist with mutual funds, equity shares, bonds, pension products, and digital investment platforms. A greater choice of products can create opportunities, but it also makes financial knowledge more important. Individuals who do not understand inflation, compound interest, diversification, or the relationship between risk and return may find it difficult to judge whether an investment suits their needs.

Financial literacy is broader than knowing the names of financial products. It includes understanding key concepts and applying them to budgeting, saving, borrowing, insurance, investing, and long-term planning. Lusardi and Mitchell (2014) describe financial literacy as economically important because it can shape decisions involving saving, retirement, and wealth accumulation. In India, research has also examined the connection between financial literacy and financial planning (Agarwal et al., 2015).

College teachers form a relevant group for studying these issues. Regular employment may provide a predictable salary, but it does not ensure that every teacher has the same level of financial

knowledge or planning skill. Teachers may need to balance routine household expenses with children's education, housing commitments, insurance, tax planning, and retirement preparation. Their investment choices may also be affected by age, income, family responsibilities, employment conditions, and attitudes towards financial risk.

This paper reviews selected secondary literature to understand how financial literacy relates to investment behaviour and to identify questions that warrant further investigation among college teachers in India.

Objective and Review Approach:

1. Objective:

- To analyse secondary evidence on the relationship between financial literacy and investment behaviour among salaried individuals, with particular reference to college teachers in India.

2. Review Approach:

The paper uses a narrative review of selected academic studies and institutional publications relevant to financial literacy, financial planning, investment behaviour, and investor participation. The sources include peer-reviewed research on Indian respondents, a study of college teachers in Arunachal Pradesh, a widely cited review of financial literacy, and SEBI's Investor Survey 2025. The evidence is synthesised thematically rather than statistically. The studies differ in sample, location, measurement, and method; therefore, their results are not treated as directly comparable. No original questionnaire, primary dataset, correlation coefficient, or regression analysis was produced for this paper.

Review of Literature:

1. Financial literacy and economic decision-making:

Lusardi and Mitchell (2014) reviewed theoretical and empirical evidence on the economic importance of financial literacy. Their discussion highlights the value of understanding compound interest, inflation, and risk diversification. These concepts are relevant to decisions over time: compound interest affects the growth of savings, inflation affects purchasing power, and diversification helps investors understand the implications of concentrating money in a limited number of assets. Their review supports treating financial literacy as a practical capability that can influence financial choices, rather than simply as familiarity with financial terminology.

2. Evidence from India:

Agarwal et al. (2015) examined financial literacy and financial planning using evidence from an Indian financial advisory programme. Their analysis considered basic financial concepts and explored how literacy related to planning and other financial tendencies, including investment preferences and risk tolerance. The study reported that financial literacy was associated with better financial planning. Its sample and setting should be kept in mind when interpreting the findings: evidence from programme participants cannot automatically represent every occupational or regional group in India.

A related study by Agarwalla et al. (2015) examined financial literacy among working young people in urban India. It considered financial knowledge, attitudes, and behaviour and reported that these dimensions did not always move together. The study also identified differences associated with demographic and family-context factors. This is useful for the present topic because it cautions against assuming

that financial knowledge alone explains how people actually manage money.

Choudhary et al. (2021) analysed questionnaire data from 477 respondents in India to examine financial literacy, investment behaviour, and sociodemographic variables. The authors used multinomial logistic regression and reported that around one-third of respondents demonstrated a higher level of financial literacy. They also found associations between literacy and characteristics such as age and income, while investment behaviour varied across demographic and work-related groups. Their results reinforce the need to consider financial literacy alongside the circumstances in which investment decisions are made.

3. Evidence relating specifically to college teachers:

Thamoung and Bora (2025) studied financial literacy and personal financial planning among 210 college teachers in Arunachal Pradesh. The research considered knowledge, attitudes, behaviour, and planning. The authors reported differences between tax-paying and non-tax-paying teachers in aspects of financial literacy. This study is particularly relevant because it focuses on the teaching profession rather than the general adult population. Nevertheless, its findings should not be assumed to describe teachers in Maharashtra: local economic conditions, salary structures, family circumstances, and retirement arrangements may differ.

4. Investor awareness and participation in India:

SEBI's Investor Survey 2025 provides recent national context on participation in securities markets. The survey covered more than 90,000 households across urban and rural India. Its published findings distinguish awareness of at least one securities-market product from actual participation, indicating that awareness does not necessarily translate into investment. This distinction is important for financial literacy research: knowing that a product exists is not the same as understanding its risks, costs, suitability, and potential role in a financial plan (Securities and Exchange Board of India [SEBI], 2026).

Analysis and Discussion:

1. Financial knowledge as a basis for evaluating investment choices:

Financial knowledge can help an investor compare alternatives on more than their advertised returns. A meaningful comparison considers risk, liquidity, costs, taxation, inflation, and the period for which money can remain invested. For example, a product with a predictable return may suit a short-term goal, while a market-linked product may involve fluctuations and require a longer horizon. Neither category is automatically appropriate for every investor. The relevant question is whether the instrument matches the investor's objectives, resources, and tolerance for loss.

Knowledge of inflation is especially important because a balance that grows in nominal terms may not grow at the same rate as the cost of living. Understanding diversification can help individuals recognise the risks of placing all savings in one asset or product. These concepts do not remove investment risk, but they can improve the quality of the questions investors ask before committing money.

2. Literacy and behaviour are related but distinct:

The reviewed evidence supports investigating an association between financial literacy and financial planning, but it does not justify treating literacy as the sole cause of investment behaviour. A teacher may understand investment products but have limited surplus income after meeting household expenses, loan repayments, or education costs. Another teacher

may invest regularly in familiar products without fully understanding inflation or diversification. Financial behaviour is therefore shaped by both knowledge and practical circumstances.

Financial attitudes and risk perception also require careful interpretation. A preference for relatively conservative products does not necessarily mean that an investor is financially illiterate; it may reflect a short investment horizon, a need for liquidity, or a low capacity to absorb losses. Conversely, willingness to accept high risk does not itself demonstrate strong financial knowledge. Research should distinguish risk tolerance, financial capacity, and objective understanding of investment concepts.

Major Findings from the Review:

The selected secondary evidence supports the following conclusions:

- Financial literacy is multidimensional: knowledge, attitudes, and behaviour are related but should be measured separately.
- Financial literacy is relevant to financial planning and may help people compare investment alternatives more thoughtfully.
- Investment behaviour is influenced by multiple factors, including income, age, family obligations, risk perception, financial goals, and access to trustworthy information.
- Awareness of investment products does not automatically lead to participation or informed decisions.
- Research on college teachers is valuable, but findings from one state or sample should not be generalised to all teachers in India.

Suggestions and Recommendations:

First, colleges and universities may arrange practical financial-literacy sessions covering compound interest, inflation, risk and return, diversification, investment costs, taxation, and retirement planning. Sessions should use realistic examples and explain how to compare products, rather than simply listing available schemes.

Second, financial education should encourage goal-based planning. Teachers can be supported in distinguishing short-term needs, emergency reserves, medium-term commitments, and long-term goals. Any investment choice should be assessed against the individual's financial position and risk capacity; generic product recommendations are unlikely to suit everyone.

Third, programmes should include fraud prevention and digital safety. Participants should learn to question guaranteed high-return claims, verify the legitimacy of intermediaries, protect authentication details, and use reliable sources of information. Digital access can broaden participation but also makes careful evaluation of online offers important.

Finally, future research should examine regular college teachers using a clearly defined sample and transparent measurement tools. Researchers may compare financial knowledge with actual investment practices and assess differences by age, income, experience, gender, family responsibilities, and retirement arrangements. Results should be reported with appropriate limitations and should avoid causal claims unless the research design supports them.

Limitations:

This paper is based on selected secondary sources and is a narrative synthesis, not a systematic review or meta-analysis. The studies reviewed use different samples, measures, and analytical methods. Some national findings concern households or general adult populations rather than college teachers specifically. Accordingly, the paper identifies a research

rationale and interprets existing evidence; it does not establish the prevalence or strength of financial literacy or investment behaviour in the target population.

Conclusion:

The literature reviewed indicates that financial literacy is relevant to financial planning and investment-related decision-making. Understanding interest, inflation, risk, diversification, and investment costs can help individuals evaluate financial choices, but knowledge alone does not determine behaviour. Income, financial commitments, risk capacity, family responsibilities, goals, and access to reliable information also influence how people invest.

Studies involving Indian respondents and college teachers provide a useful basis for further investigation. A focused regional study would help establish how financial knowledge relates to investment practices in this professional group and identify areas where practical financial education may be useful. The present secondary review therefore supports further empirical research without claiming to prove a statistically significant relationship or causation.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Algal Biodiversity of Bhokarbari Dam Taluka Parola, Dist. Jalgaon

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DOI - 10.5281/zenodo.24339366

Abstract:

Freshwater ecosystems support diverse algal communities that play an important role in primary productivity, nutrient cycling, and aquatic ecological balance. The present study focuses on the algal biodiversity of Bhokarbari Dam, Taluka Parola, District Jalgaon, Maharashtra, India, with particular emphasis on seasonal variation. The algal taxa recorded in the preliminary checklist include Pediastrum biradiatum Meyen, Hantzschia elongata (Hantzsch) Grunow, Euglena proxima Dangeard, Gloeotrichia raciborskii var. bombayense, and Oscillatoria chalybea (Mertens) Gomont. These taxa represent different algal groups, including green algae, diatoms, euglenoids, and cyanobacteria. The proposed seasonal investigation aims to document the distribution and occurrence of algal taxa during the monsoon, post-monsoon, winter, and summer seasons. Physicochemical parameters such as water temperature, pH, dissolved oxygen, transparency, and nutrient concentrations may also be assessed to investigate their relationships with algal diversity. The study will contribute to the documentation of freshwater algal biodiversity and provide baseline information for future ecological monitoring of Bhokarbari Dam.

Keywords: Pediastrum, Hantzschia elongate, Euglena proxima Dangeard, Gloeotrichia raciborskii, Oscillatoria chalybea.

Introduction:

Algae are important components of freshwater ecosystems, where they contribute to primary productivity, oxygen production, nutrient cycling, and aquatic food webs. They occur in a wide range of freshwater habitats, including ponds, lakes, rivers, and reservoirs. Their diversity and distribution are influenced by several environmental factors, such as temperature, light intensity, nutrient availability, water transparency, and pH. Changes in these conditions throughout the year can affect the composition and abundance of algal communities.

Freshwater algae comprise several major groups, including green algae, diatoms, euglenoids, and cyanobacteria. Each group responds differently to environmental conditions, making algal communities useful for understanding ecological changes in aquatic habitats. Seasonal studies of freshwater algae have shown that variations in water conditions can influence both species diversity and community composition (Laskar & Gupta, 2010;

Application of microalgal diversity in assessing the water quality of freshwater ponds, 2023).

In regions influenced by the Indian monsoon, seasonal changes may have a considerable effect on algal growth and distribution. During the monsoon, rainfall and surface runoff can introduce nutrients and suspended particles into water bodies, while increased water movement may affect algal growth. Post-monsoon conditions may favour the development of certain algal groups as the water becomes more stable. During winter and summer, changes in temperature, light availability, nutrient concentration, and water level may further influence algal communities. However, the nature and extent of these changes differ among water bodies and need to be established through systematic field observations.

Bhokarbari Dam, situated in Parola Taluka of Jalgaon District, Maharashtra, India, provides a freshwater habitat for the study of algal diversity and its seasonal variation. Documenting the algal flora of this reservoir can help establish a baseline for understanding its biological diversity. Such information may also be useful in future studies relating algal distribution to water quality and other ecological characteristics.

The preliminary list of taxa proposed for examination in the present study includes Pediastrum biradiatum Meyen, Hantzschia elongata (Hantzsch) Grunow, Euglena proxima Dangeard, Gloeotrichia raciborskii var. bombayense, and Oscillatoria chalybea (Mertens) Gomont. These taxa represent different algal groups and provide a starting point for investigating the composition of the algal community. Their identification, taxonomic placement, and occurrence at Bhokarbari Dam should be confirmed using appropriate morphological characteristics and relevant taxonomic literature before they are reported as confirmed records from the study area.

Although seasonal algal diversity has been investigated in several freshwater ecosystems in India, site-specific observations remain important because algal communities vary according to local environmental conditions. A systematic assessment of Bhokarbari Dam can therefore contribute information on its algal flora and provide a basis for further ecological investigation.

The present study aims to document the algal diversity of Bhokarbari Dam during different seasons and to examine seasonal changes in the occurrence and distribution of recorded taxa.

Where supporting environmental data are available, the study will also consider the relationship between algal diversity and selected physicochemical parameters of the water. The findings are expected to provide baseline information for future studies on freshwater biodiversity and the ecological condition of the reservoir.

Materials And Methods:

Algal samples were collected from Bhokarbari Dam, Taluka Parola, District Jalgaon, Maharashtra, during different seasons. Samples of planktonic and attached algae were collected, labelled, and brought to the laboratory for examination. The samples were observed under a compound microscope, and algal taxa were identified based on their morphological characteristics using standard taxonomic literature. The identified taxa were compiled into a checklist to document algal biodiversity and seasonal variation.

Plate 1:

- Pediastrum biradiatum Meyen.
- Hantzschia elongata (Hantz.) Grun
- Euglena proxima Dangeard

- Gloeotrichia raciborskii var. bombayense
- Oscillatoria chalybea (Mertens) Gomont

1. Pediastrum biradiatum Meyen. Pl.1, Fig.1

G.W.Prescott 1951, P.754, Pl. 47, Fig.6.

Colony perforte, the peripheral cells deeply bilobed, the lobes incised, cells adjoined along the lower part of their lateral walls, inner cells bilobed, the lobes not incised, all walls concave, diameter of cells 10-20 µm.

2. Hantzschia elongata (Hantz.) Grun. Pl.1, Fig.2

Cleve-Euler 1982, p. 51, f. 1421.

Valves 170-239 µm long, 10.5-11.5 µm linear with parallel sides, sometimes bent in the middle: end constricted, narrowed, and produced, slightly backwardly bent and subcapitate, keel excentric, keel valves 89-114.5 µm long, 3-3.8 µm broad, narrowly linear lanceolate with very slender, produced ends; keel strongly excentric, sigmoid, keel punctae 7-8 in 10 µm, small, coarse; striae 17-19 in 10 µm, fine.

3. Euglena proxima Dangeard Pl.1, Fig. 3

Wołowski and Hindák 2005, p. 31, figs.142-145.

Cells shortly spindle shaped, flagellate, anterior end bluntly truncate, broader at middle and gradually tapering towards end, cells 11.2 - 17 µm broad at the middle and
40.7 - 45 µm long, chloroplast disc shaped, paramylon bodies small.

4. Gloeotrichia raciborskii var. bombayense. Pl.1, Fig.4

T.V.Desikachary 1959, P. 563; Pl. 117, Fig. 13

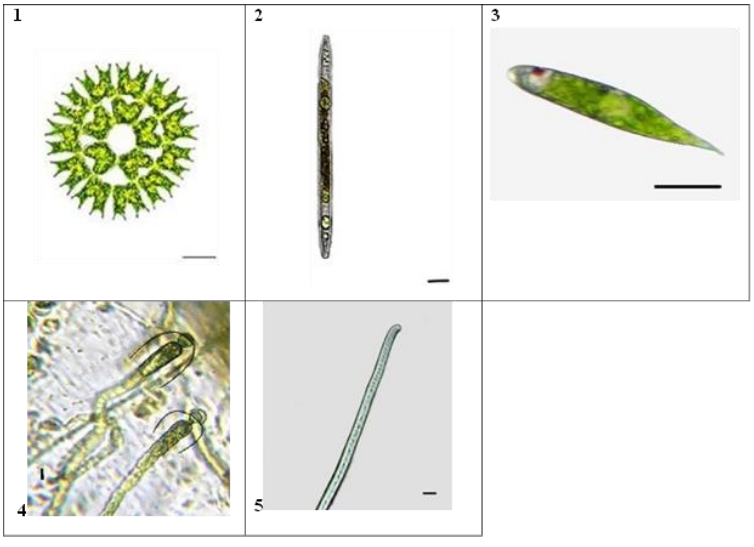
Thallus soft; trichomes 4-8 µm wide, heterocyst more or less spherical, 10.5 µm long and 8.5 µm broad; cells blue green, 5 µm long; sheath thick, stratification absent; yellowish green; spores 32 µm long and 12 µm wide.

5. Oscillatoria chalybea (Mertens) Gomont. Pl.1, Fig.5

G.W.Prescott 1951, P.878, Pl.109, Fig.9.

Trichomes aggregated to form a dark blue-green plant mass; straight for a portion of their length but much entangled and sometimes spirally twisted, gradually tapering toward the apex. Apical cell conical, with a smooth, unthickened outer membrane. Cells (6)-8-12-(13) µm in diameter, 4- 6.8 µm long; slightly constricted at the cross walls, which are not granular.

Plate :1



Results:

The study focused on documenting algal biodiversity in Bhokarbari Dam, Taluka Parola, District Jalgaon, Maharashtra. The preliminary checklist included five algal taxa: Pediastrum biradiatum Meyen, Hantzschia elongata (Hantzsch) Grunow, Euglena proxima Dangeard, Gloeotrichia raciborskii var. bombayense, and Oscillatoria chalybea (Mertens) Gomont. These taxa represent different groups of freshwater algae, including green algae, diatoms, euglenoids, and cyanobacteria. Their identification and seasonal occurrence require confirmation through microscopic observations and field records. A complete assessment of species composition and seasonal variation will depend on the results of systematic sampling and taxonomic verification.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Bridging the Institutional Support Gap: Challenges in Promoting Women Entrepreneurship through District Industries Centres (DICs)

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DOI - 10.5281/zenodo.24339398

Abstract:

Women entrepreneurship plays an important role in promoting economic participation, self-employment and inclusive regional development. However, women entrepreneurs may encounter institutional and structural barriers related to access to finance, awareness of government schemes, entrepreneurship training, market linkages and business development services. District Industries Centres (DICs) are part of the institutional framework through which industrial development and enterprise-related assistance are facilitated at the district level. Nevertheless, the availability of support programmes does not necessarily ensure that prospective and existing women entrepreneurs can access and benefit from them effectively.

This paper aims to examine the institutional support framework for women entrepreneurship, with reference to Khandesh region of Maharashtra, comprising Jalgaon, Dhule and Nandurbar district. It adopts a secondary-data-based analytical approach using published research studies, government policy documents, official reports and other relevant literature. The analysis is organized around key dimensions of institutional support, including awareness and accessibility of government schemes, financial assistance, entrepreneurship development, mentoring, and market access and business facilitation. The paper also considers the potential barriers that may arise between the designs of support policies and their practical accessibility to women entrepreneurs.

Drawing on existing literature and policy frameworks, the paper seeks to develop recommendations for strengthening institutional coordination, information dissemination and delivery of enterprise support services. It aims to provide a regional perspective on improving the institutional ecosystem for women entrepreneurship while identifying areas requiring further investigation through district-level empirical research.

Keywords: Women Entrepreneurship, District Industries Centre, Institutional Support, Government Schemes, Khandesh, Training, Financial Assistance, Entrepreneurship Development.

Introduction:

Women entrepreneurship has become an important area of discussion in the context of economic development, employment generation, poverty reduction and women's economic empowerment. Women-owned enterprises can contribute to household income, local economic activity, innovation and diversification of regional industry. However, the development and sustainability of these enterprises depend not only on individual entrepreneurial capabilities but also on the institutional, financial, social and market environments in which they operate.

In India, several government programmes and institutional initiatives seek to encourage entrepreneurship through financial assistance,

training, enterprise facilitation, infrastructure development and market support. Nevertheless, the existence of these programmes alone does not establish that their intended beneficiaries can access them effectively.

District Industries Centres are relevant to this discussion because they operate within the district level institutional framework for industrial development and enterprise facilitation. Depending on applicable programmes and administrative arrangements, DIC's may guide entrepreneurs regarding government schemes, enterprise establishment and related procedures. Their potential contribution therefor extends beyond information provision to facilitating connections between entrepreneurs and appropriate support institutions.

Maharashtra has also introduced policy measures directed towards women entrepreneurs including the special policy for Women Entrepreneurs, 2017 (Commissionerate of MSME, Maharashtra, 2017) Such policy initiatives provide a basis for examining how government support can be made accessible to women led enterprises.

The Khandesh region, comprising Jalgaon, Dhule and Nandurbar districts for this study provides a relevant geographical context for considering district-level enterprise development. However, national research and state policies alone cannot establish whether women entrepreneurs in these districts experience barriers or whether local DIC services adequately address their needs. These questions require region-specific evidence.

Accordingly, this paper examines the potential gap between institutional support formally available and the support that entrepreneurs can understand, access and uses the term institutional support gap as an analytical concept rather than a predetermine finding about DIC performance. The paper seeks to identify issues relevant to women entrepreneurship and propose practical directions for strengthening institutional support in Khandesh.

Review of Literature:

Research on women entrepreneurship identifies a combination of financial, social, managerial and institutional barriers.

Raghuvanshi et al. (2007) examined barriers to women entrepreneurship using the Decision-Making Trial and Evaluation Laboratory (DEMATEL) approach. Their study highlighted the importance of education and training, spatial mobility, family support, institutional support, entrepreneurial management and financial resources. This indicates that entrepreneurship-related difficulties are interconnected and cannot necessarily be resolved through financial assistance alone.

Jaitly and Thangallapally (2022) examined government support schemes for women entrepreneurs in India through an ecosystem perspective. Their report discusses difficulties associated with obtaining clear schemes information, understanding eligibility requirements and navigating application procedures. The report emphasizes that women entrepreneurs require coordinated support throughout different stages of enterprise development. Its findings provide a useful framework for examining institutional accessibility, although they should not be interpreted as direct evidence of conditions in Khandesh.

Ghani et al. (2013) investigated local industrial structures and female entrepreneurship in India. Their research found that the presence of existing female-owned businesses in district-industry was associated with greater subsequent female entrepreneurial entry. The study highlights the relevance of local business environments. This suggests that institutional support should be

considered alongside regional industrial conditions and opportunities for business connections.

Maharashtra's Special Policy for women Entrepreneurs, 2017 provides a state level policy context for promoting women-led enterprises (Commissionerate of MSME, Maharashtra, 2017). The policy is relevant to discussions of incentives and institutional facilitation. Nevertheless, policy provisions alone do not demonstrate the extent to which women entrepreneurs in individual districts have accessed or benefited from them.

Taken together, these sources indicate the importance of finance, information, skills, institutional accessibility and local business networks. A regional analytical question remains: how can these dimensions be examined in relation to district-level support arrangements in Khandesh? The sources reviewed here do not provide sufficient evidence to determine the actual scale of institutional support gaps in Jalgaon, Dhule and Nandurbar. The present paper therefor develops an analytical framework for understanding these issues rather than claiming to measure local outcomes.

Objectives:

1. To examine institutional framework for promoting women entrepreneurship though DICs.
2. To consider the relevance of these issues to the Khandesh region of Maharashtra.
3. To suggest measures for improving the accessibility and effectiveness of institutional support.
4. To identify the key support requirements and barriers discussed in published research on women entrepreneurship.

Research Methodology:

The paper adopts a secondary-data-based descriptive and analytical approach. Its sources include published academic research, government policy documents and reports on entrepreneurship-support schemes. The literature is examined thematically, with attention to finance, awareness, training, market access and institutional coordination.

The geographical focus is Jalgaon, Dhule and Nandurbar districts. However, the paper does not use original survey data, district-level statistical testing or direct interviews with DIC officials. Consequently, it does not estimate the prevalence of particular barriers or evaluate the implications of the sources reviewed, and district specific claims require further evidence.

Analysis and Discussion:

1. Awareness and Accessibility of Government Schemes:

Access to reliable information is an important stage in the entrepreneurial process. Women who are unaware of relevant schemes, eligibility conditions, application procedures or designated support offices may be unable to make informed decisions about starting or expanding an enterprise.

Jaitley and Thangallapally (2022) discuss information and application-related difficulties in the government scheme ecosystem. Their analysis supports the need for accessible information, clear procedural guidance and better coordination between support providers.

For DICs serving the Khandesh region, these issues provide a basis for reviewing the accessibility of information in Marathi and other locally appropriated formats, the clarity of scheme guidance and the availability of assistance during applications. However, whether these particular difficulties occur in the three districts,

and to what extent, must be established through district-specific evidence.

2. Financial Assistance and Enterprise Development:

Finance can support enterprise establishment, equipment purchases, working capital and business expansion. Women entrepreneurs who have limited collateral, credit histories or experience with formal-lending formal lending procedures may face difficulties obtaining appropriate finance.

Raghuvanshi et al. (2017) identify financial resource constraints among the important barriers discussed in their research.

Institutional facilitation may help entrepreneurs understand relevant schemes and connect with banks and other eligible finance provider.

Nevertheless, DIC guidance should not be equated with a guarantee of loan approval or financial assistance. Eligibility, lending decisions and program conditions depend on the applicable scheme and responsible institution.

In Khandesh, a useful future research direction would be to examine whether women entrepreneurs understand available finance-related support, which application difficulties they encounter and whether institutional guidance helps them navigate the process.

3. Training, Mentoring and Managerial Capabilities:

Business sustainability requires skills in financial management, marketing, production, record-keeping, digital tools and regulatory compliance. Entrepreneurship development program can help build these capabilities, particularly among first-generation entrepreneurs.

Raghuvanshi et al. (2007) highlight education, experience and training opportunities as relevant factors in the barriers to women entrepreneurship. Jaitly and Thangallapally (2022) similarly emphasis training, skilling, mentoring and networking as elements of an effective entrepreneurship ecosystem.

For district-level institutions, the implication is that enterprise facilitation should connect entrepreneurs with relevant training and mentoring opportunities rather than focus exclusively on procedural information. The suitability of program also matters: training should response to entrepreneurs' business stages, sectors and practical needs. Whether existing arrangements meet these requirements in Khandesh remains an empirical question.

4. Market Access and Business Networks:

Access to customers, suppliers and business networks can influence enterprise growth, small enterprises may struggle to identify buyers, develop marketing channels, use digital platforms or compete in wider markets.

Ghani et al. (2003) demonstrate the relevance of local industrial structures to patterns of female entrepreneurship, indicating that the surrounding business environment can shape entrepreneurial opportunities.

For Khandesh, future research could examine whether women-owned enterprise have access to these network and how institutional initiatives might strengthen market barrier Should be supported by district-level publications or primary research.

5. Institutional Coordination and Support Gap:

Entrepreneurs may need institutions, including DICs, banks, training organizations, Industry associations and other government agencies. When information and other responsibilities are fragmented, navigating the support system may become difficult. The ecosystem approach described by Jaitly and Thangallapally (2022) supports the importance of coordination across different forms of assistance. The central analytical issue is therefore, not simply whether a scheme exists, but whether

entrepreneurs can identify the requirements and access the relevant service. For DICs, potential improvements in include clear referral procedures, updated scheme information, transparent guidance and follow-up mechanisms. These are recommendation derived from-up mechanisms. These are recommendations derived from the literature, not findings that current DIC arrangements in Khandesh are necessarily inadequate.

Overall, the reviewed evidence suggests that institutional support should be understood as a connected process involving information, finance, capabilities, network and facilitation. establishing the actual performance of this process in Jalgaon, Dhule and Nandurbar requires further regional evidence.

Suggestions and Recommendations:

The following recommendations emerge from the literature and policy analysis:

1. **Improve information dissemination:** Provide updated schemes information in Marathi and accessible formats, including eligibility criteria, required documents, application procedures and relevant contacts.
2. **Strengthen application facilitation:** Offer clear guidance to entrepreneurs navigating registration, scheme applications and referrals to responsible institutions, while communicating eligibility requirements accurately.
3. **Connect entrepreneurs with finance providers:** Facilitate information sessions and appropriate referrals to banks and other eligible support agencies without promising approval or benefits.
4. **Expand practical entrepreneurship training:** Promote access to financial literacy, digital marketing, business planning, bookkeeping and sector-specific skills, complimented by mentoring where available.
5. **Develop market linkages:** Encourage connections with industry associations, exhibitions, buyers, suppliers and suitable commerce channels.
6. **Strengthen coordination and monitoring:** Establish clear referral processes between DICs and other support institutions. Monitoring could examine service accessibility, application progress, participation in training and entrepreneur's feedback.
7. **Encourage regional research:** Conduct district-specific assessments in Jalgaon, Dhule and Nandurbar to identify local needs, document service experience and available schemes.

These measures should be adapted to applicable government policies, local administrative arrangements and the evidence emerging from further research.

Conclusion:

Women entrepreneurship can contribute to inclusive economic development, but its growth depends partly on the accessibility and coordination of institutional support. Existing research identifies financial constraints, training needs, institutional barriers, information difficulties and the importance of business networks. Government policies and district level enterprise support arrangements provide a framework through which these needs may be addressed.

This paper applies these insights to the institutional context of Khandesh, comprising Jalgaon, Dhule and Nandurbar district. It argues that the effectiveness of support should be considered not only in terms of the schemes available but also in terms of information accessibility, facilitation, skills development,

market connections and coordination among institutions.

Because the paper relies on secondary sources, it does not establish the extent of any support gap in the three districts or provide a direct assessment of DIC performance. District-specific research is needed to determine how women entrepreneurs experience existing arrangements. Improving accessible information and evidence-based monitoring offers a practical direction for strengthening the institutional ecosystem for women entrepreneurship in Khandesh.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Social Innovation, Gender Equality and Rural Empowerment Building Inclusive and Sustainable Rural Communities in India

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Abstract:

Social innovation, gender equality and rural empowerment are important elements of sustainable development. Rural communities face several challenges, including poverty, unemployment, gender discrimination, limited educational opportunities, inadequate healthcare, lack of infrastructure and unequal access to financial resources. Traditional development programmes cannot solve all these problems independently. New ideas, community participation, local leadership and innovative social practices are required to create long-term change.

Social innovation refers to new ideas, methods, services and practices that address social problems and improve people's lives. Gender equality means providing women and men with equal rights, opportunities, responsibilities and respect. Rural empowerment refers to strengthening the social, economic, educational and political capacity of rural people so that they can participate in decisions affecting their lives.

This paper examines the relationship between social innovation, gender equality and rural empowerment, with special reference to India. It discusses the importance of women's self-help groups, rural entrepreneurship, digital technology, education, agricultural innovation, community participation, local governance and financial inclusion. It also examines the challenges faced by rural women, small farmers, young people and socially disadvantaged communities.

Keywords: Social Innovation, Gender Equality, Rural Empowerment, Women Empowerment, Sustainable Development.

Introduction:

Rural development is an important part of India's social and economic progress. A large number of people depend on agriculture, animal husbandry, small businesses, traditional occupations and informal employment for their livelihoods. Rural communities also preserve traditional knowledge, cultural practices, local languages and natural resources. Despite their contribution to society and the economy, many rural communities continue to face difficulties related to poverty, unemployment, education, healthcare, infrastructure and social inequality.

Women occupy a central position in rural society. They participate in agriculture, household management, animal care, food processing, family businesses and community activities. However, their contribution is not always recognised in economic calculations or public decision-making. Many women experience unequal access to land, credit, technology, education and employment. Household responsibilities may also limit their opportunities for professional development and participation in public life.

Social innovation offers one possible approach. It encourages people to develop new methods of solving social problems. Such innovation may involve a new community organisation, a digital service, a cooperative business, a local educational initiative or a new way of managing natural resources. The main purpose is to create social value and improve the quality of life.

Gender equality is equally important because social innovation cannot achieve its full potential when half of the population faces unequal opportunities. Women must have the freedom to participate in planning, leadership, entrepreneurship and decision-making. Their experiences and knowledge should be included in development programmes.

Rural empowerment connects these ideas. It focuses on strengthening the ability of rural people to identify problems, access resources, participate in institutions and improve their livelihoods.

Background of the Study:

India's rural development experience includes several approaches, such as community development programmes, agricultural development, rural employment initiatives, self-help groups, cooperative institutions, digital public services and local self-government.

These approaches have created opportunities for rural communities. However, their outcomes differ across regions and social groups. Some villages have access to markets, educational institutions and banking services, while others face geographical and institutional barriers.

Social innovation becomes relevant in this context because it encourages cooperation between communities and institutions. It also supports experimentation, local leadership and practical solutions suited to particular social conditions.

The United Nations' Sustainable Development Goals provide an important framework for this discussion. Goal 5 focuses on gender equality, Goal 8 on decent work and economic growth, Goal 9 on industry and innovation, Goal 10 on reducing inequalities and Goal 11 on sustainable communities.

These goals are closely connected. Gender equality can strengthen economic participation. Rural entrepreneurship can create employment. Digital innovation can improve access to information. Community institutions can help ensure that development programmes respond to local needs.

Research Methodology:

This paper follows a descriptive and analytical research methodology based on secondary sources.

The material is examined under the following themes:

1) Social innovation and community development.
2) Gender equality and women's participation.
3) Rural livelihoods and entrepreneurship.
4) Self-help groups and collective action.
5) Digital technology and education.
6) Financial inclusion and economic independence.
7) Local governance and sustainable development.

A limitation of the study is that the experiences of rural communities differ considerably across regions. Findings from one programme or district cannot automatically be applied to every village. Further field research would be useful to examine the actual outcomes of individual social innovation initiatives.

Understanding Social Innovation:

Social innovation refers to the development and use of new ideas, services, organisational arrangements or practices that address social problems.

Its main purpose is to improve people's lives and create positive social change.

Traditional innovation is often associated with technology, production or business efficiency. Social innovation also focuses on social relationships, public services, inclusion and community well-being.

Similarly, a village-level childcare cooperative may enable women to participate in employment or training. A community water-management committee may reduce conflict and improve access to water. A local learning centre may help children from disadvantaged families continue their education.

1. Main Features of Social Innovation:

Identification of social needs: Innovation begins by identifying a genuine problem experienced by individuals or communities.

Community participation: People affected by the problem should participate in designing and evaluating the solution.

Practical problem-solving: The approach should be suitable for local social, cultural and economic conditions.

Inclusion: The benefits should reach people who are often excluded from mainstream development.

Collaboration: Government bodies, educational institutions, community organisations and private enterprises may work together.

Sustainability: The initiative should have a realistic plan for continuing beyond the initial project period.

Learning and adaptation: Successful practices should be evaluated and modified according to local experience.

2. Social Innovation and Traditional Knowledge:

Rural communities possess valuable knowledge of agriculture, water conservation, animal care, food preservation, crafts and natural resource management.

Social innovation should not assume that every useful idea must come from outside the village.

Traditional knowledge can be combined with scientific research, digital tools and modern organisational practices.

This approach respects community knowledge while creating opportunities for improvement.

Understanding Gender Equality:

Gender equality means that people should have equal rights, opportunities and protection regardless of gender.

It does not mean that everyone must perform the same tasks. It means that gender should not determine whether a person can study, work, own property, participate in leadership or make decisions about personal and family life.

In rural communities, gender equality is connected with education, employment, health, property rights, access to technology and participation in local governance.

Women may perform extensive agricultural and household work while receiving limited recognition or control over the resulting income.

Girls may face barriers related to school distance, household responsibilities, safety concerns or expectations about marriage and employment.

Women entrepreneurs may experience difficulties obtaining credit, marketing products or participating in business networks.

These barriers cannot be removed through a single intervention. They require changes in

institutions, services, social attitudes and economic opportunities.

1. Economic Equality:

- Economic equality includes fair opportunities to earn income, own assets, obtain suitable credit and participate in productive activity.
- Women should be able to choose whether to work as employees, farmers, professionals, entrepreneurs or skilled workers.
- Economic empowerment also requires control over earnings. Receiving income does not necessarily mean that a woman has the authority to decide how it will be used.

2. Educational Equality:

- Education increases knowledge, confidence and employment opportunities.
- Rural girls and women need access to quality education, vocational training, digital learning and opportunities for lifelong learning.
- Adult education can also support women who left school early because of family responsibilities, poverty or other barriers.

3. Political Equality:

- Women should participate meaningfully in village councils, committees, community organisations and other decision-making institutions.
- Representation is important, but effective participation requires information, confidence, institutional support and the freedom to express independent views.

4. Social Equality:

- Social equality requires respect, safety and freedom from discrimination and violence.
- A development programme cannot be considered fully successful if it increases women's income but ignores their safety, health or ability to make personal decisions.
- Gender equality should therefore be included in every stage of rural planning and programme evaluation.

Rural Empowerment: Meaning and Importance:

- Rural empowerment is the process of strengthening people's ability to improve their living conditions and influence decisions affecting their communities.
- It includes economic, educational, social, political and institutional dimensions.
- Economic empowerment enables people to earn income, build assets and access financial services.
- Educational empowerment strengthens knowledge, skills and awareness.
- Social empowerment encourages participation, cooperation and freedom from discrimination.
- Political empowerment enables people to participate in local governance and public decision-making.
- Institutional empowerment improves the ability of communities to access public services, understand their rights and hold institutions accountable.
- These dimensions are interconnected.

Relationship Between Social Innovation, Gender Equality and Rural Empowerment:

- Social innovation, gender equality and rural empowerment are closely related.
- Social innovation provides new ways to address problems. Gender equality ensures that these solutions do not reproduce existing discrimination. Rural empowerment represents the wider ability of people to participate in and benefit from development.

- The relationship can be understood through a practical example.
- Suppose women in a village produce traditional food products but have limited access to markets.
- A community organisation may help them form a producer group. The group may receive training in hygiene, packaging, pricing and digital marketing. A bank may provide suitable financial services, while a local institution may connect the group with buyers.
- This is an example of social innovation because the initiative creates a new collective method of addressing an economic problem.
- It supports gender equality if women participate in leadership, control their earnings and share decisions fairly.
- It contributes to rural empowerment if the initiative creates sustainable livelihoods, strengthens community cooperation and improves women's ability to participate in economic and social life.

Women's Self-Help Groups as Instruments of Social Innovation:

Self-help groups are among the most important community-based approaches to rural women's empowerment in India.

1. Financial Inclusion:

- Regular savings can help members develop financial discipline. Bank linkage may improve access to formal credit and reduce dependence on some forms of high-cost informal borrowing.
- However, credit should be suitable for the member's needs and repayment capacity.

2. Collective Entrepreneurship:

- Members may work together in food processing, tailoring, dairy production, poultry, handicrafts, agricultural services or other local enterprises.
- Collective activity can help them share equipment, training and some marketing costs.
- The viability of each activity should be assessed according to local demand and production capacity.

3. Leadership Development:

- Managing meetings, maintaining records and communicating with institutions can strengthen organisational skills.
- These experiences may encourage members to participate in village committees and local governance.

4. Social Awareness:

- SHGs can provide opportunities to discuss education, health, sanitation, gender discrimination, legal rights and social protection.
- Such activities may help members recognise shared problems and work collectively to address them.

Social Innovation in Rural Entrepreneurship:

Rural entrepreneurship can create employment, diversify household income and encourage local economic development. It includes small manufacturing, food processing, repair services, tourism, animal husbandry, crafts, digital services and many other activities. Social innovation can improve rural entrepreneurship by changing how products are made, marketed, financed and distributed.

1. Local Products and Local Markets:

- Rural communities often produce food items, crafts, textiles and agricultural products that have economic value.
- Collective marketing can help producers reach customers beyond their immediate villages.

- Packaging, quality control, branding and reliable delivery may increase market opportunities.

2. Digital Marketing:

- Digital platforms can help rural entrepreneurs display products, communicate with customers and receive orders.
- However, digital marketing requires skills, reliable connectivity, product photographs, customer service and the ability to manage deliveries.
- Digital tools should be introduced with appropriate training and practical support.

3. Producer Groups and Cooperatives:

- Small producers may face high input costs and weak bargaining power.
- Collective purchasing, shared processing facilities and producer organisations can help reduce some costs and improve market access.
- Transparent management is necessary to ensure that the benefits reach members fairly.

4. Rural Youth Entrepreneurship:

- Young people can contribute through technology services, repair businesses, agricultural advisory services, tourism, online education and other local enterprises.
- They need access to skills, mentoring, suitable finance and information about market demand.
- Entrepreneurship programmes should not assume that every young person must start a business. Quality wage employment and apprenticeships remain equally important.

Digital Technology and Rural Empowerment:

Digital technology can improve access to information, education, financial services, public programmes and markets. Mobile phones, internet services, digital payments and online learning platforms create opportunities for rural communities. However, technology can also deepen inequality if some groups cannot access or use it effectively.

1. Digital Education:

- Digital learning can provide educational materials to students who have limited access to libraries, coaching or specialist teachers.
- Online courses can also help women and rural youth develop professional skills.
- Effective digital education requires devices, connectivity, appropriate content and support from teachers or trainers.

2. Digital Financial Services:

- Digital payments and banking services can reduce travel and transaction costs.
- They can also help small businesses maintain records of transactions.
- However, digital fraud, confusing applications, language barriers and limited digital literacy can reduce the benefits.
- Users need clear information about passwords, one-time passwords, transaction verification and complaint procedures.

3. Agricultural Information:

- Digital services may provide information about weather, agricultural practices, prices and government programmes.
- Such information can help farmers plan their activities.
- However, information must be reliable, understandable and relevant to local conditions. Farmers should not be expected to make major financial decisions based only on unverified online messages.

4. Digital Inclusion for Women:

- Women may face unequal access to personal devices, internet services or digital training.

- Programmes should provide practical opportunities to learn digital skills and use services independently.
- Training should also address privacy, online harassment and financial fraud.
- Digital empowerment should increase women's independence rather than create new forms of dependence.

Education as a Foundation for Gender Equality:

Education is a powerful means of expanding opportunities and challenging social inequality. Quality education helps rural children develop knowledge, communication skills and the ability to make informed decisions. For girls, education can improve employment opportunities, confidence and participation in public life. However, access to schooling alone is not sufficient. Schools also need trained teachers, suitable facilities, safe transport, appropriate learning materials and an environment free from discrimination.

1. Higher Education for Rural Women:

- Higher education can open opportunities in teaching, healthcare, administration, law, business, technology and research.
- Scholarships, hostels, transport assistance and digital learning can help reduce barriers for rural students.
- Colleges can also organise career guidance, entrepreneurship workshops and financial literacy programmes.

2. Vocational Education:

- Vocational education can help learners develop practical skills related to local employment opportunities.
- Possible areas include food processing, computer operation, healthcare assistance, electrical work, tailoring, accounting, agricultural services and digital marketing.
- Training programmes should be developed after assessing local demand. Certificates alone cannot guarantee employment.

3. Community Learning:

- Adult education and community learning centres can help women and older learners develop literacy, digital skills and knowledge of public services.
- Local libraries, colleges, schools and community organisations can cooperate to provide such opportunities.
- Education becomes more empowering when learners can apply their knowledge in daily life.

Rural Women and Agricultural Development:

Agriculture remains important to rural livelihoods. Women contribute to crop production, livestock care, seed selection, processing and household food security. Yet women's agricultural work may not always receive appropriate recognition. Women farmers can face difficulties related to land ownership, access to credit, extension services, equipment and markets.

Social innovation can help address some of these barriers through collective purchasing, farmer groups, digital information, shared equipment and community-based agricultural services.

1. Access to Agricultural Knowledge:

- Training can help women adopt suitable farming practices, improve animal care and understand crop management.
- Women should be included directly in agricultural extension programmes rather than relying only on information reaching male household members.

2. Climate-Resilient Agriculture:

- Changing rainfall patterns, droughts, floods and heat can affect rural livelihoods.

- Community-based water conservation, crop diversification, soil management and suitable agricultural technologies can improve resilience.
- Women should participate in decisions about which technologies and practices are introduced.

3. Ownership and Control of Resources:

- Access to land, equipment, credit and income can strengthen women's ability to make agricultural decisions.
- Programmes should examine whether women actually control productive resources rather than counting only their participation in training.

4. Reducing Workload:

- Appropriate tools, reliable water access, energy services and childcare facilities can reduce the time spent on unpaid work.
- Reducing women's workload can create more opportunities for education, employment, rest and participation in public life.

Rural Governance and Women's Leadership:

Local governance provides an important space for community participation. Gram Panchayats and other local institutions make decisions related to infrastructure, sanitation, drinking water, local services and development priorities. Women's participation can help ensure that these decisions reflect the experiences of different sections of the community.

India has a substantial presence of women in local elected institutions. However, representation should be accompanied by meaningful participation and independent decision-making.

1. Participatory Planning:

- Participatory planning involves local residents in identifying needs and setting priorities.
- Women, landless workers, persons with disabilities, young people and socially disadvantaged groups should have opportunities to express their views.
- Meetings should be organised at accessible times and locations. Information should be communicated in languages understood by local residents.

2. Transparency and Accountability:

- Public information about budgets, projects and beneficiary selection can strengthen trust.
- Social audits and community monitoring may help identify gaps in implementation.
- These processes should be accessible and should not expose participants to intimidation or retaliation.

3. Leadership Development:

- Leadership training can help women develop confidence, public speaking skills and knowledge of institutional procedures.
- Mentoring and peer networks can support women who are entering public life for the first time.
- Effective leadership also requires institutions to take women's contributions seriously.

Government Initiatives and Institutional Support in India:

Several Indian programmes are relevant to social innovation, gender equality and rural empowerment. Their effectiveness depends on implementation, coordination, local participation and the suitability of services for intended beneficiaries.

1. Deendayal Antyodaya Yojana–National Rural Livelihoods Mission:

- The National Rural Livelihoods Mission supports rural poor households through self-help groups and community institutions.
- It seeks to strengthen livelihoods and improve access to financial services.
- Its community-based approach creates opportunities for savings, collective action, training and enterprise development.
- To maximise its impact, support should extend beyond group formation to include market access, business management, digital skills and women's decision-making.

2. Mahatma Gandhi National Rural Employment Guarantee Act:

- MGNREGA provides a legal framework for rural wage employment, subject to the Act's provisions.
- It can contribute to household income and support the creation of rural assets.
- The quality of implementation matters. Timely wage payments, accessible work opportunities, safe working conditions and appropriate facilities can affect whether women benefit equally.

3. Mission Shakti:

- Mission Shakti is a Government of India umbrella programme focused on women's safety, security and empowerment.
- Its broader objectives are relevant to rural women because economic participation requires safety, access to support services and freedom from violence.
- Awareness, service delivery and coordination among institutions are important for translating policy objectives into practical protection.

4. Digital India:

- Digital initiatives can improve access to information, online services and digital transactions.
- However, rural digital inclusion requires affordable connectivity, local-language services, digital literacy and reliable support for users who experience technical problems.

Major Challenges to Social Innovation and Rural Empowerment:

1) Low household income can prevent people from investing in education, business development and technology.
2) Even a useful innovation may fail if the intended users cannot afford the required equipment or services.
3) Unequal social expectations can restrict women's mobility, employment and participation in leadership.
4) Development programmes need to address these barriers directly.
5) Limited literacy and digital skills can reduce access to online services, information and markets.
6) Training should be practical, accessible and adapted to local languages.
7) Poor roads, unreliable electricity, limited internet connectivity and inadequate storage can restrict economic opportunities.
8) Infrastructure investment is often necessary for social innovation to produce lasting results.
9) Rural entrepreneurs may struggle to find customers, maintain product quality or transport goods at reasonable cost.
10) Enterprise support should include market research, product development and buyer connections.

Social Innovation and Sustainable Development:

Sustainable development seeks to improve present living conditions without weakening the ability of future generations to meet their needs. Social innovation can support this objective by improving livelihoods, strengthening institutions and encouraging responsible use of resources. Rural communities depend heavily on land, water, forests and biodiversity. Development initiatives should therefore consider environmental consequences alongside economic benefits.

Women's participation is important in these initiatives because women often have direct experience of household water needs, fuel use, food production and local resource management. However, environmental projects should not increase women's unpaid workload or exclude them from decisions about benefits and responsibilities. Sustainable innovation requires fair participation, transparent management and a realistic plan for maintenance.

For example, community-based water conservation may support agriculture while improving local cooperation. Waste-management initiatives may create employment and improve village sanitation. Renewable energy projects may improve access to lighting and productive services.

Conclusion:

India has developed several initiatives related to self-help groups, rural employment, digital services, women's empowerment and local governance. These initiatives provide useful foundations for community-based development. Their effectiveness, however, depends on the quality of implementation and the extent to which they respond to local needs.

Women's self-help groups demonstrate the potential of collective action. Digital technology can improve access to information and services. Education can strengthen capabilities. Rural entrepreneurship can create livelihoods. Local governance can improve participation and accountability. Yet no single intervention can solve every rural problem.

A society becomes more inclusive when rural women and men can access education, earn livelihoods, use technology safely, participate in public life and live with dignity.

Therefore, social innovation becomes a meaningful instrument of rural transformation when it is guided by gender equality, community participation, institutional accountability and sustainable development.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

The Dual Role of Greenery and Botanical Bioactive Plants for Human Mental and Psychological Health

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DOI - 10.5281/zenodo.24339452

Abstract:

Due to the unfortunate circumstances related to the global pandemic many people spending most of their time at alone, Mental health has certainly been compromised for most of us. Managing one's mental health is high priority. Especially from a global pandemic, we must make extra effort towards self-care, along with the wellbeing of our loved ones. It is a scientific fact that exposure to living near green spaces and spending as much time as possible in nature, can improve mood, reduce stress, enhance cognitive skills, and promote overall well-being in people of all ages. Developments in information technology cause a great deal of stress to modern people and controlling this stress now becomes an important issue.

Historically, medicinal plant utilization focused primarily on acute disease treatment rather than proactive prevention. Contemporary pharmacological and epidemiological frameworks demonstrate that therapeutic interventions and disease prevention share a deeply interconnected continuum such as managing mild hypertension to prevent renal disease. Approximately 90% of traditional medicinal formulations incorporate plant-derived matrices. Concurrently, degraded environmental parameters (toxicological exposure, pathogen vectors, and industrial pollutants) exert significant psychological and physiological stress on human populations.

This research provides a comprehensive synthesis of key medicinal flora including Zingiber officinale (Ginger), Origanum vulgare (Oregano), Crocus sativus (Saffron), Cinnamomum verum (Cinnamon), Rosmarinus officinalis (Rosemary), Ocimum sanctum (Tulsi), Aloe vera, Papaver species, Haloxylon griffithii (Rimth Salt Bush), and Lactuca orientalis (Agheet). We examine their biochemical profiles, adaptogenic stress-mitigation mechanisms, neuroprotective roles, and physical health applications. Furthermore, we explore the psycho-environmental benefits of indoor greenery, societal strategies for mental health promotion, and ecological farming frameworks necessary to sustain botanical therapeutics for future generations.

The aim of this study was to examine psychological and physiological benefits of interaction with plants. Spending as much time as possible in both natural environment and cultivated gardens, can improve mood, reduce the negative effects of stress, encourage physical activity and other positive behaviors, improve cognition, reduce aggression, and enhance overall well-being in people of all ages under many different circumstances.

Keywords**: **Integrative Botanical Medicine, Phytochemical Profiles, Therapeutic Mechanisms, and Ecological Dimensions in Physical and Mental Health Prevention.

Introduction, Material and Methods:

The Prevention-Treatment Continuum & Environmental Health:

1. The Shifting Focus toward Preventive Phytotherapy:

Historically, medical paradigms prioritized therapeutic intervention post-pathogenesis over disease prevention. However, contemporary ethnomedicine and pharmacology recognize that a thin, highly fluid boundaries separate treatment from prevention. Managing early-stage physiological imbalances often serves as primary or secondary disease prevention. A classic clinical manifestation is blood pressure regulation: treating mild hypertension directly prevents downstream chronic kidney disease (CKD) and end-stage renal disease (ESRD). Globally, approximately 90% of traditional medicine recipes rely on medicinal plant matrices. These botanical complexes offer multi-target secondary metabolites that simultaneously treat active symptoms while protecting target organs against long-term degeneration.

2. Environmental Determinants of Human Wellbeing:

The World Health Organization (WHO) defines health as *"a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity."* Environmental degradation impairs human health through direct and indirect pathways:

1. **Infectious Disease Threats:** Vector dynamics, microbial shifts, and compromised immune barriers driven by ecosystem degradation.
2. **Toxicological Exposures:** Bioaccumulation of industrial toxic chemicals, radioactive materials, heavy metals (lead, mercury, cadmium), and trace contaminants.
3. **Chronic & Hidden Health Impacts:** Sub-acute, long-term environmental stress contributing to systemic inflammation, endocrine disruption, and chronic physical/mental ailments.

Maintaining the integrity of environmental, economic, and social dimensions is essential for preserving baseline family and community wellbeing.

Ethnobotanical Profiles and Pharmacological Mechanisms:

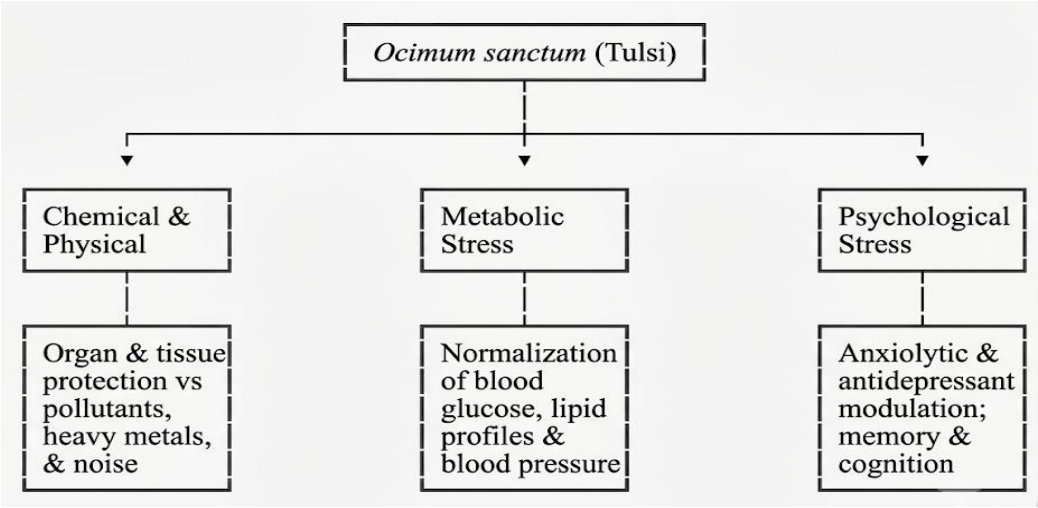
The therapeutic profile of key medicinal flora spans neurological, metabolic, anti-inflammatory, and antimicrobial applications:

Sr. No.	Botanical Name	Common / Local Names	Primary Active Bioactive Constituents	Key Pharmacological & Preventive Applications
1	***Zingiber officinale***	Ginger	Gingerols, Shogaols, Zingiberene	Antiemetic (motion sickness, pregnancy, chemotherapy), anti-osteoarthritic pain, cardiovascular protective properties.
2	***Origanum vulgare***	Oregano	Carvacrol, Thymol, Rosmarinic acid	Respiratory support (asthma, bronchitis, cough), gastrointestinal antimicrobial, anti-inflammatory, glycemic control.
3	***Crocus sativus***	Saffron	Crocin, Crocetins, Safranal, Picrocrocin	Neurotransmitter regulation, mood modification/antidepressant, antioxidant, antineoplastic, anti-inflammatory.

4	***Cinnamomum verum***	Cinnamon	Cinnamaldehyde, Eugenol, Polyphenols	Broad-spectrum antibacterial, antiviral, antifungal; glycemic regulation in Type 2 diabetes; blood pressure management.
5	***Rosmarinus officinalis***	Rosemary	Rosmarinic acid, Carnosic acid, Eucalyptol	Antispasmodic, mild analgesic (headaches, intercostal neuralgia), anxiolytic, antidepressant, neuroprotective against oxidative decay.
6	***Ocimum sanctum***	Tulsi / Holy Basil	Eugenol, Ursolic acid, Rosmarinic acid, Caryophyllene	Master adaptogen: counters physical, chemical, metabolic, and psychological stress. Organoprotective against industrial pollutants and heavy metals; cognitive enhancement.
7	***Aloe vera***	Aloe	Acemannan, Anthraquinones, Vitamins A/C/E	Topical wound healing, thermal burn treatment, gastrointestinal membrane repair, antimicrobial and anti-inflammatory agent.
8	***Papaver* spp.**	Opium Poppy (Afyun)	Morphine, Codeine, Papaverine, Noscapine	Analgesic, antitussive, anti-inflammatory, antidiabetic potential (managed carefully due to narcotic alkaloid profiles).
9	***Haloxylon griffithii***	Bundi / Rimth Salt Bush	Saponins, Alkaloids, Phenolic compounds	Traditional antiseptic, eye disorder treatments, anti-inflammatory, antidiabetic management.
10	***Lactuca orientalis***	Agheet	Sesquiterpene lactones (Lactucin, Lactucopicrin)	Mild sedative, analgesic, appetite stimulant; treats gastrointestinal distress, indigestion, bronchitis, and urinary tract infections.

Tulsi (*Ocimum sanctum*) as a Master Adaptogen Against Multi-Modal Stress:

Ocimum sanctum (Tulsi) represents an extraordinary pharmacological model for preventive medicine due to its unique adaptogenic profile:



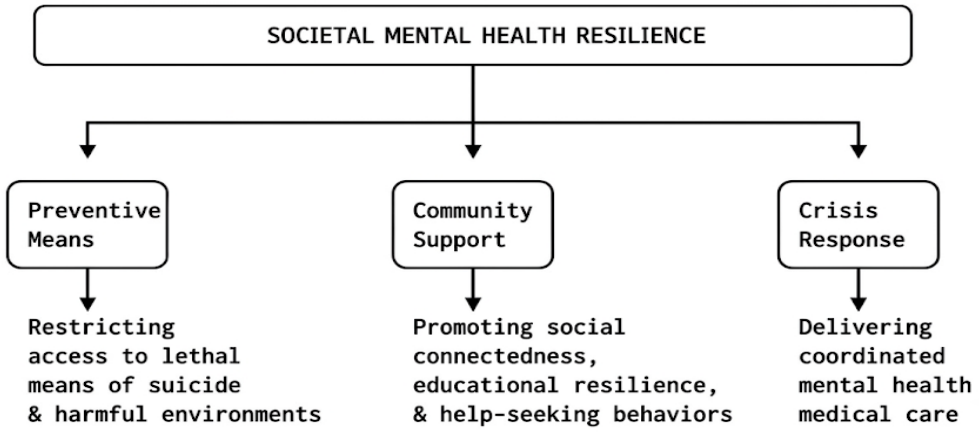
Indoor Phytotherapy and Psycho-Environmental Well-Being:

Beyond direct ingestion or extraction, living plant interactions specifically indoor greenery yield documented physiological and psychological benefits:

1. **Physiological Stress Reduction:** Exposure to indoor foliage is linked to reduced salivary cortisol levels, decreased mean arterial blood pressure, and diminished autonomic nervous system hyper-arousal.
2. **Occupational & Cognitive Outcomes:** Workplace environments containing indoor plants show higher job satisfaction ratings, enhanced focus, and lower rates of general health complaints (e.g., dry throat, fatigue, headaches).
3. **Air Purification:** Phytoremediation via indoor foliage reduces ambient concentrations of volatile organic compounds (VOCs), bio-effluents, and particulate matter.
4. **Risk Factors & Considerations:** Indoor plants require structured maintenance to mitigate mold growth, pest vector proliferation, and accidental exposure to toxic flowering plants (e.g., *Convallaria majalis* / Lily of the Valley, which contains cardiac glycosides toxic to pets and young children).

Modern Research, Social Mental Health Frameworks, and Sustainability:

1. Integrated Mental Health Promotion Strategies: Modern botanical research intersects with broader public health frameworks. Mitigating psychological stress and pathological behaviours (such as extreme internet addiction, social isolation, and impulsivity) requires holistic, multi-tiered interventions:



2. Sustainable Agriculture and Livelihood Security: The therapeutic demand for medicinal plants underlines the critical need for ethical, sustainable, and ecological farming practices:

1. **Agrarian Livelihoods:** Cultivating high-value medicinal flora provides sustainable income streams for thousands of smallholder farming families globally.
2. **Ecological Protection:** Organic and poly-culture medicinal plant cultivation prevents soil depletion, preserves biodiversity, and reduces reliance on synthetic agrochemicals.
3. **Future Preservation:** Safeguarding wild botanical strains ensures that untapped biomolecules remain available for pharmaceutical discovery in fighting

complex conditions such as cancer, metabolic syndromes, and neurodegenerative disorders.

Result and Discussion:

The analysis of botanical interactions, ethnobotanical profiles, and indoor phytotherapy reveals significant physical, psychological, and environmental health benefits:

1. **Preventive & Therapeutic Continuum:** Modern pharmacological frameworks confirm that primary interventions using plant matrices such as blood pressure regulation via botanical therapies effectively prevent severe chronic conditions like End-Stage Renal Disease (ESRD) and chronic kidney disease (CKD). Approximately 90% of traditional medicinal formulations rely on plant secondary metabolites to deliver multi-target organ protection.
2. **Phytochemical & Adaptogenic Profiles:**
   i. **Master Adaptogen (*Ocimum sanctum* / Tulsi):** Acts as a comprehensive multi-modal stress regulator, protecting against metabolic, physical, chemical, and psychological stress while defending against industrial pollutants and heavy metals.
   ii. **Neuro-Modulation & Mood (*Crocus sativus* / Saffron & *Rosmarinus officinalis* / Rosemary):** Saffron (via crocin, safranal) and Rosemary (via carnosic acid, eucalyptol) provide proven neuroprotective, anxiolytic, and antidepressant mechanisms through neurotransmitter modulation and reduction of oxidative decay.
   iii. **Physical & Metabolic Support:** Key bioactive constituents in plants such as Ginger (*Zingiber officinale*), Cinnamon (*Cinnamomum verum*), Aloe Vera, and Opium Poppy (*Papaver spp.*) offer targeted anti-inflammatory, analgesic, antimicrobial, antiemetic, and glycemic control benefits.
3. **Indoor Phytotherapy & Environmental Well-Being:** Passive interaction with living indoor foliage produces measurable bio-physiological stress reduction, including lower salivary cortisol levels, decreased mean arterial blood pressure, and reduced autonomic nervous system hyper-arousal. Additionally, indoor greenery improves workplace cognitive performance, elevates focus, and cleanses ambient air by phytoremediating volatile organic compounds (VOCs).

Conclusion:

Medicinal plants and green space interactions form a crucial link bridging ancient ethnomedical wisdom with modern preventive and psychological healthcare. In light of heightened environmental degradation, lifestyle stressors, and modern challenges, incorporating botanical therapeutics and indoor greenery offers a non-invasive, holistic, and accessible strategy to improve mood, reduce stress, enhance cognitive function, and promote overall physical and mental well-being across all age groups.

To ensure the long-term efficacy and availability of these natural remedies, public health frameworks must adopt integrated strategies that combine indoor foliage exposure with ethical, organic, and poly-culture farming practices. Protecting botanical diversity and sustaining agrarian livelihoods will safeguard vital biomolecules needed for future pharmaceutical discoveries and comprehensive public health resilience.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Impact of Mindfulness Training Programme on Stress, Anxiety, and Resilience among Adolescents: A Systematic Review

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DOI - 10.5281/zenodo.24339510

Abstract:

The present review aims to examine the effectiveness of mindfulness training programmes in reducing stress and anxiety while enhancing resilience among adolescents. Relevant studies are published in last 20 years. were reviewed from electronic databases including PubMed, Scopus, Web of Science, PsycINFO, ERIC, and Google Scholar. Randomized controlled trials, quasi-experimental studies, systematic reviews, and meta-analyses were included. The reviewed evidence consistently indicates that mindfulness training significantly reduces perceived stress, anxiety, emotional distress, and rumination while improving resilience, emotional regulation, attention, self-awareness, self-compassion, and adaptive coping. School-based mindfulness programmes were found to be particularly effective because they provide adolescents with practical psychological skills that can be integrated into their daily and academic life. Although substantial international evidence supports mindfulness trainings, research conducted among Indian adolescents remains comparatively limited. The review highlights the need for culturally appropriate school-based mindfulness programmes and longitudinal research to establish long-term effectiveness. Overall, mindfulness training represents a promising preventive mental health strategy capable of fostering emotional resilience and psychological well-being among adolescents.

Keywords: Mindfulness, Adolescents, Stress, Anxiety, Resilience, Psychological Well-being, Mindfulness Training Programme.

Introduction:

Adolescence is one of the most significant stages of human development, which is marked by rapid physical growth, cognitive maturation, emotional changes, and increasing social responsibilities. Adolescents between the ages of 12 to 18 years' experience major developmental transitions that shape, size their personality, identity, and future adjustment. During this period, they encounter number of challenges related to academic achievement, peer relationships, family expectations, career planning, social media exposure, and emotional independence. Although these experiences contribute to personal growth, they also increase vulnerability to psychological problems such as stress and anxiety.

In last few decades, adolescent mental health has been become a major public health concern worldwide. The World Health Organization has identified depression, anxiety, and stress-related disorders as leading contributors to illness among adolescents. Academic competition, examination pressure, cyberbullying, excessive use of digital technology, family conflicts, and uncertainty

regarding future careers have significantly increased psychological distress among young people. Chronic stress and persistent anxiety negatively influence concentration, emotional regulation, decision-making, interpersonal relationships, and academic performance. If left untreated, these difficulties may continue into adulthood and increase the risk of depression, substance abuse, and other mental health disorders.

Among various psychological interventions, mindfulness has received considerable scientific attention because of its effectiveness in improving emotional well-being. Mindfulness refers to intentionally paying attention to present-moment experiences with openness, curiosity, and acceptance without judgment. Rather than attempting to avoid unpleasant emotions or suppress anxious thoughts, mindfulness encourages individuals to acknowledge these experiences with awareness and compassion. Through regular practice, adolescents develop greater self-awareness, emotional regulation, attentional control, and adaptive coping skills.

Neuroscientific research further supports the effectiveness of mindfulness. Regular mindfulness practice has been associated with increased activity in the prefrontal cortex, responsible for executive functioning and emotional regulation, and decreased activation of the amygdala, which plays a central role in fear and stress responses. These neurological changes contribute to improving attention, emotional control, and resilience, making mindfulness particularly valuable during adolescence, when the brain undergoes substantial developmental changes.

Although mindfulness has been extensively investigated internationally, relatively fewer studies have focused on adolescents in India. Most Indian research has examined yoga-based interventions rather than standardized mindfulness programmes. Therefore, synthesizing available evidence is important for understanding the effectiveness of mindfulness training within educational contexts and identifying future research directions.

The present review systematically examines existing literature regarding the impact of mindfulness training programmes on stress, anxiety, and resilience among adolescents. By reviewing empirical studies conducted across different worldwide countries and educational settings, this paper aims to provide comprehensive evidence supporting mindfulness as an effectiveness preventive mental health intervention for adolescents.

Objectives of the Review:

The present review has following objectives:

1. To study the effectiveness of mindfulness training programmes in reducing stress and anxiety among adolescents.
2. To study the effectiveness of mindfulness training in enhancing resilience among adolescents.
3. To identify psychological mechanisms through which mindfulness improves adolescent mental health.

Methodology:

The present study is a systematic review of published literature examining the effectiveness of mindfulness training programmes among adolescents. Relevant studies published in last 20 years were identified through electronic databases including PubMed, PsycINFO, Scopus, ERIC, Web of Science, and Google Scholar. Search terms included mindfulness, mindfulness training, adolescents, stress, anxiety, resilience, school-based mindfulness, and mindfulness intervention.

The review included randomized controlled trials, quasi-experimental studies, longitudinal studies, systematic reviews, and meta-analyses involving adolescents. Reviews are focusing exclusively on adolescents or clinical populations outside the specified group were excluded. Information regarding participants, intervention characteristics, duration, outcome measures, and key findings was extracted and synthesized narratively to provide an overview of current evidence.

Review of Literature:

Mindfulness has emerged as one of the most widely investigated psychological interventions for improving adolescent well-being. Over the past two decades, numerous experimental studies, randomized controlled trials, systematic reviews, and meta-analyses have examined its effectiveness in reducing stress and anxiety while promoting resilience and emotional well-being. The following review summarizes the major empirical findings related to mindfulness training programmes among adolescents.

A randomized controlled trial conducted to evaluated the effectiveness of an five months Mindfulness-Based Stress Reduction (MBSR) programme among adolescents receiving outpatient psychiatric treatment. Results revealed significant reductions in perceived stress, anxiety, depression, and somatic distress, and increased self-esteem and sleep quality. The study concluded that mindfulness training is an effective intervention for improving adolescents' psychological health. (Biegel, et al, 2009)

Similarly, the *Learning to BREATHE* programme specifically for adolescents in educational settings. The programme focused on development of emotion regulation skills through the practice of mindfulness, which has been described as intentional, non-judgmental awareness of present-moment experience. Findings of the study decreased negative affect and increased feelings of calmness, relaxation, and self-acceptance. Improvements in emotion regulation and decreases in tiredness and aches and pains. (Broderick and Metz, 2009)

A study Mindfulness-Based Cognitive Therapy for Children (MBCT-C) is a manualized group psychotherapy programme specifically designed to enhance mindful attention and promote social-emotional resilience. The study included 25 children, the majority of whom were from low-income urban families, with 21 participants belonging to ethnic minority groups. The study concluded that Mindfulness-Based Cognitive Therapy for Children is a promising intervention for improving attention, reducing anxiety symptoms, enhancing behavioural functioning, and strengthening social-emotional resilience among children (Semple et al., 2010)

A systematic review and meta-analysis to examine the effectiveness of school-based mindfulness interventions among children and adolescents. The review included 24 studies, with 19 using controlled research designs, involving 1,348 students who received mindfulness training and 876 control participants from Grades 1 to 12. Overall, the review concluded that school-based mindfulness programmes are effective in promoting psychological well-being, particularly by improving cognitive functioning, strengthening resilience, and helping students cope better with stress. (Zenner, et al. 2014).

Meta-analysis to examine the effectiveness of mindfulness interventions for depression and anxiety among Youth under 18 years. The study included 20 peer-reviewed studies published between 2004 and 2011. The findings indicated that mindfulness interventions were effective in reducing psychological symptoms, particularly anxiety and depression, The benefits were found to be greater among clinical populations than non-clinical groups. and

recommended further research which focusing on youth with in clinical settings and target symptoms of psychopathology. (Zoogman, et al, 2015)

A systematic review to study the application of mindfulness-based interventions (MBIs) among students in school settings. The review included 28 studies and analysed their methodologies, participant characteristics, intervention features, and outcome measures. The findings highlighted both the strengths and limitations of the existing literature on school-based mindfulness interventions. The researcher concluded that mindfulness programmes have considerable potential for use in educational settings; however, they emphasized the need for more rigorous research designs and standardized intervention protocols to strengthen the evidence regarding their effectiveness. (Felver, et al. 2016)

Effectiveness of a school-based Mindfulness-Based Stress Reduction (MBSR) programme among low-income urban adolescent boys. The study randomly assigned 7th and 8th grade students to either a 12-session MBSR programme or a health education programme and assessed their psychological functioning, coping, sleep, and physiological stress responses. The findings revealed that students who participated in the MBSR programme experienced significantly lower anxiety and rumination, along with improved coping skills, compared with those in the health education group. Additionally, cortisol levels, an indicator of physiological stress, remained stable among the MBSR participants, whereas they increased among the comparison group during the academic term. The authors concluded that school-based mindfulness training is an effective intervention for improving psychological functioning and reducing stress among adolescent boys. (Sibinga et al., 2013)

A study of the effectiveness of an 8-week Mindful Self-Compassion (MSC) programme among adolescents in the United States of America. The study involved fourty-seven adolescents who participated in the intervention, and assessments were conducted before the programme, immediately after its completion, and at a six-week follow-up. The findings showed that the programme significantly reduced perceived stress while enhancing resilience, gratitude, and curiosity/exploration among the participants. Furthermore, increases in mindfulness and self-compassion were associated with lower levels of stress, depressive symptoms, and anxiety. Self-compassion was also positively related to resilience and curiosity, indicating its role in promoting positive psychological development. The authors concluded that the Mindful Self-Compassion programme has considerable potential for improving adolescents' mental health by reducing stress and strengthening resilience, although further controlled studies are needed to confirm these findings. (Bluth et al. 2016)

A comprehensive meta-analysis to study the effectiveness of mindfulness-based interventions (MBIs) among children and adolescents. The review synthesized findings from 76 studies involving 6,121 participants. The results indicated that mindfulness interventions produced significant improvements in overall psychological functioning, and these benefits were found to be greater at follow-up than immediately after the intervention, suggesting that the positive effects of mindfulness are sustained over time. The review also reported improvements across various therapeutic process and outcome domains, with particularly strong gains in mindfulness skills among participants. Furthermore, the effectiveness of mindfulness interventions was found to be consistent across different intervention settings and programme durations. The authors concluded that mindfulness-based interventions are an effective approach for promoting the mental health and

well-being of children and adolescents, while recommending further high-quality research to strengthen the existing evidence. (Klingbeil, et al. 2017)

A meta-analysis to study of the effectiveness of school-based mindfulness interventions on the mental health and well-being of children and adolescents. The review included 24 studies involving 3,977 students from elementary and high schools. The findings indicated that mindfulness interventions significantly improved students' mental health and overall well-being compared to control groups. The study further reported that the interventions were most effective among late adolescents (15–18 years) and when they incorporated a combination of different mindfulness activities. Additionally, the effectiveness of the programmes varied depending on whether they were delivered by external mindfulness facilitators or trained school teachers. The authors concluded that both individual characteristics and programme features influence the effectiveness of school-based mindfulness interventions and emphasized the importance of considering these factors while designing future mindfulness programmes for adolescents. (Carsley, et al. 2018)

A meta-analysis to evaluate the effectiveness of mindfulness-based interventions (MBIs) among children and adolescents using randomized controlled trials (RCTs). The review included 33 studies involving 3,666 participants and examined the effects of mindfulness on cognitive, behavioural, and emotional outcomes. The findings revealed that mindfulness interventions significantly improved mindfulness, executive functioning, attention, and reduced symptoms of depression, anxiety, stress, and negative behaviours compared with control groups. When only studies with active control groups were considered, mindfulness interventions continued to show significant improvements in mindfulness, depression, and anxiety stress. The authors concluded that mindfulness-based interventions are effective in promoting the mental health and well-being of children and adolescents and recommended larger, high-quality randomized controlled trials to further strengthen the evidence supporting their use. (Dunning et al, 2019)

A study investigated the effectiveness of the "Dot be" mindfulness in schools programme in reducing symptoms of anxiety, depression, and eating disorder risk factors among adolescents. The randomized controlled trial included 308 secondary school students who were assigned either to an eight-week mindfulness programme or to a control group receiving regular classroom lessons. The findings indicated that, although the mindfulness programme was well accepted by students, no significant improvements were observed in anxiety, depression, weight and shape concerns, or overall well-being immediately after the intervention or at the three-month follow-up. Furthermore, anxiety levels were found to be higher at follow-up among some male participants and students with lower baseline symptoms. The authors concluded that, despite the high acceptability of the programme, school-based mindfulness interventions may not always produce significant mental health benefits, emphasizing the need for further research to identify the active components, optimal intervention duration, and implementation strategies for improving their effectiveness in school settings. (Johnson et al., 2017)

A comprehensive data from 22 randomized controlled trials involving 16,558 adolescents to evaluate the effectiveness of school-based mindfulness interventions in improving adolescents' mental health and well-being. The findings indicated that, when compared with active control groups, mindfulness intervention program significantly reduced

anxiety and stress and improved overall well-being. However, when compared with all control groups combined, the interventions did not produce significant improvements in anxiety, depression, attention, executive functioning, social behaviour, negative behaviour, or overall well-being, and no significant benefits were observed at follow-up assessments. The authors concluded that the current evidence does not strongly support universal school-based mindfulness programmes as an effective preventive strategy for adolescents' mental health and recommended further high-quality research to identify more effective intervention approaches. (Galla, et al., 2024)

Discussion:

The literature reviewed in the present study demonstrates that mindfulness training programmes have become one of the most extensively investigated psychological interventions for adolescents. Across randomized controlled trials, quasi-experimental studies, systematic reviews, and meta-analyses, mindfulness consistently demonstrates positive effects on reducing stress and anxiety while promoting resilience, emotional regulation, and psychological well-being.

Mindfulness has been shown the effectiveness in reducing anxiety and stress among the adolescents. Mindfulness decreases repetitive worry, catastrophic thinking, and emotional reactivity by encouraging present-moment awareness and acceptance. Adolescents become less likely to interpret stressful events as overwhelming threats and more capable of regulating emotional responses. Consequently, improvements are observed not only in anxiety levels but also in concentration, sleep quality, classroom behaviour, and interpersonal relationships.

The literature further indicates that mindfulness contributes significantly to the development of resilience. Through repeated mindfulness practice, adolescents strengthen emotional regulation, self-awareness, cognitive flexibility, and adaptive coping skills. These psychological resources enable them to recover more effectively from setbacks and maintain emotional balance during challenging situations. Rather than eliminating adversity, mindfulness equips adolescents with skills that improve their ability to adapt successfully to life's inevitable difficulties.

However, recent research also suggests that the effectiveness of mindfulness programmes depends on several implementation factors. Programme duration, instructor competence, participant motivation, practice adherence, and cultural adaptation all influence intervention outcomes. Some recent analyses have questioned the effectiveness of universal school-based mindfulness programmes when student engagement is low, emphasizing that programme quality and voluntary participation may be important determinants of success.

Overall, studies are evidence supports mindfulness training as an effective preventive mental health intervention for adolescents. The strongest evidence indicates improvements in emotional regulation, stress management, anxiety reduction, resilience, and psychological well-being, particularly when interventions are structured, developmentally appropriate, and delivered by trained professionals.

Conclusion:

The present review studied the empirical evidence regarding the impact of mindfulness training programmes on stress, anxiety, and resilience among adolescents aged 12–18 years. Evidence obtained from randomized controlled trials, systematic reviews, and meta-analyses

consistently demonstrates that mindfulness is an effective psychological intervention for improving adolescent mental health.

The reviewed studies indicate that mindfulness significantly reduces perceived stress, anxiety, emotional distress, and maladaptive thinking while enhancing resilience, emotional regulation, self-awareness, attentional control, adaptive coping, optimism, and overall psychological well-being. Regular mindfulness practice enables adolescents to respond more effectively to academic pressures, interpersonal conflicts, and everyday life challenges by promoting present-moment awareness and emotional acceptance.

School-based mindfulness programmes appear particularly beneficial because they are practical, cost-effective, and easily integrated into educational settings. These interventions not only improve students' psychological health but also contribute to better classroom behaviour, academic engagement, and social adjustment.

Overall, mindfulness training represents a promising preventive mental health intervention capable of fostering resilient, emotionally healthy, and psychologically competent adolescents. Integrating mindfulness into school mental health programmes may contribute significantly to promoting the overall well-being and healthy development of future generations.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Enhancing Investors' Decision-Making through AI and Data Analytics-Driven Environmental Impact Assessment

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DOI - 10.5281/zenodo.24339523

Abstract:

Environmental Impact Assessments (EIAs) are central to environmental regulation, yet they remain largely compliance documents that investors rarely use when allocating capital. Delayed reporting, fragmented and unstructured data, and limited access leave a persistent information gap between environmental appraisal and investment decisions. This gap grows more costly as sustainable finance expands and concerns about greenwashing rise. This paper examines how Artificial Intelligence (AI) and data analytics can turn EIAs from static regulatory checklists into dynamic, investor-relevant sources of intelligence, with particular reference to India. Using a structured narrative review of academic literature, policy documents and regulatory reports, mainly published between 2015 and 2025, the study synthesises evidence on machine learning, natural language processing, satellite and sensor-based monitoring, and predictive analytics in environmental assessment and ESG analysis. It compares India's regulatory developments, including the PARIVESH clearance portal, the Central Pollution Control Board's online monitoring requirements and SEBI's Business Responsibility and Sustainability Reporting (BRSR) framework, with practices in the European Union, the United States and China. The paper proposes a three-layer conceptual framework that links environmental data, AI-based analytics and investor decisions. The review finds that AI-enabled EIAs can improve the timeliness, reliability and comparability of environmental information, help investors quantify environmental and transition risks, and reduce information asymmetry. Challenges remain, including model opacity, data gaps, uneven monitoring capacity and "competence greenwashing". The paper concludes with suggestions for policymakers, investors and researchers, and identifies empirical validation as a priority for future research.

Keywords: Environmental Impact Assessment; Artificial Intelligence; Data Analytics; Sustainable Investment; ESG; BRSR; India.

Introduction:

Over the past decade, environmental sustainability has moved from a specialist concern to a central consideration in economic growth, investment and corporate governance. International commitments such as the Paris Agreement (United Nations Framework Convention on Climate Change [UNFCCC], 2015) and the United Nations Sustainable Development Goals (United Nations, 2015) have made it a priority to measure and manage environmental risk, especially in high-impact industries such as energy, mining, infrastructure and manufacturing. Environmental Impact Assessment (EIA) is one of the main regulatory tools for this purpose. It requires project proponents to predict and evaluate the likely environmental effects of a proposed project, and decision-makers to consider those effects before granting approval (Glasson & Therivel, 2019). In

India, the process is governed by the EIA Notification, 2006 (Ministry of Environment, Forest and Climate Change [MoEFCC], 2006).

In practice, EIA systems are often criticised as slow, bureaucratic and contested. Reviews of international practice raise continuing questions about whether EIA genuinely shapes decisions or functions mainly as a procedural requirement (Morgan, 2012). In India, Panigrahi and Amirapu (2012) found that, despite a sound legal and administrative framework, the system suffers from limited capacity among approval authorities, poor-quality reports, inadequate public participation and weak monitoring, and that EIA tends to be used to justify projects rather than to plan them. The Draft EIA Notification, 2020 (MoEFCC, 2020), which proposed changes such as post-facto approval for projects that had begun without clearance, renewed public debate about the strength of the system. These weaknesses leave a gap between regulatory compliance and actual environmental outcomes.

At the same time, sustainable finance has grown rapidly. The Global Sustainable Investment Alliance (GSIA, 2023) reported USD 30.3 trillion in sustainable investment assets across the markets it covers at the start of 2022; the figure is lower than in 2020 mainly because the United States adopted a stricter measurement method. In India, the Securities and Exchange Board of India (SEBI) made Business Responsibility and Sustainability Reporting (BRSR) mandatory for the top 1,000 listed companies by market capitalisation from 2022–23 (SEBI, 2021), and later introduced BRSR Core, a set of key indicators subject to phased reasonable assurance (SEBI, 2023). Investors increasingly treat environmental risk as financially material. In a survey of 439 institutional investors, Krueger, Sautner and Starks (2020) found that respondents believe climate risks have financial implications for their portfolio firms, and that regulatory climate risks have already begun to materialise. Yet the detailed, project-level information contained in EIAs rarely reaches investors, because it is difficult to access, unstandardised and often out of date by the time investment decisions are made.

This gap matters. Without credible environmental information, investors are exposed to greenwashing, in which firms overstate their environmental performance (Delmas & Burbano, 2011; Schumacher, 2022). Environmental risks that are not visible at the project level can also be mispriced. Bolton and Kacperczyk (2021) find that investors already demand higher returns from firms with high carbon emissions, which suggests that better information on environmental exposure is relevant to asset prices. Projects in carbon-intensive sectors that are approved and financed without a full view of their environmental risks may later become stranded assets. Closing this gap requires tools that make environmental information more reliable, comparable and usable.

Digital technologies, particularly Artificial Intelligence (AI) and data analytics, offer a way to do this. Machine learning, natural language processing (NLP) and satellite remote sensing can process large volumes of environmental data, improve prediction and generate insights that investors can act on (Alotaibi & Nassif, 2024; Rolnick et al., 2022). Satellite imagery combined with machine learning is already used to measure outcomes such as agricultural activity and settlement patterns at scale (Burke et al., 2021), and the introduction of automatic air-quality monitoring in China substantially reduced the under-reporting of pollution (Greenstone et al., 2022). Integrated into EIA processes, such tools could turn assessments from regulatory checklists into forward-looking inputs for investment risk assessment and portfolio strategy. This direction is consistent with India's National Strategy for Artificial Intelligence, which identifies AI as a

driver of better governance and inclusive growth (NITI Aayog, 2018).

India is a particularly relevant case. It is one of the fastest-growing major economies, faces serious environmental pressures, has a growing market for Environmental, Social and Governance (ESG) investment, and is still developing its sustainability reporting regime. This paper therefore sits at the intersection of three areas: AI-based environmental analytics, regulatory EIA systems and sustainable investment decisions. It examines how these technologies can change the role of EIA in guiding investors towards environmentally sound choices, and what India can learn from the European Union, the United States and China.

Review of Literature:

The literature is reviewed under six themes: the effectiveness and limitations of EIA; AI and digital tools for environmental monitoring; NLP and text analytics for environmental and ESG disclosures; ESG data and investor decision-making; greenwashing, data governance and AI ethics; and the Indian policy and regulatory context. The section ends by identifying the research gap.

1. Environmental Impact Assessment: Effectiveness and Limitations:

EIA is designed as a predictive, pre-decision tool. It identifies and evaluates the likely effects of a project before approval, and its value depends on the quality of baseline data, public participation and follow-up monitoring (Glasson & Therivel, 2019). Morgan's (2012) review of the state of EIA practice notes that, although EIA is now established in most countries, questions remain about its effectiveness and its real influence on decisions. In India, Panigrahi and Amirapu (2012) assessed the system against international evaluation criteria and identified weaknesses in screening and scoping, report quality, public participation and monitoring. Taken together, these studies show that EIA documents are prepared for regulators, at a single point in time, usually as long narrative reports. They are not designed to be read, compared or updated by investors, which limits their usefulness for capital allocation.

2. AI and Digital Tools for Environmental Monitoring:

A growing body of work examines how AI can improve environmental monitoring. In a bibliometric analysis of 4,762 publications from 1991 to 2024, Alotaibi and Nassif (2024) show that research on AI in environmental monitoring has grown sharply since 2010, with China, the United States and India as leading contributors. They describe applications in air-quality prediction, water-quality assessment, climate forecasting and image-based wildlife monitoring, while noting challenges such as the opacity of AI models and the shortage of good-quality data in resource-limited regions. Rolnick et al. (2022) map the areas in which machine learning can help reduce emissions and support adaptation, including energy systems, land use and disaster management. Burke et al. (2021) review the use of satellite imagery with machine learning to measure sustainable development outcomes and conclude that these methods complement, rather than replace, ground-based data collection.

Evidence from China shows why automation matters for data reliability. After automatic air-quality monitoring was introduced, reported particulate pollution rose by about 35 per cent, indicating that manually reported data had been understated (Greenstone et al., 2022). Hák, Janoušková and Moldan (2016) add that such data are useful only when they are linked to relevant, well-defined indicators. For EIA, this literature suggests that AI and remote sensing can provide continuous, verifiable evidence on whether the impacts predicted at the approval stage actually occur.

3. Natural Language Processing and Text Analytics for Environmental and ESG Disclosures:

Much environmental information is held in text: EIA reports, clearance conditions, compliance reports and corporate sustainability disclosures. NLP makes it possible to analyse such text at scale. Bingler et al. (2022) used ClimateBert, a language model trained on climate-related text, to analyse the disclosures of firms that support the Task Force on Climate-related Financial Disclosures. They found that this support was largely "cheap talk", and that firms tended to report non-material climate risk information selectively. Their study shows that NLP can test whether disclosures contain substantive information or only general statements. This is relevant in India, where BRSR disclosures have improved in coverage but still face data-quality problems (CFA Institute, 2024). Applying similar methods to EIA documents and compliance reports could help investors compare projects and flag gaps between commitments and outcomes.

4. ESG Data, Materiality and Investor Decision-Making:

Investor interest in environmental information rests on evidence that it matters financially. Friede, Busch and Bassen (2015) combined the findings of more than 2,000 empirical studies and found that roughly 90 per cent report a non-negative relationship between ESG performance and corporate financial performance. Krueger et al. (2020) show that institutional investors consider climate risks financially material, and Bolton and Kacperczyk (2021) find a carbon premium in stock returns. However, the data on which investors rely are inconsistent. Berg, Kölbel and Rigobon (2022) find that ESG ratings from six major providers diverge substantially, with correlations ranging from 0.38 to 0.71, mainly because the providers measure the same attributes differently. Kotsantonis and Serafeim (2019) show that companies report even basic indicators, such as employee health and safety, in more than 20 different ways. Investors therefore make decisions using environmental information that is often indirect, aggregated and difficult to compare. Project-level EIA data, if made accessible and standardised, could provide a more direct and verifiable basis for assessing environmental risk.

5. Greenwashing, Data Governance and AI Ethics:

The credibility of environmental information is a recurring concern. Delmas and Burbano (2011) explain greenwashing as the result of external pressures, such as weak regulation and investor demand, combined with organisational and individual factors. Schumacher (2022) extends the idea to "competence greenwashing", in which organisations or professionals overstate their environmental expertise, and argues that this risk grows as sustainable finance expands. The same risk applies to AI: firms may present AI-based environmental tools as evidence of progress without the data or expertise to use them well. Alotaibi and Nassif (2024) also point to the opacity of many AI models, which makes their outputs difficult to verify, and to data gaps in regions with limited monitoring infrastructure. These concerns, together with questions of data privacy and ownership, mean that AI-enabled EIAs require clear standards for data quality, model transparency and independent verification.

6. India-Focused Policy and Regulatory Context:

India has put in place several building blocks for data-driven environmental governance. The EIA Notification, 2006 sets out the clearance process (MoEFCC, 2006), and since August 2018 proposals for environmental, forest, wildlife and coastal regulation zone clearances have been handled through PARIVESH, a single-window

online portal (MoEFCC, n.d.). Since 2014, the Central Pollution Control Board (CPCB) has required 17 categories of highly polluting industries to install online continuous emission and effluent monitoring systems that transmit data to regulators in real time (CPCB, 2014). SEBI's BRSR and BRSR Core frameworks require listed companies to report standardised sustainability information, with assurance being phased in (SEBI, 2021, 2023), and NITI Aayog's (2018) national AI strategy encourages the use of AI in public governance. However, these systems were developed separately. EIA documents, real-time monitoring data and company disclosures are not linked in a way that allows investors to trace environmental risks from individual projects to the firms and securities in which they invest.

7. Research Gap:

The literature reviewed shows three gaps. First, research on AI in environmental monitoring focuses mainly on regulatory and scientific uses rather than on investors. Second, research on ESG investing relies largely on ratings and corporate disclosures, and pays little attention to project-level EIA information. Third, little work examines these questions in the Indian context, despite India's recent reporting reforms. This paper addresses these gaps by examining how AI and data analytics can connect EIA information to investment decisions, with a focus on India and a comparison with international practice.

Research Methodology:

1. Research Question and Objectives:

This study asks how data analytics and AI can turn EIAs from static, procedural checklists into active, investor-relevant sources of intelligence for sustainable finance decisions, with particular reference to India. Its objectives are:

1. To examine how AI can make EIAs more accurate, timely and concise.
2. To evaluate the significance of AI-generated outputs for investors' decisions.
3. To assess the Indian regulatory framework and market conditions for integrating AI-enabled EIA information into investment processes.
4. To compare Indian practice with that of the European Union, the United States and China.

2. Research Design:

The study is a structured narrative review based entirely on secondary sources; no primary data were collected. The review followed four steps.

(a) *Search.* Scopus, Web of Science, ScienceDirect, SSRN and Google Scholar were searched, along with the official websites of regulators, using keywords such as "AI in environmental monitoring", "data-driven EIA", "sustainable investment", "ESG analytics" and "green finance".

(b) *Screening.* Priority was given to peer-reviewed studies and official documents published between 2015 and 2025 that were directly relevant to investment decision-making or AI-enabled environmental analysis. Earlier foundational studies and regulations were included where needed.

(c) *Synthesis.* The selected sources were analysed thematically to identify recurring patterns, technologies, regulatory developments and investor applications.

(d) *Benchmarking.* India's framework was compared with those of the European Union, the United States and China on three dimensions: project-level environmental assessment, investor-facing sustainability disclosure and automated environmental monitoring.

3. Scope and Limitations:

The analysis covers AI applications in environmental monitoring, predictive modelling and data analytics; the value of EIA outputs for sustainable investment; domestic and international regulatory and reporting requirements; and the implications for risk analysis, portfolio management and ESG investing. The approach has limitations. Because it is a narrative rather than a systematic review, source selection involved the authors' judgement, and screening counts are not reported. The findings depend on the availability and quality of published literature, and the most recent technologies and practices may not yet be reflected in it. Regulatory and market conditions differ between countries, and the comparison cannot capture every local variation. The findings are analytical and need empirical validation at sector or portfolio level.

Findings and Analysis:

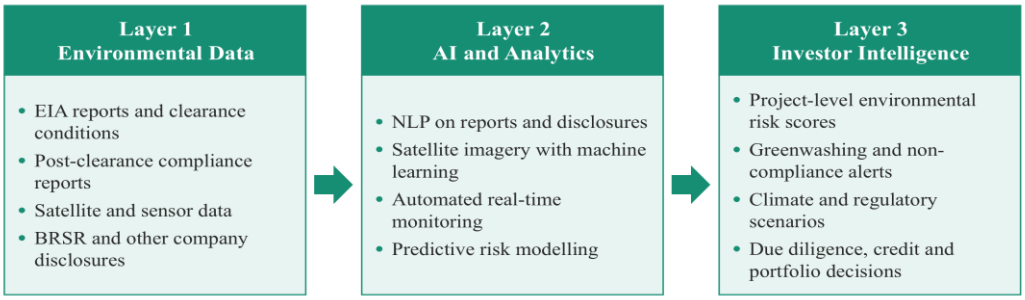
1. From Compliance Tool to Investor Intelligence:

A central finding is that traditional EIAs are not used effectively in investment decisions. They are prepared for regulators, produced once at the approval stage and written as long narrative documents, so investors find them difficult to locate, read and compare. Investors instead rely on ESG ratings and corporate disclosures, which are themselves inconsistent (Berg et al., 2022; Kotsantonis & Serafeim, 2019). The result is an information asymmetry between those who know a project's environmental risks and those who finance it. Combining AI and data analytics with EIA has the potential to correct this imbalance by making environmental information continuous, comparable and accessible.

2. A Framework for AI-Enabled EIA:

Drawing on the literature reviewed, this paper proposes a three-layer framework (Figure 1). The first layer is environmental data: EIA reports and clearance conditions, post-clearance compliance reports, satellite and sensor data, and corporate BRSR disclosures. The second layer is AI and analytics: NLP to extract commitments from text and compare them with reported outcomes (Bingler et al., 2022); satellite imagery and machine learning to observe land-use change and other physical impacts (Burke et al., 2021; Rolnick et al., 2022); automated monitoring to improve data reliability (Greenstone et al., 2022); and predictive models to estimate future environmental risks (Alotaibi & Nassif, 2024). The third layer is investor intelligence: project-level environmental risk scores, early warnings of greenwashing or non-compliance, climate and regulatory scenario analysis, and inputs into due diligence, credit appraisal and portfolio decisions.

Figure 1: *Conceptual Framework for AI-Enabled EIA in Investment Decisions*



Note. Developed by the authors from the literature reviewed.

The framework shows that the value of AI does not come from any single technology but from linking data that are currently held separately. In India, for example, an EIA

approved through PARIVESH, the real-time monitoring data reported to the Central Pollution Control Board and the parent company's BRSR disclosures may all relate to the same project, but they are rarely analysed together.

3. India's Position:

India has strong foundations for this approach: a digital clearance portal, mandatory real-time monitoring for highly polluting industries, a standardised corporate sustainability reporting framework with assurance, and a national AI strategy (CPCB, 2014; MoEFCC, n.d.; NITI Aayog, 2018; SEBI, 2023). Three limitations stand out, however. First, EIA documents remain long and unstructured, which makes them hard to analyse at scale. Second, BRSR disclosures have improved in coverage, but data-quality problems persist (CFA Institute, 2024). Third, the debate over the Draft EIA Notification, 2020 shows that the underlying regulatory framework is still contested (MoEFCC, 2020). NLP and machine learning can help standardise unstructured disclosures and reduce information asymmetry, but only if the underlying data are reliable and the methods are transparent. There are also no common standards for how asset managers should use AI-based environmental analytics.

4. Comparative Benchmarking:

Table 1 compares India with the European Union, the United States and China on the three dimensions used in this study.

Table 1 : *Comparison of Frameworks Relevant to AI-Enabled EIA*

Dimension	India	European Union	United States	China
Project-level environmental assessment	EIA Notification, 2006; online clearances through PARIVESH since 2018	EIA Directive 2011/92/EU, amended by Directive 2014/52/EU	National Environmental Policy Act, 1969	Environmental Impact Assessment Law, 2002 (amended 2016 and 2018)
Investor-facing sustainability disclosure	BRSR mandatory for top 1,000 listed companies (2021); BRSR Core with phased assurance (2023)	Sustainable Finance Disclosure Regulation (2019), within the European Green Deal agenda	SEC climate disclosure rule adopted in 2024; stayed, and the SEC ended its defence in 2025	Mandatory sustainability reporting for large listed companies under 2024 stock exchange guidelines
Automated environmental monitoring	CPCB online continuous monitoring for 17 categories of highly polluting industries (2014)	Copernicus Earth-observation data under the EU Space Programme (2021)	Continuous emission monitoring for power plants (40 C.F.R. pt. 75)	Nationwide automatic air-quality monitoring, which reduced under-reporting
Overall assessment	Strong building blocks, not yet linked or standardised for investors	Most integrated link between environmental data and investment rules	Strong monitoring; federal investor disclosure uncertain	Strong state-led monitoring; investor use still developing

Note. Compiled by the authors from CPCB (2014), MoEFCC (2006, n.d.) and SEBI (2021, 2023) for India; European Commission (2019) and European Union (2011, 2014, 2019, 2021) for the EU; National Environmental Policy Act of 1969 (1970), Continuous Emission Monitoring (40 C.F.R. pt. 75) and U.S. Securities and Exchange Commission (2024, 2025) for the US; and Clifford Chance (2024), Greenstone et al. (2022) and Standing Committee of the National People's Congress (2018) for China.

The comparison shows that India's efforts are recent but promising. The European Union has the most developed link between environmental information and investment rules: the Sustainable Finance Disclosure Regulation requires financial market participants to disclose how they integrate sustainability risks (European Union, 2019). The United States has long-established project review and emissions monitoring, but its federal climate disclosure rule for investors was stayed after adoption in 2024, and in 2025 the SEC voted to end its defence of the rule (U.S. Securities and Exchange Commission, 2024, 2025). China demonstrates the power of automated, real-time monitoring for enforcement and data reliability (Greenstone et al., 2022), and its stock exchanges introduced mandatory sustainability reporting for large listed companies in 2024 (Clifford Chance, 2024). India's opportunity lies in connecting systems it already has, namely PARIVESH, CPCB online monitoring and BRSR, and making their data available to investors in machine-readable form.

5. Implications for Investors:

From a financial perspective, AI-enabled EIA outputs could improve risk analysis, credit appraisal and portfolio construction. Machine learning allows environmental risks to be expressed in quantitative terms and built into valuation models and scenario analysis. Evidence that investors already price carbon risk (Bolton & Kacperczyk, 2021) and regard climate risk as material (Krueger et al., 2020) suggests that more reliable, project-level environmental information would be of value to them. Such information also supports wider goals, including the Sustainable Development Goals on climate action and on industry, innovation and infrastructure (United Nations, 2015). Whether AI-enabled EIA information improves risk-adjusted returns in practice, however, remains to be tested empirically.

6. Challenges and Risks:

The review also identifies several challenges. The first is model opacity: many AI models are difficult to interpret, which makes their outputs hard to verify (Alotaibi & Nassif, 2024). The second is data quality: models trained on inconsistent ESG data will reproduce that inconsistency (Berg et al., 2022), and monitoring capacity is uneven, particularly between urban and rural areas. The third is greenwashing, including competence greenwashing, in which AI is presented as evidence of environmental progress without real substance (Delmas & Burbano, 2011; Schumacher, 2022). The fourth is data privacy, ownership and access, since sensor, satellite and corporate data are held by different parties. The fifth is regulatory uncertainty, illustrated by the debate over India's Draft EIA Notification, 2020 and the reversal of the US climate disclosure rule. Without ethical standards and robust validation, the potential value of AI-enhanced EIAs may not be realised.

Discussion and Suggestions:

Combining AI and data analytics with EIA offers a practical way to support sustainable investment decisions. Conventional EIAs, designed mainly as compliance instruments, do not deliver timely, systematic and investor-relevant information. AI-based methods such as machine learning, predictive analysis and NLP can make this information more continuous, reliable and comparable. Based on the findings, the following suggestions are made.

1. For Policymakers:

Regulators should publish EIA reports, clearance conditions and compliance reports in standardised, machine-readable formats, and link project records on PARIVESH with company

identifiers used in BRSR filings so that environmental information can be traced from projects to listed firms. They should also set standards for the use of AI in environmental reporting, covering data quality, model transparency and independent validation, align these with international practice, and invest in the technical capacity of regulators.

2. For Investors and Financial Institutions:

Banks, asset managers and other institutions should incorporate AI-enabled EIA outputs into due diligence, credit appraisal and portfolio risk analysis, rather than relying on a single ESG rating. They should validate the data and models they use, disclose their methods, and periodically review data integrity and ethics compliance to avoid competence greenwashing.

3. For Researchers:

Researchers should test the proposed framework empirically across sectors, examine whether signals derived from EIA data predict financial outcomes such as returns, credit risk or project delays, and build India-specific text datasets of EIA and compliance documents for NLP research.

Conclusion:

AI-enabled EIAs can turn environmental intelligence from a static regulatory obligation into a strategic asset for investors. By applying AI and data analytics to environmental information, India and other emerging economies can narrow the gap between environmental performance and investment decisions, increase transparency and strengthen long-term ecological and financial resilience. India already has many of the necessary building blocks, including a digital clearance portal, real-time monitoring of polluting industries and a standardised corporate sustainability reporting framework, but these systems are not yet connected or designed with investors in mind. Challenges of model opacity, data quality, greenwashing and regulatory uncertainty remain. Future research should test these ideas empirically across sectors, assess their effect on investment outcomes, and examine how emerging AI technologies interact with regulatory requirements, so that sustainability becomes a measurable and actionable part of financial decisions.

Declarations:

Conflict of interest. The authors declare no conflict of interest.

Funding. This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Use of generative AI. During the preparation of this manuscript, the authors used Claude (Anthropic) to assist with language editing, restructuring and reference checking. The authors reviewed and edited the content and take full responsibility for the published work.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Socio-Economic Challenges and Professional Growth of Private Practicing Advocates

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DOI - 10.5281/zenodo.24339552

Abstract:

The legal profession plays an important role in protecting the rights of citizens and ensuring justice in society. However, private practicing advocates face several socio-economic and professional challenges, particularly during the early years of their careers. These challenges include irregular income, financial insecurity, lack of professional guidance, limited access to clients, gender-related difficulties, and the increasing need to use digital technology. First-generation advocates may face additional problems because they do not have established professional networks or family support within the legal profession.

The present study examines the socio-economic challenges and professional growth of private practicing advocates with the help of secondary data. The study is based on published research papers, books, reports, articles, and relevant institutional publications. It reviews the available literature to understand the financial conditions, working environment, professional opportunities, and major difficulties faced by advocates. The study indicates that financial stability, professional guidance, access to technology, and equal career opportunities are important for the sustainable growth of private practicing advocates. It also highlights the need for better professional support, improved court infrastructure, and effective welfare measures. The study suggests that appropriate institutional and policy support can help advocates build stable careers and contribute more effectively to the administration of justice.

Keywords: Private Practicing Advocates, Socio-Economic Challenges, Financial Stability, Professional Growth, Legal Profession, Secondary Data.

Introduction:

The legal profession is an important part of the Indian judicial system. Advocates help people understand their legal rights, represent them before courts, and obtain justice. They also play an important role in protecting constitutional values and maintaining the rule of law. However, the professional life of an advocate involves several challenges that may affect financial stability, working conditions, and career development.

Private practicing advocates generally earn their income through legal services provided to clients. Unlike salaried employees, many independent advocates do not receive a fixed monthly income. Their earnings depend on the number of clients, nature of cases, professional experience, and ability to establish a reputation. As a result, maintaining financial stability can be difficult, particularly during the initial years of practice.

First-generation advocates may face additional challenges because they do not have family members in the legal profession to guide them or introduce them to clients. They may need to establish professional contacts, arrange office facilities, purchase legal reference materials, and develop their own client base. These requirements

can create financial pressure and make professional growth difficult.

Women advocates may also experience difficulties related to workplace facilities, family responsibilities, professional opportunities, and safety. Similarly, changes in the legal system have increased the importance of digital knowledge. Online legal research, e-filing, virtual hearings, and digital case management require advocates to have access to suitable technology and the skills to use it effectively.

Previous studies and published reports have discussed different aspects of these challenges, including professional entry barriers, financial difficulties, gender inequality, legal aid, and technological developments. However, the available literature needs to be examined together to develop a broader understanding of the socio-economic conditions and professional growth of private practicing advocates.

Therefore, the present study examines the challenges faced by private practicing advocates by reviewing secondary data from published sources. It aims to understand the major problems affecting their professional development and identify possible measures to improve their working conditions and career opportunities.

Statement of the Problem:

The study focuses on the difficulties faced by private practicing advocates, especially during the early years of their careers. Many junior advocates do not receive a fixed monthly stipend. They may also lack health insurance, paid leave, maternity support and pension-related benefits. Getting work may depend on personal and family contacts rather than open and fair selection. These conditions can make it difficult for first-generation advocates, women and people from financially weaker backgrounds to continue in private practice.

Objectives of the Study:

1. To study the income, monthly payment and early-career financial condition of private practicing advocates.
2. To compare the professional opportunities available to first-generation advocates and advocates from families already involved in law.
3. To understand gender-related, social and regional difficulties, including safety and court facilities.
4. To study how e-filing, virtual hearings, digital legal resources and new technology affect independent and junior advocates.

Conceptual Framework and Review of Literature:

Factors that Affect Professional Growth:

The study uses ideas associated with sociologist Pierre Bourdieu to explain why some advocates find it easier to build a successful practice. Three types of resources are important:

- Financial resources: Family savings, personal income and financial help can allow a new advocate to continue working while building a client base. Without this support, a junior may need to borrow money, take another job or leave litigation.
- Knowledge and communication skills: Legal knowledge, confidence in court, language skills and familiarity with professional practices can help advocates. Some new advocates may find it harder to access this knowledge or develop these skills without guidance.
- Professional contacts: Relationships with senior advocates, clients, bar associations and other legal professionals can help a lawyer find work and gain experience. Advocates with family members already in the profession may begin with more contacts than first-generation advocates.

These factors can work together. An advocate who has financial support and useful contacts may have more time and opportunities to develop a practice. An advocate without these resources may face greater difficulty even when they have good academic knowledge and ability.

Review of Earlier Studies:

Earlier studies have described differences between lawyers who serve large companies and those who serve individuals and small businesses. The latter may face lower fees and greater uncertainty in their income. Research on the Indian legal profession has also discussed how social background, traditional networks and the structure of legal chambers can affect professional opportunities.

Other studies have considered the growth of corporate law firms and the movement of some law graduates away from trial-court practice. Researchers have also questioned the idea that every junior advocate must accept years of financial hardship as a normal part of learning. If early practice is possible only for people who can afford to work with little income, capable candidates from financially weaker families may be forced to leave.

1. Narang (2011) – Regulatory Barriers to Litigation in India:

Narang examined the difficulties faced by young law graduates entering the litigation profession in India. The study explained that although becoming an advocate does not involve many formal entry barriers, starting an independent legal practice is difficult. Young advocates often depend on senior lawyers for training, guidance, and professional opportunities. Advocates from families with a legal background may have better access to clients and professional networks. The study highlighted that financial difficulties and the existing structure of legal practice discourage talented graduates from choosing litigation as a career. This study is relevant because it explains the economic and professional barriers faced by first-generation advocates. pure.jgu.edu.in

2. Makhija and Raha (2012) – Challenges Faced by Indian Women Legal Professionals:

Makhija and Raha studied the challenges experienced by women working in the Indian legal profession. Their report focused on women legal professionals in Delhi, Mumbai, and Bengaluru, particularly working mothers. The study addressed the difficulties women face in managing professional responsibilities and family commitments. Such responsibilities can affect their working hours, professional opportunities, and career development. The research is relevant to understanding the additional challenges faced by women advocates in private practice. It also highlights the importance of supportive working conditions and measures that help women continue their legal careers while managing family responsibilities. University of Helsinki Research Portal

3. Vidhi Centre for Legal Policy (2020) – A Survey of Advocates Practicing Before the High Courts:

Jain, Tripathy, and Sekhar reported the findings of a survey of 2,800 advocates practicing before eight High Courts in India. The study examined advocates' experiences, professional positions, and relationships with Bar Councils, income levels, and career prospects. It highlighted the importance of understanding the working conditions of advocates when discussing judicial reforms. The report also pointed out that the Indian legal profession had received limited systematic research attention. This study is particularly relevant because it provides information about practicing advocates in India and supports the need for further research into their financial conditions and professional development. Vidhi Legal Policy

4. Gautam (2024) – Outline of Legal Practice in India: Developing the Future of the Indian Legal Profession:

Gautam examined the development and changing structure of the Indian legal profession. The study discussed the historical development of legal practice and the effects of economic liberalization and globalization. It explained that the growth of corporate law firms and changes in legal education have created new opportunities for lawyers. However, professional opportunities and access to influential networks are not equally distributed. The study also discussed the importance of professional relationships in gaining entry into established legal chambers. This research is relevant to the present study because it helps explain the differences between corporate legal careers and independent litigation practice. It also provides a broader understanding of the factors influencing professional growth among advocates in India. Taylor & Francis Online

5. Sailaja, Brahmam, and Satyanarayana (2023) – The Role of Lawyers in Strengthening Access to Justice in India:

Sailaja, Brahmam, and Satyanarayana discussed the importance of lawyers in providing access to justice in India. Their study examined the legal framework, the role of legal aid, and the difficulties that prevent people from obtaining legal services. It also discussed problems such as a lack of legal awareness, inadequate infrastructure, delays in the judicial system, and the digital divide. The study highlighted the need to improve legal services and strengthen the institutions responsible for providing justice. This research is relevant to the present study because the availability of proper court facilities, digital resources, and effective legal aid systems can influence the working conditions and professional opportunities of private practicing advocates. ijfans.org

6. Singh (2025) – From Law School to Litigation: Barriers, Mentorship Gaps, and the Sustainability Crisis Facing India's Junior Advocates:

Singh examined the difficulties faced by junior advocates when they begin practising law in India. The study used interviews and a questionnaire involving 55 junior advocates practising in the Delhi High Court and district courts. It discussed financial insecurity, inadequate professional guidance, irregular payment, and the absence of a structured training system. The study explained that first-generation advocates may face greater difficulties because they cannot depend on family members for professional guidance and established connections. It also highlighted the risk that talented young advocates may leave litigation because they cannot manage the financial pressure of the early years. The study is closely related to the present research because it focuses on the economic problems, mentoring needs, and career sustainability of junior private practicing advocates. IJLLR Journal

Research Gap:

The above literature indicates that private practicing advocates face several professional challenges, including financial insecurity, unequal career opportunities, lack of professional guidance, gender-related difficulties, and limited access to technology. Previous studies have examined these issues from different perspectives, including the overall structure of the legal profession, the problems of junior advocates, women's professional experiences, and the development of digital legal services.

However, **there is a need for more focused research on the socio-economic conditions and professional challenges of private practicing advocates in Jalgaon District, Maharashtra.** Local conditions may

influence advocates' income, access to clients, professional networks, court facilities, digital resources, and opportunities for career growth.

Therefore, the present study aims to examine the socio-economic background of private practicing advocates, their financial difficulties, professional working conditions, technological awareness, access to court infrastructure, and the factors affecting their professional growth and stability.

Research Methodology:

Research Design:

The present study follows a descriptive research design based on secondary data. It examines the socio-economic challenges and professional growth of private practicing advocates by reviewing information already published by researchers, institutions, and other reliable sources.

Nature of Data:

The study uses secondary data. No original questionnaire, personal interview, or primary survey is claimed as part of the research. The information is drawn from existing publications relevant to the legal profession and the working conditions of advocates.

Sources of Data:

The study uses the following sources of secondary data:

1. Published research papers and academic journal articles.
2. Books relating to the legal profession and professional development.
3. Reports published by legal research organisations and institutions.
4. Publications of Bar Councils and other relevant professional bodies.
5. Government reports and documents relating to the legal profession and access to justice.
6. Reliable online academic databases and institutional websites.

Method of Data Analysis:

The information collected from secondary sources is examined through descriptive analysis. Relevant findings from different publications are organised according to major themes, such as financial stability, professional opportunities, working conditions, gender-related challenges, social security, legal aid, and digitalisation.

The study compares the information available in these sources to identify common issues, differences in findings, and areas requiring further research. Conclusions are drawn from the published information reviewed.

Scope of the Study:

The study focuses on the socio-economic and professional challenges of private practicing advocates. It covers financial difficulties, professional growth, and access to clients, professional guidance, gender-related issues, court infrastructure, and technological developments. The findings are interpreted in the context of the available literature and are not presented as the results of a new survey.

Limitations of the Study:

The study depends on the availability and reliability of published information. The findings may be limited by differences in the geographical coverage, time period, and methods used in the original studies. Furthermore, the available literature may not provide complete information about the specific conditions of private practicing advocates in Jalgaon District. Therefore, the conclusions should be understood in the context of the secondary sources reviewed.

Findings of the Study:

The review of available secondary literature provides the following major findings regarding the socio-economic challenges and professional growth of private practicing advocates.

Financial Insecurity: The literature highlights financial insecurity as an important challenge in private legal practice. Advocates may not receive a fixed monthly income, and their earnings often depend on the number of clients and cases handled. This uncertainty can make it difficult to manage personal expenses and professional costs, particularly during the early years of practice.

Challenges Faced by First-Generation Advocates: First-generation advocates may face difficulties in establishing professional contacts and developing a regular client base. Unlike advocates from established legal families, they may not have access to inherited professional networks or direct guidance from experienced family members. This can make the process of building a successful practice more difficult.

Importance of Professional Guidance: The reviewed literature indicates that guidance from experienced advocates can help young practitioners develop legal knowledge, drafting skills, courtroom confidence, and professional relationships. The absence of suitable mentoring and structured training may affect their professional development.

Unequal Professional Opportunities: Access to clients, professional networks, and important legal assignments can influence an advocate's career growth. The literature suggests that personal connections and professional background may affect access to opportunities. Transparent recruitment, mentoring, and fair distribution of professional assignments may help improve access to the profession.

Gender-Related Challenges: Published studies on women legal professionals highlight difficulties associated with balancing professional and family responsibilities. Workplace facilities, safety, and access to equal opportunities may also affect their professional development. Supportive working conditions are important for helping women advocates continue their careers.

Limited Social Security and Welfare Support: The literature raises concerns about the availability of financial and welfare support for advocates. Independent practitioners may not have the same benefits as salaried employees, such as regular paid leave, employer-provided health insurance, or retirement benefits. Effective welfare schemes and accessible insurance arrangements can help reduce financial vulnerability.

Court Infrastructure and Working Conditions: Court infrastructure plays an important role in the daily work of advocates. Access to suitable working spaces, basic facilities, legal reference materials, and administrative support can affect work efficiency. Improvements in court facilities may contribute to a better professional environment.

Digitalization and Technological Skills: The increasing use of e-filing, online legal research, virtual hearings, and digital case management has made technological knowledge important for advocates. However, differences in access to computers, internet services, digital resources, and training may create difficulties for some practitioners. Affordable digital facilities and training can support professional development.

Legal Aid and Professional Development: Legal aid can provide advocates with opportunities to represent people who cannot afford legal services. However, the effectiveness of legal aid as a professional opportunity depends on appropriate remuneration, timely payment, and proper administrative arrangements. Better support may help make legal aid work more sustainable for advocates.

Need for Institutional Reforms: The reviewed literature points to the importance of institutional support for improving the working conditions of advocates. Measures such as professional mentoring, transparent allocation of opportunities, accessible welfare schemes, better court

infrastructure, and digital training may help address several challenges. The effectiveness of these measures depends on their proper implementation.

Conclusion:

The present study examines the socio-economic challenges and professional growth of private practicing advocates through secondary data. The review of published literature indicates that financial insecurity, irregular income, limited professional networks, lack of mentoring, gender-related difficulties, and unequal access to technology can affect the professional development of advocates.

The early years of legal practice may be particularly difficult for first-generation advocates who must establish their professional identity and client base without established family connections. Women advocates may also require better workplace facilities and support to manage professional and family responsibilities. In addition, the increasing use of digital technology has created a need for affordable technological resources and appropriate training.

The study highlights the importance of professional guidance, accessible welfare schemes, improved court infrastructure, fair professional opportunities, and effective legal aid arrangements. These measures may help advocates establish more stable practices and improve the quality of legal services.

Since the study is based on secondary data, its conclusions are limited to the information available in the published sources reviewed. Further research using reliable local publications and institutional records would help develop a clearer understanding of the specific challenges faced by private practicing advocates in Jalgaon District.

In conclusion, improving the socio-economic conditions of private practicing advocates is important not only for their professional growth but also for strengthening access to justice. Appropriate institutional support and equal professional opportunities can contribute to a more inclusive and sustainable legal profession.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

On Classical *n*-Absorbing Subsemimodules of Semimodules over Semirings

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DOI - 10.5281/zenodo.24339570

Abstract:

Let R be a commutative semiring with identity element and M be an R-semimodule. In this paper, we investigate some properties of n-absorbing subsemimodules of M as a generalization of 2-absorbing subsemimodules. We also define the classical n absorbing subsemimodule: a proper subsemimodule N of an R-semimodule M is called a classical n-absorbing subsemimodule if whenever $a_1a_2 \ldots a_{n+1} m \in N$ for $a_1, a_2, \ldots, a_{n+1} \in R$and $m \in M$, there are n of the a_i's whose product with m is in N. Using subtractive and partitioning (or Q)-subsemimodules, we give some characterizations of n-absorbing and classical n-absorbing subsemimodules under some conditions.

1 Introduction

Throughout this paper, we assume that all semirings are commutative with $1 \neq 0$. Let R be a commutative semiring and M be an R-semimodule. The theory of semirings and semimodules generalizes classical ring and module theory, with applications in theoretical computer science, automata theory, and optimization. A systematic treatment can be found in Golan [12].

Unlike modules over rings, semimodules over semirings lack additive inverses. Consequently, concepts such as subtractive subsemimodules (also called k-subsemimodules) and partitioning (or Q-) subsemimodules play a crucial role. These notions were introduced by Atani and Atani [4] and independently by Chaudhari and Bonde [7].

Prime ideals play a crucial role in the ring theory. A proper ideal I of a ring R is called a prime ideal if whenever $ab \in I$ for $a, b \in R$, then $a \in I$ or $b \in I$. A proper submodule N of an R-module M is said to be a prime submodule if whenever $a \in R$, $m \in M$, and $am \in N$, then $a \in (N : M)$ or $m \in N$.

In [6], Badawi introduced a new generalization of prime ideals. He defined a nonzero proper ideal I of R to be a 2-absorbing ideal if whenever $a, b, c \in R$ and $abc \in I$, then $ab \in I$ or $ac \in I$ or $bc \in I$. The concept of 2-absorbing ideal has been transferred to modules. A proper submodule N of an R-module M is a 2-absorbing submodule [9] if whenever $abm \in N$ for $a, b \in R$ and $m \in M$, then $am \in N$ or $bm \in N$ or $ab \in (N : M)$.

In [13], Mostafanasab, Tekir, and Oral introduced the notion of classical 2-absorbing submodules. In this article, we investigate some properties of n-absorbing subsemimodules

of M as a generalization of 2-absorbing subsemimodules. We also define the classical n-absorbing subsemimodule and give some characterizations under some conditions using subtractive and partitioning subsemimodules.

2 Preliminaries

Definition 2.1. *A left R-semimodule consists of a commutative monoid $(M,+)$ with identity 0_M, equipped with a scalar multiplication map $R\times M \to M$, $(r,x)\mapsto rx$, satisfying the following axioms for all $r,r' \in R$ and $x,y \in M$:*

(1) $(rr')x = r(r'x)$;

(2) $r(x+y) = rx + ry$;

(3) $(r+r')x = rx + r'x$;

(4) $1_R x = x$;

(5) $r0_M = 0_M = 0_R x$.

A non-empty subset N of a left R-semimodule M is called a subsemimodule of M if N is closed under addition and closed under scalar multiplication. Throughout this paper, by an R-semimodule we mean a left semimodule over a semiring R. Every semiring R is a $(\mathbb{Z}_0^+,+,\cdot)$-semimodule [12, p. 151].

Definition 2.2. *A subsemimodule N of M is called* subtractive *(or a k-subsemimodule) if for any $x,y \in M$, $x+y \in N$ and $x \in N$ implies $y \in N$.*

Definition 2.3. *A subsemimodule N of M is called* partitioning *(or a Q-subsemimodule) if there exists a subset $Q \subseteq M$ such that:*

(1) $M = \cup\{q+N : q \in Q\}$;

(2) for $q_1,q_2 \in Q$, $(q_1+N)\cap(q_2+N) \neq \emptyset$ if and only if $q_1 = q_2$.

If N is a partitioning subsemimodule of an R-semimodule M, then $M/N_{(Q)} = \{q+N : q \in Q\}$ forms an R-semimodule under the operations $(q_1+N)\oplus(q_2+N) = q_3+N$ and $r\odot(q_1+N) = q_4+N$ where $q_3 \in Q$ is the unique element such that $q_1+q_2+N \subseteq q_3+N$ and $q_4 \in Q$ is the unique element such that $rq_1+N \subseteq q_4+N$. This R-semimodule $M/N_{(Q)}$ (or simply M/N) is called the quotient semimodule *of M by N (cf. [7]).*

Here, we list some results that we need throughout the paper.

Lemma 2.4 ([8], Lemma 2.10)**.** *Let I be a subtractive ideal of a semiring R and* rad I *denote the radical of I. If $a \in I$, $a+b \in$ rad I, then $b \in$ rad I.*

Lemma 2.5 ([7], Lemma 1.4)**.** *Let N be a subsemimodule of M and $x,y \in M$ such that $x+N \subseteq y+N$. Then for all $z \in M$ and $r \in R$, $x+z+N \subseteq y+z+N$, and $rx+N \subseteq ry+N$.*

Lemma 2.6 ([7], Lemma 3.4)**.** *Let N be a Q-subsemimodule of M. For each $x \in M$, there exists a unique $q \in Q$ such that $x+N \subseteq q+N$. Hence $x = q+a$ for some $a \in N$.*

Theorem 2.7 ([7])**.** *Let N be a Q-subsemimodule of M and let A be a subtractive subsemimodule of M with $N \subseteq A$. Then:*

(1) N is a $(Q \cap A)$-subsemimodule of A.

(2) $A/N_{(Q\cap A)} = \{q + N : q \in Q \cap A\}$ is a subtractive subsemimodule of $M/N_{(Q)}$.

Lemma 2.8 (Chaudhari and Bonde [7]). *If N is a Q-subsemimodule of M, then for each $x \in M$ there exists a unique $q \in Q$ such that $x + N \subseteq q + N$. Hence $x = q + a$ for some $a \in N$.*

Lemma 2.9. *If N is a subtractive subsemimodule of M and $m \in M$, then:*

1. *$(N :_R M) = \{r \in R : rM \subseteq N\}$ is a subtractive ideal of R;*
2. *$(N :_R m) = \{r \in R : rm \in N\}$ is a subtractive ideal of R;*
3. *$(0 :_R m)$ and $(0 :_R M)$ are subtractive ideals of R.*

For any element x of M, the ideal $(N : x)$ is defined by $(N : x) = \{r \in R : rx \in N\}$. For $a \in R$, $N_a = \{x \in M : ax \in N\}$ is a subsemimodule of M.

A cyclic subsemimodule generated by $m \in M$ is $Rm = \{rm : r \in R\}$ (denoted $\langle m \rangle$).

The set of zero divisors of M, denoted by $Zd(M)$, is defined by $Zd(M) = \{r \in R : \exists x \in M, x \neq 0, rx = 0\}$.

An R-semimodule M is called a *multiplication semimodule* if every subsemimodule N of M has the form IM for some ideal I of R.

3 n-Absorbing Subsemimodules

The concept of 2-absorbing has been extended to n-absorbing in ideals and submodules, where n is any positive integer. In this section, we investigate some properties of n-absorbing subsemimodules over semirings.

Definition 3.1. *[14] A proper ideal I of a semiring R is said to be an* n-absorbing ideal *if whenever $a_1 \dots a_{n+1} \in I$ for $a_1, \dots, a_{n+1} \in R$, then there are n of the a_i's whose product is in I.*

Definition 3.2. *[10] A proper subsemimodule N of an R-semimodule M is called an* n-absorbing subsemimodule *if whenever $a_1 \dots a_n m \in N$ for $a_1, \dots, a_n \in R$ and $m \in M$, then either $a_1 \dots a_n \in (N :_R M)$ or there are $n-1$ of the a_i's whose product with m is in N.*

Proposition 3.3. *If N is an n-absorbing subsemimodule of an R-semimodule M, then $(N :_R m)$ is an n-absorbing ideal of R for all $m \in M \setminus N$.*

Proof. For $m \in M \setminus N$, $(N :_R m)$ is a proper ideal of R. Assume that $a_1 \dots a_{n+1} \in (N :_R m)$ for $a_1, \dots, a_{n+1} \in R$. Then $a_1 \dots a_{n+1} m = a_1 \dots a_n (a_{n+1} m) \in N$. Since N is an n-absorbing subsemimodule, either $a_1 \dots a_n \in (N :_R M) \subseteq (N :_R m)$ or there are $n-1$ of the a_i's $(1 \leq i \leq n)$ whose product with $a_{n+1} m$ is in N. The latter case means that there are $n-1$ of the a_i's whose product with a_{n+1} belongs to $(N :_R m)$. Thus, $(N :_R m)$ is an n-absorbing ideal of R. □

Proposition 3.4. *[5] Let M be an R-semimodule and N a proper subsemimodule of M. Then $Zd(M/N) = \bigcup_{x \in M\setminus N} (N :_R x)$.*

Proposition 3.5. *Let N be an n-absorbing subsemimodule of M. If the set of all zero divisors of M/N, $Zd(M/N)$, forms an ideal of R, then it is an n-absorbing ideal of R.*

Proof. Let $a_1 \dots a_{n+1} \in Zd(M/N)$. By Proposition 3.4, $a_1 \dots a_{n+1} \in (N :_R m')$ for some $m' \in M \setminus N$. Since N is an n-absorbing subsemimodule, by Proposition 3.3 we get $(N :_R m')$ is an n-absorbing ideal of R. Therefore, there are n of the a_i's whose product belongs to $(N :_R m')$, and hence to $Zd(M/N)$. □

Remark 3.6. *The set of all zero divisors may not be an ideal. For example, consider the $\mathbb{Z}$-semimodule $M = \mathbb{Z}_6$. We have $2, 3 \in Zd(M)$ but $2 + 3 = 5 \notin Zd(M)$.*

The following theorem characterizes n-absorbing subsemimodules in terms of submodules.

Theorem 3.7. *Let N be a subsemimodule of an R-semimodule M. The following are equivalent:*

1. *N is an n-absorbing subsemimodule.*
2. *For $a_1, \dots, a_n \in R$ such that $a_1 \dots a_n \notin (N :_R M)$,*

$$N_{a_1 \dots a_n} = \bigcup_{i=1}^{n} N_{\hat{a}_i},$$

where $\hat{a}_i = a_1 \dots a_{i-1} a_{i+1} \dots a_n$.

Proof. (1) ⇒ (2): Let $m \in N_{a_1 \dots a_n}$. Assume that $a_1 \dots a_n \notin (N :_R M)$. Then $a_1 \dots a_n m \in N$. Since N is n-absorbing, there are $n-1$ of the a_i's such that $\hat{a}_i m \in N$. Hence $m \in N_{\hat{a}_i}$. Thus $N_{a_1 \dots a_n} \subseteq \bigcup_{i=1}^{n} N_{\hat{a}_i}$. The reverse inclusion is clear.

(2) ⇒ (1): Let $a_1, \dots, a_n \in R$ and $m \in M$ such that $a_1 \dots a_n m \in N$. Assume that $a_1 \dots a_n \notin (N :_R M)$. Then $m \in N_{a_1 \dots a_n} = \bigcup_{i=1}^{n} N_{\hat{a}_i}$, so $m \in N_{\hat{a}_j}$ for some j, implying $\hat{a}_j m \in N$. Thus N is n-absorbing. □

Theorem 3.8. *Let N be an n-absorbing subsemimodule of an R-semimodule M. Then $(N :_R M)$ is an $(n-1)$-absorbing ideal of R if and only if $(N :_R m)$ is an $(n-1)$-absorbing ideal of R for all $m \in M \setminus N$.*

Proof. (⇒): Let $a_1, \dots, a_n \in R$, $m \in M \setminus N$, and $a_1 \dots a_n \in (N :_R m)$. Then $a_1 \dots a_n m \in N$. Since N is n-absorbing, either $a_1 \dots a_n \in (N :_R M)$ or there are $n-1$ of the a_i's whose product with m is in N. If $a_1 \dots a_n \in (N :_R M)$, then by assumption there are $n-1$ of the a_i's whose product belongs to $(N :_R M) \subseteq (N :_R m)$. If there are $n-1$ of the a_i's whose product with m is in N, then those $n-1$ a_i's belong to $(N :_R m)$. Thus $(N :_R m)$ is $(n-1)$-absorbing.

(⇐): Let $a_1 \dots a_n \in (N :_R M)$. Assume that for every i there exists $m_i \in M$ such that $\hat{a}_i m_i \notin N$. By $a_1 \dots a_n m_i \in N$, it follows that $\hat{a}_j m_i \in N$ for $j \neq i$ since $(N :_R m_i)$ is $(n-1)$-absorbing. If $\sum_{i=1}^{n} m_i \in N$, then $\hat{a}_j m_j \in N$, a contradiction. Thus $\sum_{i=1}^{n} m_i \notin N$. Now $a_1 \dots a_n \sum_{i=1}^{n} m_i \in N$ implies there are $n-1$ of the a_i's whose product is in $(N :_R \sum_{i=1}^{n} m_i)$, so $\hat{a}_k m_k \in N$ for some k, a contradiction. Therefore, there are $n-1$ of the a_i's whose product with M is contained in N. Hence $(N :_R M)$ is $(n-1)$-absorbing. □

Proposition 3.9. *Let N be an n-absorbing subsemimodule of an R-semimodule M, $y \in M$, and $a_1, \ldots, a_n \in R$. If $a_1 \ldots a_n \notin (N :_R M)$, then*

$$(N :_R a_1 \ldots a_n y) = \bigcup_{i=1}^{n} (N :_R \hat{a}_i y),$$

where $\hat{a}_i = a_1 \ldots a_{i-1} a_{i+1} \ldots a_n$.

Proof. Let $r \in (N :_R a_1 \ldots a_n y)$. Then $r a_1 \ldots a_n y = a_1 \ldots a_n (ry) \in N$. Since N is n-absorbing and $a_1 \ldots a_n \notin (N :_R M)$, we have $\hat{a}_i (ry) \in N$ for some i. So $r \in (N :_R \hat{a}_i y) \subseteq \bigcup_{i=1}^{n} (N :_R \hat{a}_i y)$. Therefore, $(N :_R a_1 \ldots a_n y) \subseteq \bigcup_{i=1}^{n} (N :_R \hat{a}_i y)$. For the other inclusion, let $r \in \bigcup_{i=1}^{n} (N :_R \hat{a}_i y)$. Then $r \in (N :_R \hat{a}_j y)$ for some j. Therefore $r a_j \hat{a}_j y = r a_1 \ldots a_n y \in N$. So $r \in (N :_R a_1 \ldots a_n y)$. Hence $\bigcup_{i=1}^{n} (N :_R \hat{a}_i y) \subseteq (N :_R a_1 \ldots a_n y)$. □

3.1 Homomorphisms and Localization

Proposition 3.10. *Let $f : M \to M'$ be an R-semimodule homomorphism.*

1. *If f is onto and* steady *(i.e., $f(x) = f(y)$ implies $x + \ker f = y + \ker f$), and N' is an n-absorbing subsemimodule of M', then $f^{-1}(N')$ is an n-absorbing subsemimodule of M.*

2. *If N is an n-absorbing subtractive subsemimodule of M containing $\ker f$, then $f(N)$ is an n-absorbing subsemimodule of M'.*

Proof. (1) Let $a_1, \ldots, a_n \in R$ and $m \in M$ such that $a_1 \ldots a_n m \in f^{-1}(N')$. Then $a_1 \ldots a_n f(m) \in N'$. Since N' is n-absorbing subsemimodule, either $a_1 \ldots a_n \in (N' :_R M')$ or $\hat{a}_i f(m) \in N'$ for some i. If $a_1 \ldots a_n \in (N' :_R M')$, then $a_1 \ldots a_n M \subseteq f^{-1}(N')$. If $\hat{a}_i f(m) \in N'$, then $f(\hat{a}_i m) \in N'$, so $\hat{a}_i m \in f^{-1}(N')$. Thus $f^{-1}(N')$ is n-absorbing subsemimodule.

(2) Let $a_1, \ldots, a_n \in R$ and $m' \in M'$ with $a_1 \ldots a_n m' \in f(N)$. Choose $m \in M$ with $f(m) = m'$ and $t \in N$ such that $f(t) = a_1 \ldots a_n m'$. Then $f(a_1 \ldots a_n m - t) = 0$. So $a_1 \ldots a_n m - t \in \ker f \subseteq N$. Hence $a_1 \ldots a_n m \in N$. Since N is an n-absorbing subsemimodule, either $a_1 \ldots a_n \in (N :_R M)$ or $\hat{a}_i m \in N$. Thus, $a_1 \ldots a_n \in (f(N) :_R M')$ or $\hat{a}_i m' \in f(N)$. □

Proposition 3.11. *Let S be a multiplicatively closed subset of R and $S^{-1}M$ the semimodule of fractions.*

1. *If N is an n-absorbing subsemimodule of M such that $(N :_R M) \cap S = \emptyset$, then $S^{-1}N$ is an n-absorbing subsemimodule of $S^{-1}M$.*

2. *If $S^{-1}N$ is an n-absorbing subsemimodule of $S^{-1}M$ such that $Zd(M/N) \cap S = \emptyset$, then N is an n-absorbing subsemimodule of M.*

Proof. (1) Assume that $\frac{a_1 \ldots a_n m}{s_1 \ldots s_n l} \in S^{-1}N$. Then there exists $s' \in S$ such that $s' a_1 \ldots a_n m = a_1 \ldots a_n (s'm) \in N$. Since N is an n-absorbing subsemimodule, either $a_1 \ldots a_n \in (N :_R M)$ or $\hat{a}_i s' m \in N$ for some i. If $a_1 \ldots a_n \in (N :_R M)$, then $\frac{a_1 \ldots a_n}{s_1 \ldots s_n} \in S^{-1}(N :_R M) \subseteq (S^{-1}N :_R S^{-1}M)$. If $\hat{a}_i s' m \in N$, then $\frac{\hat{a}_i m}{s_i l} \in S^{-1}N$. Hence $S^{-1}N$ is an n-absorbing subsemimodule.

(2) Let $a_1 \ldots a_n m \in N$. Then $\frac{a_1 \ldots a_n m}{1} \in S^{-1}N$. Since $S^{-1}N$ is an n-absorbing subsemimodule, either $\frac{a_1 \ldots a_n}{1} \in (S^{-1}N :_R S^{-1}M)$ or $\frac{\hat{a}_i m}{1} \in S^{-1}N$ for some i. If $\frac{\hat{a}_i m}{1} \in S^{-1}N$,

there exists $s \in S$ with $s\hat{a}_i m \in N$. Since $S \cap Zd(M/N) = \emptyset$, we have $\hat{a}_i m \in N$. If $\frac{a_1 \dots a_n}{1} \in (S^{-1}N :_R S^{-1}M)$, then $a_1 \dots a_n S^{-1}M \subseteq S^{-1}N$, and for any $m' \in M$, there exists $t \in S$ with $ta_1 \dots a_n m' \in N$. Again $a_1 \dots a_n m' \in N$, gives us $a_1 \dots a_n \in (N :_R M)$. Thus, N is an n-absorbing subsemimodule. □

4 Classical n-Absorbing Subsemimodules

In this section, we introduce and study the concept of classical n-absorbing subsemimodules as a generalisation of n-absorbing subsemimodules.

Definition 4.1. *A proper subsemimodule N of an R-semimodule M is called a* classical n-absorbing subsemimodule *if whenever $a_1 a_2 \dots a_{n+1} m \in N$ for $a_1, a_2, \dots, a_{n+1} \in R$ and $m \in M$, there are n of the a_i's whose product with m is in N.*

Example 4.2. *(1) Let $R = \mathbb{Z}_0^+$ (nonnegative integers) and $M = R \times R$. The subsemimodule $N = \{(k, k) : k \in R\}$ is a classical n-absorbing subsemimodule of an R-semimodule M.*

(2) Let $R = \mathbb{Z}_0^+$, $M = \mathbb{Z}_3 \oplus \mathbb{Q}_0^+ \oplus \mathbb{Z}_0^+$. Take $n = 2$. The subsemimodule $N = \{\bar{0}\} \oplus \{0\} \oplus \mathbb{Z}_0^+$ is a classical 2-absorbing subsemimodule of an R-semimodule M.

Proposition 4.3. *Let N be a proper subsemimodule of an R-semimodule M.*

1. *If N is an n-absorbing subsemimodule of M, then N is a classical n-absorbing subsemimodule of M.*

2. *If N is an n-absorbing subsemimodule of M and $(N :_R M)$ is an $(n-1)$-absorbing ideal of R, then N is a classical $(n-1)$-absorbing subsemimodule of M.*

Proof. (1) Assume that N is n-absorbing subsemimodule. Let $a_1, \dots, a_{n+1} \in R$ and $m \in M$ with $a_1 \dots a_{n+1} m \in N$. Write $a_1 \dots a_{n+1} m = a_1 \dots a_n (a_{n+1} m) \in N$. Then either there are $n-1$ of a_i's $(1 \leq i \leq n)$ whose product with $a_{n+1} m$ is in N, or $a_1 \dots a_n \in (N :_R M)$. The first case gives n of the a_i's (including a_{n+1}) whose product with m is in N. In the second case, $a_1 \dots a_n m \in N$, so again n of a_i's work. Hence N is a classical n-absorbing subsemimodule.

(2) Let $a_1 \dots a_n m \in N$ such that no $n-1$ of the a_i's have product with m in N. Then $a_1 \dots a_n \in (N :_R M)$. Since $(N :_R M)$ is an $(n-1)$-absorbing ideal, there are $n-1$ of the a_i's whose product is in $(N :_R M)$, a contradiction. Thus, N is a classical $(n-1)$-absorbing subsemimodule. □

Remark 4.4. *The converse of Proposition 4.3(1) is not true. Take $n = 2$, $R = \mathbb{Z}$, $M = \mathbb{Z}_3 \oplus \mathbb{Z}_5 \oplus \mathbb{Z}$. The zero subsemimodule of M is a classical 2-absorbing subsemimodule, but is not 2-absorbing since $3 \cdot 5(1,1,0) = (0,0,0)$ but $3(1,1,0) \neq 0$, $5(1,1,0) \neq 0$, and $15 \notin (0 :_R M) = 0$.*

The following theorem characterizes the classical n-absorbing subsemimodules in terms of n-absorbing ideals.

Theorem 4.5. *Let M be an R-semimodule and N a proper subsemimodule of M. The following are equivalent:*

1. *N is a classical n-absorbing subsemimodule of M.*

2. $(N :_R m)$ *is an* n*-absorbing ideal of* R *for every* $m \in M \setminus N$.

Proof. (1) $\Rightarrow$ (2): Let N be a classical n-absorbing subsemimodule. Since $m \notin N$ $(N :_R m) \neq R$. Let $a_1 \dots a_{n+1} \in (N :_R m)$. Then $a_1 \dots a_{n+1}m \in N$. Since N is classical n-absorbing, there are n of the a_i's whose product with m is in N. Hence those n a_i's belong to $(N :_R m)$. Thus $(N :_R m)$ is a n-absorbing ideal.

(2) $\Rightarrow$ (1): Let $(N :_R m)$ be an n-absorbing ideal for every $m \notin N$. Let $a_1, \dots, a_{n+1} \in R$ and $m \in M$ with $a_1 \dots a_{n+1}m \in N$. If $m \in N$, then we are done. Assume that $m \notin N$. Then $a_1 \dots a_{n+1} \in (N :_R m)$. Since $(N :_R m)$ is an n-absorbing ideal, there are n of the a_i's whose product is in $(N :_R m)$, i.e., those n a_i's multiplied by m are in N. Hence N is a classical n-absorbing subsemimodule. □

Theorem 4.6. *Let* M *be a cyclic* R*-semimodule and* N*, a subsemimodule of* M*. If* N *is a classical* n*-absorbing subsemimodule, then* N *is an* n*-absorbing subsemimodule of* M*.*

Proof. Let $M = Rm$ for some $m \in M$. Suppose $a_1 \dots a_n x \in N$ for $a_1, \dots, a_n \in R$ and $x \in M$. Then there exists $a_{n+1} \in R$ such that $x = a_{n+1}m$. Hence $a_1 \dots a_n a_{n+1}m \in N$. Since N is a classical n-absorbing subsemimodule, there are n of the a_i's whose product with m is in N. Since M is cyclic, $(N :_R m) = (N :_R M)$. Thus either those n a_i's include all $a_1, \dots, a_n$ (so their product is in $(N :_R M)$) or the product of $n-1$ of the a_i's with m is in N, giving the product of $n-1$ of the a_i's with x in N. Therefore N is a n-absorbing subsemimodule. □

Corollary 4.7. *Let* M *be a cyclic* R*-semimodule and* N*, a subsemimodule of* M*. Then the following are equivalent:*

1. N *is a classical* n*-absorbing subsemimodule of* M*.*
2. N *is an* n*-absorbing subsemimodule of* M*.*

Corollary 4.8. *Let* M *be a cyclic multiplication* R*-semimodule and* N*, a subsemimodule of* M*. Then the following are equivalent:*

1. N *is a classical* n*-absorbing subsemimodule of* M*.*
2. $(N :_R M)$ *is an* n*-absorbing ideal of* R*.*

Proof. By Corollary 4.7 and [10, Proposition 2.4]. □

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

हरित तंत्रज्ञान आणि शाश्वत विकास : जळगाव जिल्ह्याचा भौगोलिक दृष्टिकोनातून अभ्यास

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DOI - 10.5281/zenodo.24339595

सारांश (Abstract):

हरित तंत्रज्ञान हे पर्यावरणीय प्रदूषण कमी करणे, नैसर्गिक संसाधनांचे संवर्धन करणे आणि आर्थिक विकासासोबत पर्यावरणाचा समतोल राखणे यासाठी महत्त्वाचे साधन आहे. शाश्वत विकासाच्या संकल्पनेत वर्तमान पिढीच्या गरजा पूर्ण करताना भावी पिढ्यांच्या गरजा पूर्ण करण्याच्या क्षमतेला बाधा पोहोचू न देणे अपेक्षित आहे. या संशोधनाचा मुख्य उद्देश महाराष्ट्रातील जळगाव जिल्ह्यात हरित तंत्रज्ञानाची उपयुक्तता, त्याचे भौगोलिक स्वरूप आणि शाश्वत विकासातील योगदान यांचा अभ्यास करणे हा आहे.

जळगाव जिल्हा केळी उत्पादन, कापूस शेती आणि इतर कृषी उत्पादनांसाठी प्रसिद्ध आहे. जिल्ह्याचे भौगोलिक स्थान, तापमानातील चढ-उतार, पर्जन्यमान, तापी नदीचे खोरे आणि भूजलावरील शेतीचे अवलंबित्व यांमुळे हरित तंत्रज्ञानाला विशेष महत्त्व प्राप्त होते.

या अभ्यासात सौरऊर्जा, ठिबक सिंचन, पावसाच्या पाण्याचे संकलन, जलसंधारण, सेंद्रिय शेती, कृषी अवशेषांचे व्यवस्थापन आणि पर्यावरणपूरक कचरा व्यवस्थापन या उपायांचा विचार केला आहे. संशोधनासाठी वर्णनात्मक व विश्लेषणात्मक पद्धतीचा वापर सुचविण्यात आला असून शासकीय अहवाल, प्रकाशित संशोधन आणि उपलब्ध दुय्यम माहिती हे प्रमुख स्रोत आहेत.

बीजशब्द: हरित तंत्रज्ञान, शाश्वत विकास, भौगोलिक विश्लेषण, जळगाव जिल्हा, सौरऊर्जा, जलसंधारण, शाश्वत शेती, पर्यावरण संवर्धन.

प्रस्तावना:

विसाव्या शतकाच्या उत्तरार्धापासून औद्योगिकीकरण, नागरीकरण, लोकसंख्यावाढ आणि नैसर्गिक संसाधनांच्या वाढत्या वापरामुळे पर्यावरणीय समस्या गंभीर झाल्या आहेत. हवामान बदल, पाण्याची टंचाई, मृदा ऱ्हास, जैवविविधतेचा ऱ्हास आणि प्रदूषण या समस्या विकास प्रक्रियेसमोर आव्हान निर्माण करतात. त्यामुळे विकास आणि पर्यावरण संवर्धन यांच्यात समतोल साधण्याची गरज वाढली आहे.

हरित तंत्रज्ञान म्हणजे नैसर्गिक संसाधनांचा कार्यक्षम वापर करून प्रदूषण व कचरा कमी करणारे, ऊर्जा बचत करणारे आणि पर्यावरणावरील प्रतिकूल परिणाम मर्यादित करणारे तंत्रज्ञान होय. सौरऊर्जा, पवनऊर्जा, ऊर्जा कार्यक्षम उपकरणे, ठिबक सिंचन, सांडपाण्याचा पुनर्वापर

आणि जैविक कचऱ्यापासून खतनिर्मिती ही त्याची उदाहरणे आहेत.

भूगोलाच्या दृष्टीने हरित तंत्रज्ञानाचा अभ्यास करताना नैसर्गिक पर्यावरण, हवामान, जलसंपत्ती, मृदा, लोकसंख्या, शेती, वसाहती आणि आर्थिक क्रियाकलाप यांचा परस्परसंबंध विचारात घेतला जातो. प्रत्येक प्रदेशाची भौगोलिक परिस्थिती वेगळी असल्यामुळे हरित तंत्रज्ञानाचे स्वरूप आणि परिणामही प्रदेशानुसार बदलतात.

जळगाव जिल्ह्याच्या संदर्भात हरित तंत्रज्ञानाचा अभ्यास महत्त्वाचा आहे. जिल्ह्यातील शेती, विशेषतः केळी व इतर पिकांचे उत्पादन, सिंचनासाठी पाण्याची गरज आणि उन्हाळ्यातील उष्ण हवामान यांमुळे जल व ऊर्जा व्यवस्थापनाला महत्त्व प्राप्त होते. त्यामुळे जिल्ह्याच्या शाश्वत विकासासाठी हरित तंत्रज्ञानाच्या संधी आणि मर्यादा यांचे भौगोलिक विश्लेषण आवश्यक आहे.

अभ्यासक्षेत्राचा भौगोलिक परिचय:

जळगाव जिल्हा महाराष्ट्राच्या वायव्य भागात स्थित आहे. जिल्ह्याच्या उत्तरेस सातपुडा पर्वतरांग, दक्षिणेस अजिंठा पर्वतरांग आणि जिल्ह्याच्या प्रमुख नैसर्गिक वैशिष्ट्यांमध्ये तापी नदीचा समावेश होतो. तापी नदी आणि तिच्या उपनद्यांचे खोरे जिल्ह्याच्या जलसंपत्ती व कृषी व्यवस्थेसाठी महत्त्वाचे आहे. जिल्ह्यात ज्वालामुखीय उत्पत्तीचे बेसॉल्ट खडक आणि तापी खोऱ्यात गाळाची संरचना आढळते.

जिल्ह्याचे सरासरी वार्षिक पर्जन्यमान सुमारे ६९० मिमी असल्याची माहिती जिल्हा प्रशासनाच्या संकेतस्थळावर दिली आहे. मात्र पर्जन्यमानात वर्षानुसार आणि स्थानानुसार बदल होऊ शकतो. उन्हाळ्यातील उष्णता आणि पावसाच्या हंगामी स्वरूपामुळे जलसंधारण, सिंचन कार्यक्षमता आणि पिकांचे नियोजन यांना महत्त्व आहे.

जळगाव जिल्ह्याची अर्थव्यवस्था कृषी आणि कृषीपूरक व्यवसायांशी संबंधित आहे. केळी, कापूस, कडधान्ये आणि इतर पिकांचे उत्पादन जिल्ह्याच्या ग्रामीण अर्थव्यवस्थेत महत्त्वाची भूमिका बजावते. या पार्श्वभूमीवर हरित तंत्रज्ञानाचा अवलंब केल्यास संसाधनांचा कार्यक्षम वापर आणि पर्यावरण संवर्धन यांना चालना मिळू शकते.

संशोधन समस्येचे विधान:

जळगाव जिल्ह्यातील कृषी उत्पादन, ग्रामीण विकास आणि नैसर्गिक संसाधनांचे व्यवस्थापन यांसाठी ऊर्जा व पाण्याचा कार्यक्षम वापर आवश्यक आहे. पारंपरिक ऊर्जा स्रोतांवरील अवलंबित्व, सिंचनासाठी वाढती पाण्याची गरज, कृषी अवशेषांचे व्यवस्थापन आणि पर्यावरणीय बदल यांचा स्थानिक विकासावर परिणाम होऊ शकतो.

हरित तंत्रज्ञान हे या समस्यांवर उपाय देऊ शकते; तथापि त्याची उपलब्धता, खर्च, तांत्रिक ज्ञान, देखभाल, शेतकऱ्यांची आर्थिक क्षमता आणि स्थानिक भौगोलिक परिस्थिती यांमुळे त्याचा अवलंब सर्व भागांत समान असेलच असे नाही. त्यामुळे जळगाव जिल्ह्यात हरित तंत्रज्ञानाचा अवलंब कोणत्या स्वरूपात करता येऊ शकतो आणि त्याद्वारे शाश्वत विकासाला कशा प्रकारे चालना मिळू शकते, ही या संशोधनाची प्रमुख समस्या आहे.

संशोधनाची उद्दिष्टे:

1. हरित तंत्रज्ञान आणि शाश्वत विकास या संकल्पनांचा भौगोलिक दृष्टिकोनातून अभ्यास करणे.
2. जळगाव जिल्ह्याची भौगोलिक, हवामानविषयक आणि कृषीविषयक वैशिष्ट्ये स्पष्ट करणे.

3. जिल्ह्यात सौरऊर्जा आणि इतर अक्षय ऊर्जा स्रोतांच्या संभाव्य वापराचा अभ्यास करणे.
4. जळगाव जिल्ह्याच्या शाश्वत विकासासाठी योग्य उपाययोजना सुचविणे.

संशोधनाची गृहीतके:

1. हरित तंत्रज्ञानाचा योग्य वापर केल्यास ऊर्जा आणि पाण्याचा कार्यक्षम वापर वाढण्यास मदत होऊ शकते.
2. सौरऊर्जा आणि कार्यक्षम सिंचन तंत्रज्ञानामुळे कृषी क्षेत्रातील पारंपरिक ऊर्जा स्रोतांवरील अवलंबित्व कमी करण्याची संधी उपलब्ध होऊ शकते.

संशोधन पद्धती:

प्रस्तुत संशोधनासाठी वर्णनात्मक, विश्लेषणात्मक आणि भौगोलिक दृष्टिकोनाचा वापर करण्यात येईल. अभ्यासात प्राथमिक व दुय्यम माहिती या दोन्ही प्रकारांचा समावेश करता येईल.

१. प्राथमिक माहिती:

प्राथमिक माहिती संकलित करण्यासाठी पुढील साधनांचा वापर करता येईल: शेतकरी, ग्रामपंचायत प्रतिनिधी आणि स्थानिक नागरिक यांच्या मुलाखती. सौरऊर्जा वापरणारे शेतकरी आणि ठिबक सिंचन वापरणाऱ्या शेतकऱ्यांचे सर्वेक्षण. निवडक गावांमध्ये प्रत्यक्ष क्षेत्रभेटी आणि निरीक्षण. पाणी, ऊर्जा आणि कृषी अवशेष व्यवस्थापनाविषयी प्रश्नावली. हरित तंत्रज्ञान वापरणाऱ्या आणि न वापरणाऱ्या शेतकऱ्यांच्या अनुभवांची तुलना.

२. दुय्यम माहिती:

दुय्यम माहिती पुढील स्रोतांमधून संकलित करता येईल: जळगाव जिल्हा प्रशासनाचे अहवाल. महाराष्ट्र शासनाचा कृषी व ऊर्जा विभाग. केंद्रीय भूजल मंडळाचे अहवाल. महाराष्ट्र शासनाचा भूजल सर्वेक्षण व विकास यंत्रणेचा उपलब्ध डेटा. भारताची जनगणना, जिल्हा सांख्यिकी अहवाल आणि प्रकाशित संशोधन लेख. हरित तंत्रज्ञान व शाश्वत विकासाशी संबंधित पुस्तके आणि शोधनिबंध. जळगाव जिल्ह्यासाठी केंद्रीय भूजल मंडळाने जलधर नकाशे आणि भूजल व्यवस्थापन आराखडा प्रकाशित केला आहे. भूजल संसाधनांचा अभ्यास करण्यासाठी हा उपयुक्त संदर्भ आहे.

३. माहिती विश्लेषणाची तंत्रे:

संकलित माहितीचे विश्लेषण पुढील पद्धतींनी करता येईल: टक्केवारी पद्धत: हरित तंत्रज्ञान वापरणाऱ्या शेतकऱ्यांचे प्रमाण मोजणे. तुलनात्मक विश्लेषण: तंत्रज्ञान वापरणाऱ्या व न वापरणाऱ्या शेतकऱ्यांच्या खर्चाची आणि पाण्याच्या वापराची तुलना करणे. नकाशे व आलेख: सौरऊर्जा, सिंचन पद्धती आणि जलसंधारण उपक्रमांचे भौगोलिक वितरण दाखविणे. स्थानिक विश्लेषण: तालुका व गावनिहाय तंत्रज्ञानाचा अवलंब आणि नैसर्गिक संसाधनांची उपलब्धता तपासणे. गुणात्मक विश्लेषण: शेतकऱ्यांच्या अनुभवांवरून तंत्रज्ञानाच्या अडचणी व संधी समजून घेणे.

हरित तंत्रज्ञानाचे स्वरूप आणि जळगाव जिल्ह्यातील उपयुक्तता:

१. सौरऊर्जा तंत्रज्ञान:

सौरऊर्जा ही सूर्यप्रकाशापासून प्राप्त होणारी अक्षय ऊर्जा आहे. जळगाव जिल्ह्यात उन्हाळ्यातील उष्ण हवामान आणि सौरऊर्जेच्या वापराची संभाव्यता लक्षात घेता या तंत्रज्ञानाला महत्त्व आहे. तथापि, प्रत्यक्ष सौरऊर्जा उत्पादन हे सूर्यप्रकाशाचा कालावधी, ढगाळ हवामान, धूळ, उपकरणांची क्षमता आणि देखभाल यांवर अवलंबून असते.

सौरऊर्जेचा वापर पुढील क्षेत्रांत करता येऊ शकतो: शेतांमध्ये सौरऊर्जेवर चालणारे पंप. घरांच्या आणि

सार्वजनिक इमारतींच्या छतांवरील सौर पॅनेल. ग्रामीण भागातील लहान उद्योगांना वीजपुरवठा. कृषी उत्पादनांच्या साठवणुकीसाठी आवश्यक ऊर्जेचा काही भाग. कृषी पंपांच्या वीजपुरवठ्याचे सौर ऊर्जेद्वारे विद्युतीकरण.

महाराष्ट्र शासनाची मुख्यमंत्री सौर कृषी वाहिनी योजना २.० ही कृषी क्षेत्राला सौरऊर्जेद्वारे वीजपुरवठा करण्याच्या उद्देशाने राबविली जाते. सौरऊर्जेमुळे पारंपरिक ऊर्जेवरील अवलंबित्व कमी करण्यास मदत होऊ शकते. मात्र सौर पंपांचा वापर करताना भूजल उपलब्धता आणि पाण्याचा विवेकी वापर यांचा विचार करणे आवश्यक आहे. स्वस्त किंवा सहज उपलब्ध ऊर्जा मिळाल्यामुळे अनियंत्रित भूजल उपसा वाढणार नाही, यासाठी योग्य नियोजन गरजेचे आहे.

२. शाश्वत शेती आणि मृदासंवर्धन:

शाश्वत शेतीमध्ये जमिनीची सुपीकता, पाण्याची उपलब्धता, जैवविविधता आणि शेतकऱ्यांचे आर्थिक हित यांचा समतोल राखण्यावर भर दिला जातो.

जळगाव जिल्ह्यात पुढील उपायांचा विचार करता येईल: परीक्षणानुसार खतांचा वापर. सेंद्रिय खत आणि कंपोस्ट निर्मिती. पीक फेरपालट आणि योग्य आंतरपीक पद्धती. मृदा धूप रोखण्यासाठी समतल चर व योग्य बांधबंदिस्ती. कृषी अवशेषांचे कंपोस्ट किंवा इतर उपयुक्त उत्पादनांत रूपांतर. पाण्याची उपलब्धता आणि हवामानानुसार पीक नियोजन.

केळी व कापूस यांसारख्या पिकांमधून निर्माण होणाऱ्या अवशेषांचे योग्य व्यवस्थापन केल्यास कचरा कमी करणे आणि जैविक संसाधनांचा पुनर्वापर करणे शक्य होते. मात्र प्रत्येक अवशेषाचा वापर स्थानिक तांत्रिक व आर्थिक व्यवहार्यतेनुसार ठरविणे आवश्यक आहे.

३. कचरा व्यवस्थापन आणि पुनर्वापर:

ग्रामीण आणि शहरी भागांमध्ये निर्माण होणाऱ्या जैविक व अजैविक कचऱ्याचे योग्य व्यवस्थापन शाश्वत विकासासाठी महत्त्वाचे आहे.

प्रमुख उपाय: घरगुती ओल्या कचऱ्यापासून कंपोस्ट खत तयार करणे. प्लास्टिक कचऱ्याचे वर्गीकरण आणि पुनर्चक्रण. कृषी अवशेषांचा पुनर्वापर. सांडपाण्यावर प्रक्रिया करून योग्य वापरासाठी पुनर्वापर. बाजारपेठा आणि सार्वजनिक ठिकाणी कचरा वर्गीकरण व्यवस्था. यामुळे कचऱ्याचे प्रमाण कमी करणे, संसाधनांचा पुनर्वापर आणि स्थानिक पातळीवर रोजगारनिर्मिती यांना मदत होऊ शकते.

जळगाव जिल्ह्यात हरित तंत्रज्ञानाच्या विकासासाठी उपलब्ध संधी:

१. कृषी क्षेत्रातील संधी:

जळगाव जिल्ह्याची कृषिप्रधान अर्थव्यवस्था हरित तंत्रज्ञानाच्या विकासासाठी महत्त्वाची संधी उपलब्ध करून देते. ठिबक सिंचन, सौरऊर्जा, माती परीक्षण, हवामानविषयक माहिती आणि कृषी अवशेषांचे व्यवस्थापन यांचा समन्वित वापर केल्यास शेती अधिक संसाधन-कार्यक्षम बनू शकते.

२. अक्षय ऊर्जा क्षेत्रातील संधी:

सौरऊर्जेचा वापर शेतांमध्ये, घरांमध्ये, शाळांमध्ये, ग्रामपंचायत कार्यालयांमध्ये आणि लघुउद्योगांमध्ये वाढविण्याची संधी आहे. स्थानिक गरजा आणि उपलब्ध जागेनुसार छतावरील सौरऊर्जा प्रकल्प तसेच सामूहिक सौरऊर्जा प्रकल्प विकसित करता येऊ शकतात.

३. ग्रामीण रोजगारनिर्मिती:

हरित तंत्रज्ञानाच्या विस्तारामुळे सौरऊर्जा उपकरणांची स्थापना, देखभाल, ठिबक सिंचन दुरुस्ती,

सेंद्रिय खतनिर्मिती आणि कचरा पुनर्चक्रण यांसारख्या क्षेत्रांत रोजगाराच्या संधी निर्माण होऊ शकतात.

४. शैक्षणिक आणि संशोधनविषयक संधी:

महाविद्यालये, विद्यापीठे आणि संशोधन संस्थांच्या मदतीने तालुकानिहाय हरित तंत्रज्ञानाचा वापर, पाण्याची उपलब्धता, शेतकऱ्यांचा दृष्टिकोन आणि तंत्रज्ञानाचा आर्थिक परिणाम यांचा अभ्यास करता येईल.

हरित तंत्रज्ञानाच्या प्रसारातील प्रमुख समस्या:

जळगाव जिल्ह्यात हरित तंत्रज्ञानाचा व्यापक वापर करताना पुढील संभाव्य अडचणींचा विचार करणे आवश्यक आहे.

1. **प्रारंभिक खर्च:** सौरऊर्जा, ठिबक सिंचन आणि आधुनिक उपकरणे बसविण्यासाठी सुरुवातीला भांडवलाची गरज असते.
2. **तांत्रिक ज्ञानाचा अभाव:** उपकरणांचा योग्य वापर आणि देखभाल करण्यासाठी प्रशिक्षण आवश्यक असते.
3. **भूजलावरील अवलंबित्व:** सिंचनासाठी भूजलाचा अतिवापर झाल्यास पाण्याच्या उपलब्धतेवर दबाव निर्माण होऊ शकतो.
4. **हवामानातील अनिश्चितता:** पावसाचे अनियमित वितरण आणि तापमानातील बदल शेतीच्या नियोजनावर परिणाम करू शकतात.
5. **लहान शेतकऱ्यांच्या मर्यादा:** आर्थिक साधनांची कमतरता आणि कर्ज मिळविण्यातील अडचणी यामुळे काही शेतकऱ्यांना आधुनिक तंत्रज्ञान स्वीकारणे कठीण जाऊ शकते.
6. **देखभाल आणि दुरुस्ती:** तांत्रिक सेवा, सुटे भाग आणि प्रशिक्षित मनुष्यबळ उपलब्ध नसल्यास उपकरणांची कार्यक्षमता कमी होऊ शकते.
7. **माहितीची कमतरता:** स्थानिक पातळीवरील हरित तंत्रज्ञानाचा वापर, खर्च आणि परिणाम यांची अद्ययावत आकडेवारी उपलब्ध असणे आवश्यक आहे.

शाश्वत विकासासाठी उपाययोजना आणि शिफारसी:

जळगाव जिल्ह्याच्या भौगोलिक परिस्थितीचा विचार करून पुढील उपाययोजना सुचविता येतील.

१. **सौरऊर्जेचा नियोजनबद्ध विस्तार:** कृषी पंप, सार्वजनिक इमारती आणि लघुउद्योगांमध्ये सौरऊर्जेच्या वापराला प्रोत्साहन द्यावे.

२. **सूक्ष्म सिंचनाचा प्रसार:** केळी व इतर पिकांसाठी पाण्याच्या गरजेनुसार ठिबक सिंचन आणि योग्य सिंचन वेळापत्रकाचा वापर वाढवावा.

३. **गावनिहाय जलव्यवस्थापन:** पावसाचे पाणी साठविणे, भूजल पुनर्भरण आणि जलस्रोतांचे संरक्षण यासाठी स्थानिक आराखडे तयार करावेत.

४. **शाश्वत पीक नियोजन:** जमिनीची गुणवत्ता, पाण्याची उपलब्धता आणि हवामान यांचा विचार करून पीकपद्धती निश्चित करण्यासाठी शेतकऱ्यांना मार्गदर्शन करावे.

५. **आर्थिक सहाय्य आणि प्रशिक्षण:** हरित तंत्रज्ञान स्वीकारणाऱ्या शेतकऱ्यांना उपलब्ध शासकीय योजनांची माहिती, तांत्रिक प्रशिक्षण आणि पात्रतेनुसार आर्थिक सहाय्य मिळविण्यास मदत करावी.

६. **कृषी अवशेषांचे व्यवस्थापन:** केळीचे खोड, पिकांचे अवशेष आणि जैविक कचरा यांपासून कंपोस्ट व इतर उपयुक्त उत्पादने तयार करण्याच्या व्यवहार्य पद्धती विकसित कराव्यात.

७. **भौगोलिक माहिती प्रणालीचा वापर:** GIS आणि दूरसंवेदन तंत्रज्ञानाच्या साहाय्याने जमीन वापर, जलस्रोत, सिंचन, वनक्षेत्र आणि सौरऊर्जा प्रकल्पांचे वितरण नकाशांद्वारे अभ्यासावे.

८. **जनजागृती:** शेतकरी मेळावे, प्रशिक्षण शिबिरे, ग्रामसभा आणि शैक्षणिक कार्यक्रमांद्वारे हरित तंत्रज्ञानाविषयी माहिती प्रसारित करावी.

९. **परिणामांचे मूल्यमापन:** तंत्रज्ञान स्वीकारण्यापूर्वी आणि नंतर पाण्याचा वापर, ऊर्जा खर्च, उत्पादन आणि पर्यावरणीय परिणाम यांची तुलना करावी.

१०. **स्थानिक सहभाग:** ग्रामपंचायती, शेतकरी गट, सहकारी संस्था, संशोधन संस्था आणि स्थानिक प्रशासन यांच्या समन्वयातून हरित तंत्रज्ञानाचे कार्यक्रम राबवावेत.

निष्कर्ष:

हरित तंत्रज्ञान आणि शाश्वत विकास यांचा परस्परसंबंध समजून घेण्यासाठी जळगाव जिल्हा हा महत्त्वाचा भौगोलिक अभ्यासविषय आहे. जिल्ह्याची कृषिप्रधान अर्थव्यवस्था, केळी उत्पादन, तापी नदीचे खोरे, हंगामी पर्जन्यमान आणि सिंचनासाठी पाण्याची गरज या वैशिष्ट्यांमुळे नैसर्गिक संसाधनांचे शाश्वत व्यवस्थापन महत्त्वाचे ठरते.

सौरऊर्जा, ठिबक सिंचन, पावसाच्या पाण्याचे संकलन, भूजल पुनर्भरण, शाश्वत शेती आणि कृषी अवशेषांचे व्यवस्थापन या उपायांचा समन्वित वापर केल्यास पर्यावरण संरक्षण आणि ग्रामीण विकासाला मदत होऊ शकते. मात्र या तंत्रज्ञानाचा प्रत्यक्ष परिणाम स्थानिक भौगोलिक परिस्थिती, खर्च, उपलब्ध पाणी, तांत्रिक ज्ञान आणि व्यवस्थापनावर अवलंबून असतो.

विशेषतः सौरऊर्जेवर चालणाऱ्या सिंचन व्यवस्थेसोबत भूजल संवर्धनाची जोड देणे आवश्यक आहे. अन्यथा ऊर्जा उपलब्धतेत सुधारणा झाली तरी पाण्याचा अतिवापर होण्याची शक्यता नाकारता येत नाही. त्यामुळे हरित तंत्रज्ञानाचा प्रसार करताना ऊर्जा, पाणी, जमीन आणि आर्थिक संसाधने यांचा एकात्मिक विचार करणे गरजेचे आहे.

अखेरीस, जळगाव जिल्ह्याचा शाश्वत विकास साधण्यासाठी हरित तंत्रज्ञानाचा भौगोलिक परिस्थितीनुसार वापर, स्थानिक लोकसहभाग, शासकीय योजनांचा प्रभावी लाभ आणि नियमित परिणाममापन या बाबींना प्राधान्य देणे आवश्यक आहे.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

पारोळा तालुक्याच्या स्थानिक इतिहासाचे डिजिटल दस्तऐवजीकरण : ऐतिहासिक साधनांच्या आधारे एक अभ्यास

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संशोधक विद्यार्थी, इतिहास, कवयित्री बहिणाबाई चौधरी उत्तर महाराष्ट्र विद्यापीठ, जळगाव

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DOI - 10.5281/zenodo.24339637

प्रस्तावना:

स्थानिक इतिहास हा इतिहासलेखनातील अत्यंत महत्त्वाचा स्तर आहे. राष्ट्रीय किंवा प्रादेशिक इतिहासाच्या व्यापक चौकटीत मोठ्या राजकीय घटना, सत्तांतर, प्रशासकीय बदल आणि आर्थिक प्रवाह यांचा विचार केला जातो; परंतु त्या प्रक्रियांचा प्रत्यक्ष परिणाम एखाद्या गावावर, बाजारपेठेवर, नगरावर किंवा तालुक्यावर कसा झाला, हे समजून घेण्यासाठी स्थानिक इतिहासाची आवश्यकता असते. स्थानिक इतिहासामध्ये प्रशासन, लोकसंख्या, शेती, व्यापार, शिक्षण, धार्मिक-सांस्कृतिक संस्था, वाहतूक, नागरी सुविधा, सामाजिक संबंध आणि स्थानिक स्मृती यांचा परस्परसंबंध तपासला जातो. त्यामुळे स्थानिक इतिहास हा केवळ एखाद्या ठिकाणच्या भूतकाळाची नोंद नसून सामाजिक परिवर्तनाचा सूक्ष्म अभ्यास ठरतो.

पारोळा तालुका हा खानदेशाच्या ऐतिहासिक प्रदेशाशी निगडित असलेला जळगाव जिल्ह्यातील महत्त्वाचा भौगोलिक व प्रशासकीय प्रदेश आहे. पारोळ्याचा इतिहास समजून घेताना केवळ राजकीय घटनांचा किंवा ऐतिहासिक वास्तूंचा विचार पुरेसा ठरत नाही. प्रशासकीय रचनेतील बदल, गावांची संख्या व रचना, लोकसंख्येतील बदल, नगरपालिकेची निर्मिती व कार्य, शेतीचे स्वरूप, बाजारपेठा, वाहतूक, शिक्षण आणि स्थानिक सामाजिक-सांस्कृतिक जीवन या सर्व बाबींच्या परस्पर संदर्भातून पारोळ्याच्या इतिहासाची पुनर्रचना करावी लागते. [1]

या अभ्यासात उपलब्ध अधिकृत व संस्थात्मक ऐतिहासिक साधनांपैकी १९६१ चे जळगाव जिल्हा जनगणना हँडबुक आणि १९६२ चे महाराष्ट्र राज्य गॅझेटिअर्स : जळगाव जिल्हा या साधनांना केंद्रस्थानी ठेवले आहे. जनगणना हँडबुकमध्ये तालुक्याचे क्षेत्रफळ, गावे, नगर आणि लोकसंख्या यांसारखी संख्यात्मक माहिती मिळते; तर गॅझेटिअरमध्ये प्रशासन, शेती, जमीन महसूल, व्यापार, वाहतूक, नगरपालिका, शिक्षण आणि लोकसंख्या अशा विविध क्षेत्रांशी संबंधित वर्णनात्मक माहितीची व्यापक चौकट उपलब्ध होते. [2]

या साधनांचे महत्त्व केवळ त्यातील माहितीपुरते मर्यादित नाही. त्यांचे शास्त्रीय पद्धतीने डिजिटल दस्तऐवजीकरण झाल्यास जुने दस्तऐवज शोधणे, विषयवार वर्गीकरण करणे, संदर्भ तपासणे, विविध स्रोतांची तुलना करणे आणि भावी संशोधनासाठी त्यांचे जतन करणे अधिक सुलभ होऊ शकते. म्हणून प्रस्तुत अभ्यासात डिजिटल

दस्तऐवजीकरणाकडे इतिहासलेखन आणि ग्रंथालयशास्त्र या दोन्हींच्या संगमावर उभ्या असलेल्या प्रक्रियेप्रमाणे पाहिले आहे.

या लेखाचा मुख्य भर पारोळा तालुक्याशी संबंधित ऐतिहासिक साधनांचे स्वरूप, त्यातील माहितीचे संशोधनमूल्य, डिजिटल स्वरूपात त्यांची मांडणी, मेटाडेटा व संदर्भ नोंद, विषयवार वर्गीकरण, डिजिटल जतन आणि भविष्यातील स्थानिक डिजिटल ऐतिहासिक संग्रहाच्या शक्य रचनेवर आहे. येथे सुचविलेला डिजिटल संग्रह हा संकल्पित आराखडा आहे; प्रत्यक्ष अस्तित्वात असलेल्या स्वतंत्र पारोळा डिजिटल रिपॉझिटरीचा दावा या लेखात केलेला नाही.

पारोळा तालुक्याची ऐतिहासिक व प्रशासकीय पार्श्वभूमी:

पारोळ्याचा इतिहास खानदेशाच्या व्यापक ऐतिहासिक विकासाशी जोडलेला आहे. खानदेश प्रदेशातील प्रशासकीय रचना ब्रिटिश काळात विविध टप्प्यांत बदलत गेली. उपलब्ध जिल्हा जनगणना साहित्याच्या विश्लेषणात्मक नोंदींनुसार १९०६ मध्ये खानदेशाचे विभाजन करून पूर्व खानदेश व पश्चिम खानदेश अशी प्रशासकीय रचना करण्यात आली आणि पारोळा पेठेचा समावेश पूर्व खानदेशातील प्रशासकीय चौकटीत झाला. पुढे १९१७ मध्ये पारोळा पेठेला तालुका दर्जा मिळाल्याची नोंद उपलब्ध आहे. या प्रशासकीय बदलांचा अभ्यास स्थानिक इतिहासाच्या कालक्रमासाठी महत्त्वाचा ठरतो.[3]

१९५६ मधील राज्य पुनर्रचना आणि १९६० मध्ये महाराष्ट्र राज्याची निर्मिती यामुळे प्रशासकीय सीमांमध्ये आणि जिल्हानिहाय व्यवस्थेत बदल झाले. पूर्व खानदेशाचे पुढे जळगाव जिल्ह्यात रूपांतर झाले. या व्यापक प्रशासकीय बदलांचा परिणाम स्थानिक महसूल व्यवस्था, प्रशासकीय केंद्रे, वाहतूक, शैक्षणिक संस्था आणि नागरी प्रशासनावर झाला असण्याची शक्यता तपासण्यासाठी त्या काळातील अधिकृत नोंदींचा परस्पर संदर्भ घेणे आवश्यक आहे.

स्थानिक इतिहासाच्या दृष्टीने पारोळा तालुक्याचा अभ्यास करताना प्रशासन हा एकमेव केंद्रबिंदू मानता येत नाही. प्रशासनाच्या बदलांसोबत लोकसंख्येतील वाढ किंवा घट, ग्रामीण व नागरी वस्तीचे प्रमाण, शेतीवर असलेले अवलंबित्व, बाजारपेठांचा विकास, रस्ते व वाहतूक व्यवस्था, शिक्षणाच्या संधी आणि नगरपालिकेच्या कार्याचा विस्तार या बाबींचाही अभ्यास करावा लागतो. त्यामुळे पारोळ्याचा इतिहास हा बहुआयामी सामाजिक इतिहास म्हणून मांडण्याची शक्यता निर्माण होते.

स्थानिक इतिहासाच्या अभ्यासासाठी उपलब्ध ऐतिहासिक साधने:

स्थानिक इतिहासाची पुनर्रचना एका साधनावर आधारित करता येत नाही. प्रत्येक साधनाची निर्मिती विशिष्ट प्रशासकीय, सामाजिक किंवा संस्थात्मक उद्देशाने झालेली असते. म्हणून स्रोताचा उपयोग करताना त्याची निर्मितीची पार्श्वभूमी, लेखक किंवा संस्था, कालखंड, माहिती संकलनाची पद्धत आणि मर्यादा यांचा विचार करणे आवश्यक असते. पारोळा तालुक्याच्या अभ्यासासाठी सरकारी जनगणना प्रकाशने, जिल्हा जनगणना हँडबुक, गॅझेटिअर, प्रशासकीय नोंदी, नगरपालिका नोंदी, नकाशे, वर्तमानपत्रे, छायाचित्रे, स्थानिक संस्थांचे दस्तऐवज आणि मौखिक इतिहास यांचा परस्परपूरक वापर करता येतो.

ऐतिहासिक साधन	उपलब्ध माहिती	स्थानिक इतिहासातील उपयोग
जनगणना अहवाल	लोकसंख्या, लिंग, ग्रामीण-नागरी रचना, साक्षरता इ.	लोकसंख्येतील दीर्घकालीन बदलांचा अभ्यास
जिल्हा जनगणना हँडबुक	गाव निर्देशिका, क्षेत्रफळ, तालुका-गाव तक्ते, लोकसंख्या	गावनिहाय व तालुकानिहाय इतिहासाची पुनर्रचना
जिल्हा गॅझेटिअर	प्रशासन, शेती, जमीन महसूल, व्यापार, वाहतूक, नगरपालिका, शिक्षण	सामाजिक-आर्थिक व प्रशासकीय इतिहासाचा अभ्यास
जुने नकाशे	प्रशासकीय सीमा, रस्ते, वस्ती, भौगोलिक रचना	सीमा व अवकाशीय बदलांचा अभ्यास
नगरपालिका नोंदी	कर, सार्वजनिक कामे, नागरी सुविधा, प्रशासकीय निर्णय	नागरी इतिहासाचा अभ्यास
वर्तमानपत्रे व छायाचित्रे	घटना, व्यक्ती, सामाजिक-सांस्कृतिक जीवन	दृश्य व घटनात्मक इतिहास
मौखिक इतिहास	स्थानिक आठवणी, अनुभव, परंपरा	लोकस्मृती व सामाजिक इतिहासाचा पूरक अभ्यास

१. जनगणना हँडबुकचे संशोधनमूल्य:

जनगणना हँडबुक हे स्थानिक इतिहासासाठी संख्यात्मक आधार देणारे महत्त्वाचे साधन आहे. त्यामध्ये तालुका व गावांच्या पातळीवरील लोकसंख्या, क्षेत्रफळ, वस्तीचे स्वरूप आणि विविध सांख्यिकीय घटकांची नोंद आढळते. अशा नोंदींमुळे एका विशिष्ट कालखंडातील स्थानिक समाजाचे संरचनात्मक चित्र तयार करता येते. पुढील जनगणना वर्षांशी तुलना केल्यास लोकसंख्येतील बदल, ग्रामीण-नागरी संक्रमण आणि वस्तीच्या विस्ताराचा मागोवा घेण्याची संधी मिळते.

तथापि, जनगणना आकडेवारीचा अर्थ लावताना तिच्या वर्गीकरण पद्धती आणि त्या काळातील प्रशासकीय सीमांचा विचार करणे आवश्यक आहे. एखाद्या तालुक्याची सीमा बदलली असल्यास दोन वेगवेगळ्या वर्षांची आकडेवारी थेट तुलना करणे दिशाभूल करणारे ठरू शकते. त्यामुळे डिजिटल संग्रहामध्ये प्रत्येक सांख्यिकीय नोंदीसोबत संबंधित जनगणना वर्ष, प्रशासकीय सीमा आणि मूळ पृष्ठ क्रमांक नोंदविणे महत्त्वाचे आहे.

२. जिल्हा गॅझेटिअरचे संशोधनमूल्य:

जिल्हा गॅझेटिअर हे स्थानिक इतिहासासाठी बहुआयामी संदर्भसाधन आहे. १९६२ च्या जळगाव जिल्हा गॅझेटिअरच्या विषयविभागात भौतिक वैशिष्ट्ये व नैसर्गिक साधने, प्रशासन, शेती, जमीन महसूल, व्यापार, वाहतूक, नगरपालिका, शिक्षण आणि लोकसंख्या यांसारख्या विविध अंगांचा समावेश आहे. त्यामुळे पारोळा तालुक्याचा इतिहास एका विषयाच्या चौकटीत न पाहता परस्पर संबंधित आर्थिक, सामाजिक आणि प्रशासकीय प्रक्रियांच्या रूपात समजून घेण्यासाठी गॅझेटिअर उपयुक्त ठरतो. [4]

१९६१ च्या जनगणना हँडबुकमधून पारोळ्याचे ऐतिहासिक स्वरूप:

१९६१ च्या जळगाव जिल्हा जनगणना हँडबुकमध्ये पारोळा तालुक्याचे क्षेत्रफळ २९१.४ चौ. मैल

अर्थात ७५४.७ चौ. किमी अशी नोंद आहे. तालुक्यात १०७ वस्तीची गावे आणि १ नगर असल्याचे नमूद केले आहे. एकूण लोकसंख्या ८७,६०० असून त्यापैकी ७०,३८९ लोक ग्रामीण भागात आणि १७,२११ लोक नागरी भागात राहत होते.[5]

या आकडेवारीतून पारोळा तालुक्याची ग्रामीण-नागरी रचना स्पष्ट होते. एकूण लोकसंख्येपैकी ग्रामीण लोकसंख्येचे प्रमाण मोठे असल्यामुळे त्या काळातील सामाजिक व आर्थिक जीवनात ग्रामीण व कृषी क्षेत्राचे महत्त्व अधोरेखित होते. त्याचवेळी १७,२११ इतकी नागरी लोकसंख्या पारोळा नगराच्या स्थानिक प्रशासकीय व व्यापारी भूमिकेकडे लक्ष वेधते. ही आकडेवारी पुढील दशकांतील जनगणना आकडेवारीशी जोडून पाहिल्यास नागरीकरणाची प्रक्रिया अधिक स्पष्टपणे तपासता येईल.

१९६१ च्या हँडबुकमध्ये पारोळा हे जुन्या नगरपालिका असलेल्या नगरांमध्ये नमूद केलेले आहे. त्यामुळे स्थानिक नागरी प्रशासनाच्या इतिहासासाठी जनगणना हँडबुक हा केवळ लोकसंख्येचा स्रोत न राहता नगरपालिका आणि नागरी रचनेच्या अभ्यासासाठीही संदर्भबिंदू ठरतो.[6]

पारोळा तालुका : १९६१ मधील निवडक सांख्यिकीय चित्र:

घटक	**१९६१ मधील नोंद**
क्षेत्रफळ	२९१.४ चौ. मैल / ७५४.७ चौ. किमी
वस्तीची गावे	१०७
नगर	१
एकूण लोकसंख्या	८७,६००
ग्रामीण लोकसंख्या	७०,३८९
नागरी लोकसंख्या	१७,२११

स्रोत : भारत सरकार, जनगणना संचालनालय, महाराष्ट्र, जिल्हा जनगणना हँडबुक : जळगाव, १९६१, पृ. १११.[7]

वरील तक्त्यातील माहिती स्थानिक इतिहासासाठी दोन पातळ्यांवर उपयुक्त आहे. पहिली पातळी म्हणजे १९६१ मधील पारोळा तालुक्याचे स्थिर चित्र; दुसरी पातळी म्हणजे पुढील काळातील बदलांची तुलना करण्यासाठी मिळणारा आधारबिंदू. उदाहरणार्थ, गावांची संख्या, नगरांची स्थिती आणि ग्रामीण-नागरी लोकसंख्येचे प्रमाण यांमध्ये नंतर काय बदल झाला, याचा स्वतंत्र अभ्यास करता येतो. अशा तुलनात्मक अभ्यासातून स्थानिक विकासाच्या प्रक्रियेचे अधिक स्पष्ट चित्र उभे राहू शकते.

ऐतिहासिक साधनांचे चिकित्सक वाचन आणि परस्पर संदर्भ:

इतिहास संशोधनात एखाद्या दस्तऐवजात माहिती उपलब्ध आहे म्हणून ती माहिती अंतिम सत्य मानता येत नाही. प्रत्येक स्रोताची निर्मिती विशिष्ट काळात आणि विशिष्ट उद्देशाने झाली असते. सरकारी अहवालांची भाषा प्रशासकीय असू शकते, जनगणनेतील वर्गीकरण त्या काळातील सांख्यिकीय निकषांवर आधारित असू शकते आणि गॅझेटिअरमधील वर्णन त्या काळातील अधिकृत ज्ञानरचनेचे प्रतिबिंब असू शकते. त्यामुळे स्रोताची माहिती

स्वीकारण्यापूर्वी त्याची निर्मिती, संदर्भ आणि मर्यादा तपासणे आवश्यक आहे.[8]

पारोळ्याच्या इतिहासाच्या संदर्भात जनगणना हँडबुकमधील संख्यात्मक माहिती आणि गॅझेटिअरमधील वर्णनात्मक माहिती यांची तुलना करणे विशेष उपयुक्त ठरते. लोकसंख्येतील बदल समजून घेताना शेती, बाजारपेठ, वाहतूक आणि प्रशासनातील बदलांचा संदर्भ घेतला तर केवळ आकडेवारीवर आधारित निष्कर्षांपेक्षा अधिक व्यापक ऐतिहासिक अर्थनिर्णय करता येतो. त्याचप्रमाणे जुन्या नकाशांमधील सीमा आणि प्रशासकीय नोंदींची तुलना करून एखाद्या प्रदेशाच्या अवकाशीय बदलांचा अभ्यास करता येतो.[9]

स्थानिक स्मृती आणि मौखिक इतिहास यांचा वापरही महत्त्वाचा आहे; मात्र मौखिक माहितीला लिखित स्रोतांचा पर्याय न मानता पूरक स्रोत म्हणून वापरणे अधिक शास्त्रीय ठरते. एखाद्या स्थानिक घटनेची आठवण अनेक व्यक्तींमध्ये समान स्वरूपात आढळल्यास तिचे दस्तऐवजी स्रोतांशी संदर्भसंबंध तपासता येतात. अशा प्रकारे विविध स्रोतांच्या परस्पर पडताळणीमधून स्थानिक इतिहास अधिक विश्वासार्हपणे मांडता येतो.

ऐतिहासिक साधनांचे डिजिटल दस्तऐवजीकरण : संकल्पना आणि प्रक्रिया:

डिजिटल दस्तऐवजीकरण म्हणजे ऐतिहासिक कागदपत्रांचे केवळ स्कॅन करून संगणकात ठेवणे नव्हे. दस्तऐवजाची ओळख, डिजिटल प्रत तयार करणे, फाइलचे नाव व स्वरूप निश्चित करणे, मेटाडेटा नोंदविणे, मूळ पृष्ठक्रमांक कायम ठेवणे, विषयवार वर्गीकरण करणे, शोधसुविधा निर्माण करणे आणि दीर्घकालीन डिजिटल जतनाची व्यवस्था करणे या सर्वांचा समावेश या प्रक्रियेत होतो.[10]

जुन्या कागदपत्रांच्या डिजिटल प्रत निर्मितीमध्ये प्रतिमेची स्पष्टता महत्त्वाची आहे. स्कॅन केलेल्या पानामध्ये मजकूर, तक्ते, शिक्के, हस्तलिखित नोंदी किंवा नकाशातील सूक्ष्म माहिती स्पष्ट दिसली पाहिजे. त्यानंतर ओसीआरचा उपयोग शोधक्षमता वाढविण्यासाठी करता येतो; मात्र ओसीआरमधून तयार झालेला मजकूर हा मूळ दस्तऐवजाचा पर्याय नसतो. विशेषतः जुनी देवनागरी किंवा इतर लिपी, अस्पष्ट अक्षरे आणि खराब कागदामुळे ओसीआरमध्ये चुका होऊ शकतात. त्यामुळे मूळ प्रतिमा आणि ओसीआर मजकूर दोन्ही जतन करणे उपयुक्त ठरते.

टप्पा	**मुख्य कार्य**	**संशोधनातील उपयोग**
१. साधन ओळख	दस्तऐवज, ग्रंथ, नकाशा किंवा छायाचित्राची ओळख	मूळ स्रोत निश्चित करणे
२. डिजिटल प्रत निर्मिती	स्कॅन/फोटोग्राफी आणि फाइल तयार करणे	मूळ सामग्रीचे डिजिटल संरक्षण
३. मेटाडेटा नोंद	शीर्षक, वर्ष, संस्था, पृष्ठ, विषय, स्थान इ.	स्रोताचा संदर्भ अचूक ठेवणे
४. विषयवार वर्गीकरण	इतिहास, प्रशासन, लोकसंख्या, शेती, शिक्षण इ.	शोध व वापर सुलभ करणे
५. संग्रह व शोधसुविधा	सुरक्षित साठवण, अनुक्रमणिका, शोध	संशोधकांना दीर्घकालीन उपलब्धता

चित्र १ : स्थानिक ऐतिहासिक साधनांच्या डिजिटल दस्तऐवजीकरणाची संकल्पित प्रक्रिया

ऐतिहासिक साधन ओळख → डिजिटल प्रत निर्मिती → मेटाडेटा व संदर्भ नोंद → विषयवार वर्गीकरण → डिजिटल संग्रह → शोध व संशोधन वापर

मेटाडेटा, संदर्भ नोंद आणि डिजिटल शोधक्षमता:

डिजिटल संग्रहाची गुणवत्ता केवळ स्कॅन केलेल्या प्रतिमांच्या संख्येवर ठरत नाही. एखाद्या दस्तऐवजाची प्रत कोणती आहे, ती कोठून मिळाली, कोणत्या संस्थेने प्रकाशित केली, प्रकाशन वर्ष कोणते, संबंधित पृष्ठ कोणते आणि त्या दस्तऐवजात कोणत्या विषयाची माहिती आहे हे शोधता आले पाहिजे. यासाठी मेटाडेटा अत्यावश्यक ठरतो. [11]

पारोळा तालुक्याशी संबंधित प्रत्येक डिजिटल दस्तऐवजासाठी शीर्षक, लेखक किंवा संस्था, प्रकाशन वर्ष, प्रकाशनस्थळ, मूळ संग्रहाचे नाव, दस्तऐवजाचा प्रकार, संबंधित तालुका/गाव, विषय, पृष्ठ क्रमांक, डिजिटल फाइलचे नाव, डिजिटल प्रत तयार करण्याची तारीख आणि प्रवेशाधिकार यांसारख्या नोंदी ठेवता येतील. शक्य असल्यास मूळ स्रोताची संदर्भसूचीतील नोंद आणि डिजिटल फाइल यांच्यात स्पष्ट दुवा ठेवावा.

अशा मेटाडेटामुळे संशोधकाला एखादा दस्तऐवज पुन्हा शोधणे सोपे होते. उदाहरणार्थ, "पारोळा + नगरपालिका + १९६१" किंवा "पारोळा + लोकसंख्या + जनगणना" अशा शोधशब्दांद्वारे संबंधित सामग्रीपर्यंत पोहोचता येणे ही डिजिटल संग्रहाची महत्त्वाची कार्यक्षमता ठरू शकते. ग्रंथालयशास्त्रातील सूचीकरण आणि अनुक्रमणिका तत्त्वांचा वापर येथे विशेष उपयुक्त ठरतो.

जळगाव जिल्हा गॅझेटिअर : बहुआयामी स्थानिक इतिहासाचा आधार [12]:

महाराष्ट्र शासनाच्या गॅझेटिअर्स विभागाने प्रकाशित केलेला १९६२ चा जळगाव जिल्हा गॅझेटिअर हा जिल्ह्याच्या इतिहास, भूगोल, प्रशासन आणि सामाजिक-आर्थिक जीवनाचा अभ्यास करण्यासाठी महत्त्वाचा संदर्भग्रंथ आहे. त्याच्या विषयविभागात भौतिक वैशिष्ट्ये व नैसर्गिक साधने, प्रशासन आणि इतर सामाजिक-आर्थिक क्षेत्रांचा समावेश आढळतो. [13]

पारोळा तालुक्याचा अभ्यास करताना गॅझेटिअरमधील माहिती स्वतंत्रपणे न वापरता जनगणना, प्रशासकीय नोंदी, नकाशे आणि स्थानिक साधनांशी जोडणे अधिक उपयुक्त ठरेल. गॅझेटिअर वर्णनात्मक चौकट देतो, तर जनगणना हँडबुक संख्यात्मक आधार देते. दोन्ही स्रोतांची तुलना केल्यास स्थानिक समाजाच्या रचनेतील बदल, आर्थिक क्रियाकलाप आणि प्रशासकीय प्रक्रियांबाबत अधिक चिकित्सक प्रश्न उपस्थित करता येतात. [14]

डिजिटल दस्तऐवजीकरणाच्या दृष्टीने गॅझेटिअरचे विषयवार विभाजन करून प्रत्येक विभागासाठी स्वतंत्र मेटाडेटा तयार करता येईल. उदाहरणार्थ प्रशासन, शेती, जमीन महसूल, व्यापार, वाहतूक, नगरपालिका आणि शिक्षण अशा विषयांनुसार डिजिटल अनुक्रमणिका तयार केल्यास संशोधकाला संपूर्ण ग्रंथ वाचण्याव्यतिरिक्त आवश्यक विषयाच्या विभागापर्यंत जलद पोहोचता येईल. [15]

पारोळा डिजिटल ऐतिहासिक संग्रहाची संकल्पना:

पारोळा तालुक्याशी संबंधित ऐतिहासिक साधने विविध ग्रंथालये, शासकीय कार्यालये, स्थानिक संस्था, संशोधक, कुटुंबीय संग्रह आणि व्यक्तींकडे विखुरलेली असण्याची शक्यता आहे. या सामग्रीचे डिजिटल दस्तऐवजीकरण एकत्रित चौकटीत झाले तर स्थानिक इतिहासासाठी संदर्भाधारित डिजिटल संग्रह उभारता येऊ शकतो. येथे सुचविलेली संकल्पना ही भविष्यातील संशोधन व संस्थात्मक सहकार्याच्या दृष्टीने मांडलेली आहे.

विभाग	संग्रहातील सामग्री	संशोधन उपयोग
ऐतिहासिक पार्श्वभूमी	खानदेश, पूर्व खानदेश, प्रशासकीय नोंदी	कालक्रम व प्रशासकीय इतिहास
जनगणना संग्रह	जनगणना अहवाल, जिल्हा हँडबुक	लोकसंख्या व सामाजिक इतिहास
गॅझेटिअर संग्रह	जळगाव व संबंधित गॅझेटिअर्स	बहुआयामी स्थानिक इतिहास
गावनिहाय संग्रह	गाव निर्देशिका, स्थानिक नोंदी	गावांच्या इतिहासाची पुनर्रचना
नकाशा संग्रह	जुने प्रशासकीय व भौगोलिक नकाशे	सीमा व अवकाशीय बदल
दृश्य संग्रह	छायाचित्रे, वास्तू, जुने दस्तऐवज	दृश्य इतिहास
मौखिक इतिहास	स्थानिक आठवणी, मुलाखती	लोकस्मृती व सामाजिक इतिहास

अशा संग्रहात प्रत्येक नोंदीला स्वतंत्र ओळख क्रमांक दिल्यास दस्तऐवज व्यवस्थापन अधिक शिस्तबद्ध होईल. उदाहरणार्थ, “PAR-CEN-1961-001” अशा प्रकारच्या संकेतांकाने जनगणना दस्तऐवज, “PAR-GAZ-1962-001” अशा संकेतांकाने गॅझेटिअर सामग्री आणि “PAR-MAP-XXXX-001” अशा संकेतांकाने नकाशा संग्रह ओळखता येईल. हे संकेतांक फक्त उदाहरणार्थ आहेत; प्रत्यक्ष संग्रह उभारताना संस्थेच्या दस्तऐवज व्यवस्थापन धोरणानुसार संकेतांक प्रणाली निश्चित करावी.

डिजिटल संग्रहामध्ये मूळ दस्तऐवजाची उच्च-गुणवत्तेची प्रत, वापरासाठी अनुकूल प्रत, ओसीआर मजकूर, मेटाडेटा आणि संदर्भ नोंद स्वतंत्रपणे ठेवणे उपयुक्त ठरेल. प्रवेशाधिकारानुसार काही सामग्री सार्वजनिक, काही संशोधकांसाठी मर्यादित आणि काही सामग्री फक्त मेटाडेटा स्तरावर उपलब्ध ठेवता येऊ शकते.

डिजिटल दस्तऐवजीकरणात ग्रंथालयांची भूमिका:

ग्रंथालये ही ज्ञानसंकलन, संघटन, संरक्षण आणि प्रसारणाची संस्थात्मक केंद्रे आहेत. स्थानिक इतिहासाशी संबंधित ग्रंथ, जनगणना अहवाल, गॅझेटिअर्स, संशोधन प्रबंध, नियतकालिके, वर्तमानपत्रे, छायाचित्रे आणि स्थानिक दस्तऐवज यांचे संकलन व संघटन करण्याची क्षमता ग्रंथालयांकडे असते. त्यामुळे स्थानिक डिजिटल वारसा जतन करण्याच्या प्रक्रियेत ग्रंथालयांची भूमिका मध्यवर्ती ठरू शकते.[16]

ग्रंथालयशास्त्रातील वर्गीकरण, सूचीकरण, विषयशीर्षके, अनुक्रमणिका आणि मेटाडेटा या संकल्पनांचा डिजिटल स्थानिक इतिहास संग्रहासाठी वापर करता येतो. एखाद्या दस्तऐवजाचे योग्य वर्णन तयार केल्यास भविष्यातील संशोधकाला केवळ दस्तऐवजाचे नाव नव्हे तर त्यातील विषय, कालखंड, भौगोलिक संदर्भ आणि संबंधित व्यक्ती किंवा संस्था यांच्याद्वारेही तो शोधता येतो.

स्थानिक शाळा, महाविद्यालये, संशोधन केंद्रे, नगरपालिका आणि स्थानिक इतिहास अभ्यासक यांच्याशी सहकार्य करून ग्रंथालये "स्थानिक इतिहास संकलन अभियान" राबवू शकतात. जुन्या छायाचित्रांचे डिजिटल प्रतिरूप, स्थानिक कुटुंबांकडील कागदपत्रे, जुनी पत्रे, संस्थात्मक अहवाल आणि स्मरणिका यांचे मेटाडेटासह संकलन केल्यास स्थानिक इतिहासाच्या अभ्यासासाठी नवीन प्राथमिक साधने उपलब्ध होऊ शकतात.

डिजिटल दस्तऐवजीकरणातील प्रमुख आव्हाने:

- जुन्या कागदपत्रांची जीर्ण, फाटलेली किंवा खराब झालेली अवस्था.
- अस्पष्ट अक्षरे, जुन्या लिपी, जुनी भाषा आणि मुद्रणातील त्रुटी.
- ओसीआर प्रक्रियेत विशेषतः देवनागरी मजकुरातील वाचनाच्या चुका.
- मूळ स्रोत, प्रकाशन वर्ष आणि पृष्ठ क्रमांक यांची अचूक नोंद न राहण्याचा धोका.
- डिजिटल संग्रहासाठी प्रशिक्षित मनुष्यबळ आणि आवश्यक उपकरणांची मर्यादा.
- दीर्घकालीन डिजिटल साठवण, बॅकअप आणि तांत्रिक स्वरूपातील बदल.
- कॉपीराइट, प्रवेशाधिकार आणि वैयक्तिक माहितीशी संबंधित प्रश्न.
- डिजिटल प्रत आणि मूळ दस्तऐवज यांच्यातील प्रामाणिकता कायम ठेवण्याचे आव्हान.

या आव्हानांपैकी दस्तऐवजाची प्रामाणिकता आणि संदर्भ नोंद ही इतिहास संशोधनासाठी विशेष महत्त्वाची आहे. डिजिटल प्रत उपलब्ध झाली म्हणून ती मूळ स्रोतापेक्षा अधिक विश्वसनीय ठरत नाही. उलट, डिजिटल प्रत तयार करताना मूळ पृष्ठक्रमांक, प्रकाशनाची ओळख, संग्रहाचे नाव आणि उपलब्ध असल्यास मूळ प्रत कुठे जतन आहे याची माहिती ठेवणे आवश्यक आहे.

डिजिटल जतन ही एकदाच पूर्ण होणारी प्रक्रिया नाही. सुरक्षित संचयन, एकापेक्षा अधिक प्रतिकृती, नियमित तपासणी, फाइल स्वरूपांचे व्यवस्थापन आणि आवश्यकतेनुसार नवीन माध्यमावर स्थलांतर यांचा सातत्याने विचार करावा लागतो. डिजिटल वारसा जतन करण्याच्या व्यापक तत्त्वांमध्ये संरक्षणाबरोबरच संदर्भमाहिती आणि भविष्यातील प्रवेशक्षमता यांनाही महत्त्व आहे. [17]

स्थानिक इतिहास, डिजिटल वारसा आणि सांस्कृतिक स्मृती:

स्थानिक इतिहासातील अनेक घटक मुद्रित ग्रंथांमध्ये पूर्णपणे नोंदलेले नसतात. एखाद्या गावातील जुनी वास्तू, उत्सव, बाजारपेठ, शाळा, सार्वजनिक संस्था, स्थानिक व्यक्ती, सामाजिक चळवळ किंवा कौटुंबिक दस्तऐवज यांची माहिती विखुरलेली असू शकते. अशा सामग्रीचे डिजिटल दस्तऐवजीकरण केल्यास भौतिक स्वरूपातील सामग्री नष्ट झाली तरी तिची संदर्भित डिजिटल प्रत भावी संशोधनासाठी उपलब्ध राहण्याची शक्यता वाढते.

डिजिटल सांस्कृतिक वारशाचा अर्थ फक्त जुने दस्तऐवज इंटरनेटवर ठेवणे असा मर्यादित नाही. एखाद्या दस्तऐवजासोबत त्याचा संदर्भ, निर्मितीचा काळ, स्थान, संबंधित संस्था, विषय आणि वापराधिकार यांची माहिती दिली तर तो दस्तऐवज संशोधनासाठी अधिक अर्थपूर्ण ठरतो. त्यामुळे डिजिटल संग्रह हा माहितीचा गोदाम न राहता संदर्भित ज्ञानसंपदा बनतो.

पारोळा तालुक्याच्या संदर्भात स्थानिक ऐतिहासिक वास्तू, जुने बाजारमार्ग, प्रशासकीय इमारती, शैक्षणिक संस्था, धार्मिक-सांस्कृतिक स्थळे, जुन्या छायाचित्रांचा संग्रह आणि स्थानिक स्मृती यांचे डिजिटल दस्तऐवजीकरण भविष्यातील संशोधनासाठी उपयुक्त ठरू शकते. मात्र अशा सामग्रीच्या संकलनात स्थानिक व्यक्तींची परवानगी, बौद्धिक संपदा आणि संवेदनशील माहितीचे संरक्षण यांचा विचार करणे आवश्यक आहे.

इतिहास संशोधनाच्या दृष्टीने चिकित्सक मूल्यांकन:

डिजिटल स्वरूपात उपलब्ध झालेली माहिती आपोआप विश्वसनीय ठरत नाही. डिजिटल प्रत, ओसीआर मजकूर किंवा ऑनलाइन नोंद वापरताना इतिहास संशोधकाने मूळ स्रोत कोणता आहे, दस्तऐवज कोणी तयार केला, तो कोणत्या काळात तयार झाला, त्याचा उद्देश काय होता आणि त्यातील माहिती इतर स्रोतांशी जुळते का हे तपासणे आवश्यक आहे. [18]

पारोळ्याच्या इतिहासाच्या संदर्भात एकाच विषयासाठी अनेक स्रोत वापरणे आवश्यक ठरते. उदाहरणार्थ, लोकसंख्या समजून घेण्यासाठी जनगणना, प्रशासन समजण्यासाठी प्रशासकीय नोंदी, आर्थिक जीवनासाठी गॅझेटिअर आणि स्थानिक बाजारपेठेच्या इतिहासासाठी वर्तमानपत्रे किंवा स्थानिक नोंदी वापरता येतील. या सर्व स्रोतांची तुलना केल्यास स्थानिक इतिहासाचे अधिक संतुलित चित्र तयार होऊ शकते. [19]

डिजिटल दस्तऐवजीकरणाचा आणखी एक महत्त्वाचा परिणाम म्हणजे संशोधनातील पुनर्तपासणीची शक्यता. एखाद्या लेखात वापरलेल्या माहितीसमोर दस्तऐवजाचा अचूक पृष्ठ क्रमांक आणि डिजिटल संग्रहातील ओळख क्रमांक दिल्यास इतर संशोधकाला तो स्रोत पुन्हा तपासता येतो. त्यामुळे संदर्भ पारदर्शकता आणि संशोधनाची पुनरुत्पादकता वाढण्यास मदत होते.

निष्कर्ष:

पारोळा तालुक्याचा स्थानिक इतिहास हा खानदेशाच्या व्यापक इतिहासाचा महत्त्वाचा घटक आहे. पारोळा पेठेपासून तालुका दर्जापर्यंत झालेला प्रशासकीय विकास, ग्रामीण-नागरी रचना, नगरपालिका, शेती, व्यापार, वाहतूक आणि शिक्षण यांसारख्या घटकांच्या परस्परसंबंधातून या प्रदेशाचा सामाजिक इतिहास अधिक व्यापकपणे समजून घेता येतो. या इतिहासाच्या पुनर्रचनेसाठी विविध अधिकृत, संस्थात्मक आणि स्थानिक साधनांचा परस्पर संदर्भ आवश्यक आहे.

१९६१ च्या जळगाव जिल्हा जनगणना हँडबुकमध्ये पारोळा तालुक्याचे क्षेत्रफळ २९१.४ चौ. मैल, १०७ वस्तीची गावे, १ नगर आणि ८७,६०० लोकसंख्या अशी नोंद आहे. ग्रामीण लोकसंख्या ७०,३८९ आणि नागरी लोकसंख्या १७,२११ होती. ही आकडेवारी १९६१ मधील स्थानिक समाजरचनेचा महत्त्वाचा आधारबिंदू उपलब्ध करून देते. [20]

१९६२ चा जळगाव जिल्हा गॅझेटिअर प्रशासन, शेती, जमीन महसूल, व्यापार, वाहतूक, नगरपालिका, शिक्षण आणि लोकसंख्या यांसारख्या विविध विषयांना एकत्रितपणे हाताळतो. त्यामुळे जनगणना हँडबुक आणि गॅझेटिअर यांचा संयुक्त वापर केल्यास पारोळ्याच्या इतिहासातील संख्यात्मक आणि वर्णनात्मक दोन्ही पैलूंचा अभ्यास करता येतो. [21]

या ऐतिहासिक साधनांचे शास्त्रीय डिजिटल दस्तऐवजीकरण केल्यास त्यांचे संरक्षण, शोधक्षमता, संदर्भपारदर्शकता आणि संशोधनातील उपयोगिता वाढू शकते. मात्र डिजिटल दस्तऐवजीकरण करताना मूळ स्रोत,

पृष्ठ क्रमांक, प्रकाशन वर्ष, स्रोतसंस्था, मेटाडेटा, प्रवेशाधिकार आणि डिजिटल जतन यांचा काटेकोर विचार करणे आवश्यक आहे. डिजिटल प्रत ही मूळ स्रोताची संदर्भित प्रत आहे, याची जाणीव संशोधकाने कायम ठेवली पाहिजे.

भविष्यात पारोळा तालुक्याशी संबंधित जनगणना, गॅझेटिअर, प्रशासकीय कागदपत्रे, नकाशे, छायाचित्रे, वर्तमानपत्रे, संस्थात्मक स्मरणिका आणि मौखिक इतिहास यांचा एकत्रित डिजिटल संग्रह उभारता आला तर स्थानिक इतिहास संशोधनाला नवीन दिशा मिळू शकते. अशा संग्रहामुळे संशोधक, विद्यार्थी, शिक्षक, ग्रंथालये आणि स्थानिक समाज यांना एकाच संदर्भचौकटीतून ऐतिहासिक साधनांपर्यंत पोहोचता येईल. परिणामी पारोळ्याचा इतिहास केवळ मुद्रित दस्तऐवजांमध्ये मर्यादित न राहता संरक्षित, शोधण्यायोग्य आणि भावी पिढ्यांसाठी उपलब्ध असलेल्या डिजिटल ज्ञानसंपदेत रूपांतरित होऊ शकतो.

संदर्भसूची:

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२२. उपरोक्त, पृ. १११.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

महात्मा गांधींचे तत्त्वज्ञान आणि सक्षमीकरणासाठी नवोपक्रम : एक अभ्यास

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DOI - 10.5281/zenodo.24339671

सारांश:

महात्मा गांधींचे तत्त्वज्ञान सत्य, अहिंसा, स्वदेशी, स्वावलंबन, ग्रामस्वराज्य आणि सर्वोदय या मूल्यांवर आधारित आहे. एकविसाव्या शतकात नवोपक्रम आणि तंत्रज्ञान आर्थिक व सामाजिक विकासाची महत्त्वाची साधने बनली आहेत. तथापि, तंत्रज्ञानाचा लाभ समाजातील सर्व घटकांपर्यंत समान प्रमाणात पोहोचत नसल्यामुळे आर्थिक विषमता, ग्रामीण बेरोजगारी, डिजिटल दरी आणि पर्यावरणीय समस्या ही आव्हाने कायम आहेत. या पार्श्वभूमीवर गांधीवादी तत्त्वज्ञान आणि आधुनिक नवोपक्रम यांचा समन्वय साधण्याची आवश्यकता अधोरेखित होते.

प्रस्तुत संशोधनाचा मुख्य उद्देश गांधीवादी विचारांचा आर्थिक, सामाजिक, शैक्षणिक आणि राजकीय सक्षमीकरणाशी असलेला संबंध स्पष्ट करणे हा आहे. या अभ्यासासाठी दुय्यम माहितीवर आधारित वर्णनात्मक, गुणात्मक आणि ऐतिहासिक-विश्लेषणात्मक संशोधन पद्धतीचा वापर करण्यात आला आहे. गांधीजींचे लेखन, संदर्भग्रंथ आणि उपलब्ध संशोधन साहित्य यांच्या आधारे चरखा व खादी, ग्रामस्वराज्य, नयी तालीम, विश्वस्तत्व आणि महिला सक्षमीकरण या संकल्पनांचे विश्लेषण केले आहे. अभ्यासातून असे दिसून येते की गांधीवादी मूल्ये आधुनिक नवोपक्रमांना मानवी प्रतिष्ठा, सामाजिक न्याय, स्थानिक स्वावलंबन आणि पर्यावरणीय जबाबदारीची दिशा देऊ शकतात. हा अभ्यास संकल्पनात्मक स्वरूपाचा असून निष्कर्षांची अनुभवजन्य पडताळणी करण्यासाठी स्वतंत्र क्षेत्रीय संशोधन आवश्यक आहे.

मुख्य शब्द: महात्मा गांधी, गांधीवादी तत्त्वज्ञान, सक्षमीकरण, नवोपक्रम, ग्रामस्वराज्य, स्वदेशी, शाश्वत विकास.

प्रस्तावना:

एकविसाव्या शतकात सक्षमीकरण (Empowerment) आणि नवोपक्रम (Innovation) या संकल्पनांना विकासप्रक्रियेत विशेष महत्त्व प्राप्त झाले आहे. आधुनिक काळात नवोपक्रमाचा संबंध प्रामुख्याने कृत्रिम बुद्धिमत्ता, डिजिटल तंत्रज्ञान, औद्योगिक उत्पादकता आणि व्यवसायवृद्धीशी जोडला जातो. तथापि, नवोपक्रमाचे महत्त्व केवळ तांत्रिक प्रगतीपुरते मर्यादित नसून सामाजिक समस्या सोडविणे, स्थानिक संसाधनांचा प्रभावी वापर करणे आणि वंचित घटकांना विकासाच्या संधी उपलब्ध करून देणे यांतही आहे.

महात्मा गांधींच्या तत्त्वज्ञानात स्वावलंबन, स्वदेशी, ग्रामस्वराज्य, श्रमप्रतिष्ठा आणि सर्वोदय या संकल्पनांना केंद्रस्थानी स्थान आहे. गांधीजींच्या मते, विकासाचा लाभ समाजातील शेवटच्या व्यक्तीपर्यंत पोहोचणे आवश्यक आहे. त्यामुळे आर्थिक प्रगतीबरोबर सामाजिक समानता, मानवी प्रतिष्ठा आणि नैतिक जबाबदारी यांचाही विचार करणे महत्त्वाचे ठरते.

गांधीजींच्या विचारांमध्ये चरखा, खादी, ग्रामोद्योग आणि नयी तालीम यांसारख्या उपक्रमांना विशेष स्थान होते. हे उपक्रम रोजगारनिर्मिती, कौशल्यविकास, स्वावलंबन आणि सामुदायिक सहभाग यांना प्रोत्साहन देणारे होते. आजच्या संदर्भात या तत्त्वांचा संबंध सामाजिक उद्योजकता, डिजिटल बाजारपेठा, कृषी मूल्यवर्धन, कौशल्याधारित शिक्षण आणि पर्यावरणपूरक उत्पादनपद्धती यांच्याशी जोडता येतो.

या पार्श्वभूमीवर गांधीवादी तत्त्वज्ञानाचा आधुनिक नवोपक्रमांशी असलेला संबंध समजून घेणे आणि सक्षमीकरणासाठी त्याची उपयुक्तता स्पष्ट करणे आवश्यक आहे.

संशोधन समस्या:

आधुनिक तंत्रज्ञान आणि उद्योजकतेमुळे विकासाच्या नवीन संधी निर्माण झाल्या असल्या, तरी ग्रामीण-शहरी विषमता, बेरोजगारी, आर्थिक असुरक्षितता आणि डिजिटल साधनांच्या उपलब्धतेतील तफावत कायम आहे. अनेकदा आर्थिक वाढीला प्राधान्य देताना सामाजिक समावेशन आणि पर्यावरणीय परिणामांकडे पुरेसे लक्ष दिले जात नाही.

या परिस्थितीत गांधीवादी स्वावलंबन, स्वदेशी, ग्रामस्वराज्य आणि सर्वोदय या संकल्पनांचा आधुनिक नवोपक्रमांशी समन्वय साधून सर्वसमावेशक सक्षमीकरण कसे साधता येईल, ही प्रस्तुत संशोधनाची मध्यवर्ती समस्या आहे.

संशोधनाची उद्दिष्टे:

१. महात्मा गांधींच्या तत्त्वज्ञानातील प्रमुख संकल्पनांचा सक्षमीकरणाच्या दृष्टिकोनातून अभ्यास करणे.
२. चरखा, खादी, ग्रामस्वराज्य आणि नयी तालीम यांसारख्या उपक्रमांचे आर्थिक, सामाजिक आणि शैक्षणिक महत्त्व स्पष्ट करणे.
३. आधुनिक तंत्रज्ञान, सामाजिक उद्योजकता आणि डिजिटल नवोपक्रम यांची सक्षमीकरणातील संभाव्य भूमिका विशद करणे.
४. महिला, युवक, शेतकरी आणि ग्रामीण कारागीर यांच्या स्वावलंबनासाठी गांधीवादी विचारांची उपयुक्तता तपासणे.
५. गांधीवादी मूल्ये आणि शाश्वत विकास यांचा समन्वय साधण्यासाठी उपाय सुचविणे.

वाङ:मय पुनरावलोकन:

गांधीवादी तत्त्वज्ञान, आर्थिक विचार आणि सामाजिक परिवर्तन यांचा अभ्यास विविध विचारवंतांनी केला आहे.

गांधी : *हिंद स्वराज* आणि *रचनात्मक कार्यक्रम* या लेखनातून स्वराज्य, स्वदेशी, ग्रामोद्योग, सामाजिक सुधारणा आणि स्वावलंबन यांचा विचार स्पष्ट होतो. ही मूळ साधने गांधीवादी तत्त्वज्ञानाच्या अभ्यासासाठी महत्त्वपूर्ण आहेत.

कुमारप्पा (1945): *Economy of Permanence* या ग्रंथात गांधीवादी अर्थव्यवस्थेशी संबंधित शाश्वतता, नैसर्गिक संसाधनांचा विवेकपूर्ण वापर आणि ग्रामीण अर्थव्यवस्थेचे महत्त्व स्पष्ट केले आहे. हा दृष्टिकोन आर्थिक विकास आणि पर्यावरणीय संतुलन यांच्यातील संबंध समजून घेण्यासाठी उपयुक्त ठरतो.

बोन्डूरांत (1958): *Conquest of Violence: The Gandhian Philosophy of Conflict* या ग्रंथात सत्याग्रह आणि अहिंसक संघर्षपद्धतीचे विश्लेषण केले आहे. सत्याग्रहाला अन्यायाविरुद्ध संघटित सामाजिक कृतीचे साधन म्हणून समजून घेता येते. या दृष्टिकोनातून

गांधीवादी विचार सामाजिक सक्षमीकरणाशी संबंधित ठरतात.

पारेख (1989): गांधींच्या राजकीय विचारांच्या अभ्यासातून नैतिकता, सत्ता, स्वराज्य आणि सामाजिक परिवर्तन यांच्यातील संबंध स्पष्ट होतात. गांधीवादी दृष्टिकोनातून राजकीय स्वातंत्र्याबरोबर व्यक्तीची स्वायत्तता आणि सामाजिक जबाबदारी यांनाही महत्त्व प्राप्त होते.

प्रल्हाद (2004): *The Fortune at the Bottom of the Pyramid* या ग्रंथात आर्थिक पिरॅमिडच्या तळाशी असलेल्या लोकांसाठी परवडणारी उत्पादने आणि सेवा विकसित करण्याच्या व्यावसायिक संधींचा विचार केला आहे. हा दृष्टिकोन गांधीवादी सर्वोदयाशी काही बाबतींत सुसंगत असला, तरी दोन्ही संकल्पनांची उद्दिष्टे आणि वैचारिक पार्श्वभूमी समान आहेत असे मानता येत नाही.

संशोधन कार्यपद्धती:

प्रस्तुत संशोधन दुय्यम माहितीवर आधारित आहे. अभ्यासासाठी गांधीजींचे मूळ लेखन, गांधीवादी अर्थशास्त्रावरील संदर्भग्रंथ, संशोधन लेख आणि संबंधित संस्थांचे अधिकृत दस्तऐवज यांचा आधार घेतला आहे. माहितीचे विश्लेषण गुणात्मक आणि ऐतिहासिक-विश्लेषणात्मक पद्धतीने करण्यात आले आहे. गांधीवादी तत्त्वांचे वर्गीकरण करून त्यांच्या सक्षमीकरणातील संभाव्य योगदानाचे परीक्षण केले आहे.

गांधीवादी तत्त्वज्ञानाचे मूलभूत स्तंभ:

सत्य आणि अहिंसा: गांधीवादी तत्त्वज्ञानात सत्य आणि अहिंसा ही मूलभूत मूल्ये आहेत. सत्याचा आग्रह आणि अहिंसक मार्गाने अन्यायाला विरोध करणे हे गांधीवादी सामाजिक परिवर्तनाचे महत्त्वाचे घटक आहेत. सक्षमीकरणाच्या संदर्भात ही मूल्ये व्यक्तीला अन्यायाविरुद्ध आवाज उठविण्याचे, सामूहिक कृतीत सहभागी होण्याचे आणि संघर्षाचे शांततामय मार्ग शोधण्याचे नैतिक अधिष्ठान देतात.

सर्वोदय: सर्वोदय म्हणजे सर्वांच्या कल्याणाचा विचार. गांधीवादी दृष्टिकोनात विकासाच्या प्रक्रियेत दुर्बल घटकांचे हित दुर्लक्षित होऊ नये, यावर भर दिला जातो. आधुनिक नवोपक्रमांच्या संदर्भात ही संकल्पना तंत्रज्ञान आणि व्यवसायाच्या संधी सर्वसामान्य लोकांपर्यंत पोहोचविण्याशी संबंधित आहे.

स्वदेशी: स्वदेशीमध्ये स्थानिक उत्पादन, स्थानिक कौशल्ये आणि समुदायाच्या गरजांना महत्त्व दिले जाते. स्थानिक उद्योगांना प्रोत्साहन देणे, ग्रामीण रोजगारनिर्मिती आणि स्थानिक संसाधनांचा जबाबदार वापर ही या विचाराची आधुनिक अनुप्रयोगक्षेत्रे आहेत.

स्वावलंबन आणि ग्रामस्वराज्य: स्वावलंबन म्हणजे स्वतःच्या गरजा पूर्ण करण्यासाठी आवश्यक कौशल्ये आणि क्षमता विकसित करणे. ग्रामस्वराज्याच्या संकल्पनेत स्थानिक समुदायाचा निर्णयप्रक्रियेतील सहभाग आणि विकेंद्रित विकासाला महत्त्व आहे. या विचारांचा उपयोग स्थानिक उद्योजकता, ग्रामविकास नियोजन आणि समुदायाधारित उपक्रमांमध्ये करता येतो.

सक्षमीकरणासाठी गांधीवादी नवोपक्रम:

१. चरखा आणि खादी : आर्थिक सक्षमीकरण:

चरखा आणि खादी हे गांधीवादी स्वावलंबनाचे महत्त्वपूर्ण प्रतीक बनले. ब्रिटिश राजवटीतील आर्थिक शोषणाच्या पार्श्वभूमीवर खादी चळवळीने स्थानिक उत्पादन, श्रमप्रतिष्ठा आणि स्वदेशीच्या विचारांना चालना दिली. आधुनिक संदर्भात या विचाराचा उपयोग ग्रामीण हस्तकला, हातमाग, स्थानिक उत्पादनांचे ब्रँडिंग, ई-कॉमर्स आणि सूक्ष्म उद्योगांच्या विकासासाठी करता येतो. तथापि, अशा

उपक्रमांचे प्रत्यक्ष आर्थिक परिणाम बाजारपेठ, उत्पादनखर्च आणि व्यवस्थापनावर अवलंबून असतात.

२. ग्रामस्वराज्य : राजकीय व प्रशासकीय सक्षमीकरण:

गांधींच्या ग्रामस्वराज्याच्या संकल्पनेत गावाला स्थानिक निर्णयप्रक्रियेचे महत्त्वपूर्ण केंद्र मानले आहे. स्थानिक लोकांनी आपल्या गरजा ओळखून विकासाचे प्राधान्यक्रम निश्चित करावेत. आज ग्रामसभा, ग्रामपंचायत, सहकारी संस्था आणि समुदायाधारित विकास प्रकल्पांद्वारे सहभागी शासनाला प्रोत्साहन देता येते. त्यांना गांधीवादी विकेंद्रीकरणाच्या विचारांशी वैचारिकदृष्ट्या जोडता येते.

३. नयी तालीम : शैक्षणिक सक्षमीकरण:

गांधीजींनी शिक्षणाला जीवनोपयोगी कौशल्ये, हस्तकला आणि श्रमप्रतिष्ठेशी जोडण्यावर भर दिला. नयी तालीम किंवा बुनियादी शिक्षणाच्या संकल्पनेत विद्यार्थ्यांच्या सर्वांगीण विकासाला आणि अनुभवाधारित शिक्षणाला महत्त्व दिले गेले. NEP या आधुनिक शिक्षणात या दृष्टिकोनाचा उपयोग कौशल्याधारित अभ्यासक्रम, इंटर्नशिप, प्रत्यक्ष उद्योगानुभव, उद्योजकता शिक्षण आणि स्थानिक समस्यांवर आधारित प्रकल्प यांसाठी करता येतो. अशा पद्धतींमुळे विद्यार्थ्यांना सैद्धांतिक ज्ञानाबरोबर व्यावहारिक कौशल्ये विकसित करण्याची संधी मिळते.

४. विश्वस्त तत्व सिद्धांत : सामाजिक व आर्थिक जबाबदारी:

गांधीवादी विश्वस्त तत्वाच्या सिद्धांतानुसार संपत्ती आणि संसाधनांचा वापर सामाजिक कल्याणाच्या दृष्टीने करण्याची नैतिक जबाबदारी महत्त्वाची आहे. आधुनिक व्यवसायात या तत्त्वाचा संबंध सामाजिक उत्तरदायित्व, कामगारकल्याण, पर्यावरणीय जबाबदारी, पारदर्शकता आणि स्थानिक समुदायाच्या विकासाशी जोडता येतो. कॉर्पोरेट सामाजिक जबाबदारी (CSR) आणि गांधीवादी विश्वस्तत्व यांच्यात काही साम्य असले, तरी या दोन्ही संकल्पना पूर्णपणे समान नाहीत.

५. महिला सक्षमीकरण:

गांधीजींनी स्वातंत्र्य चळवळीत महिलांच्या सहभागाला प्रोत्साहन दिले. महिलांना सामाजिक सुधारणांमध्ये आणि सार्वजनिक जीवनात सहभागी होण्याची संधी मिळणे हे व्यापक सामाजिक परिवर्तनाच्या दृष्टीने महत्त्वाचे होते. आज महिला बचत गट, सूक्ष्म उद्योग, सहकारी संस्था, कौशल्यविकास आणि डिजिटल उद्योजकता यांच्या माध्यमातून आर्थिक सक्षमीकरणाच्या संधी वाढविता येतात. या उपक्रमांमध्ये स्वावलंबन, सामूहिक कृती आणि मानवी प्रतिष्ठा या गांधीवादी मूल्यांचा उपयोग होऊ शकतो.

आधुनिक नवोपक्रम आणि गांधीवादी विचारांची प्रासंगिकता:

डिजिटल तंत्रज्ञान:

डिजिटल पेमेंट, ऑनलाइन बाजारपेठा, मोबाईल-आधारित माहिती आणि डिजिटल शिक्षण यांमुळे ग्रामीण उद्योजकांना नवीन संधी मिळू शकतात. तथापि, डिजिटल साक्षरता, इंटरनेट सुविधा आणि सायबर सुरक्षेची उपलब्धता आवश्यक आहे. तंत्रज्ञानाचा उपयोग मानवी क्षमताविकासासाठी होणे हा गांधीवादी दृष्टिकोनाशी सुसंगत विचार आहे.

कृषी मूल्यवर्धन:

शेतमालावर प्रक्रिया करणे, उत्पादनांचे पॅकेजिंग, सामूहिक विपणन आणि थेट ग्राहकांपर्यंत पोहोचणे यांद्वारे ग्रामीण अर्थव्यवस्थेत मूल्यवर्धनाच्या संधी निर्माण होऊ शकतात. उदाहरणार्थ, केळी उत्पादक क्षेत्रात केळीपासून प्रक्रिया केलेली उत्पादने किंवा केळीच्या खोडापासून तंतू तयार करण्याच्या उपक्रमांचा व्यवहार्यता अभ्यास करता

येईल. असे प्रकल्प स्थानिक रोजगाराला चालना देऊ शकतात; मात्र त्यासाठी तांत्रिक क्षमता, बाजारपेठ आणि आर्थिक व्यवहार्यतेची तपासणी आवश्यक आहे.

सामाजिक उद्योजकता:

सामाजिक उद्योजकता आर्थिक व्यवहार्यता आणि सामाजिक उद्दिष्टे यांचा समन्वय साधण्याचा प्रयत्न करते. शिक्षण, आरोग्य, पर्यावरण, ग्रामीण रोजगार आणि आर्थिक समावेशन यांसारख्या समस्यांवर उपाय विकसित करणारे व्यवसाय या क्षेत्रात येतात.गांधीवादी सर्वोदय आणि स्वावलंबन या मूल्यांमुळे सामाजिक उद्योजकतेला नैतिक दिशा मिळू शकते. मात्र, सामाजिक उद्दिष्टे साध्य होत आहेत का, याचे नियमित मूल्यमापन आवश्यक आहे.

शाश्वत विकास आणि पर्यावरण संवर्धन:

गांधीवादी विचारांमध्ये गरज आणि हव्यास यांतील फरक, संयमित उपभोग आणि संसाधनांचा विवेकपूर्ण वापर यांना महत्त्व आहे. आधुनिक काळात या मूल्यांचा संबंध पुनर्वापर, कचरा व्यवस्थापन, नवीकरणीय ऊर्जा, पाण्याचे संवर्धन आणि परिपत्र अर्थव्यवस्था यांच्याशी जोडता येतो. संयुक्त राष्ट्रसंघाच्या शाश्वत विकास ध्येयांशी गांधीवादी विचारांचे काही महत्त्वपूर्ण साम्य दिसते, विशेषतः गरिबी निर्मूलन, लिंगभाव समानता, जबाबदार उपभोग आणि शाश्वत समुदाय या क्षेत्रांत. तथापि, SDGs आणि गांधीवादी तत्त्वज्ञान यांची ऐतिहासिक पार्श्वभूमी व संकल्पनात्मक चौकट वेगवेगळी आहे.

संशोधनाचे प्रमुख निष्कर्ष:

दुय्यम माहितीच्या आधारे आपण पुढील प्रमाणे निष्कर्ष मांडू शकतो.

१. गांधीवादी तत्त्वज्ञान आधुनिक नवोपक्रमांना नैतिकता, सामाजिक न्याय आणि मानवी प्रतिष्ठेची दिशा देऊ शकते.
२. स्वावलंबन, स्वदेशी आणि ग्रामस्वराज्य या संकल्पना ग्रामीण उद्योजकता, स्थानिक उत्पादन आणि विकेंद्रित विकासाशी जोडता येतात.
३. विश्वस्त तत्व आणि सर्वोदय या संकल्पना सामाजिकदृष्ट्या जबाबदार व्यवसाय आणि समावेशक विकासासाठी उपयुक्त वैचारिक चौकट देतात.
४. डिजिटल तंत्रज्ञान आणि कौशल्यविकास यांच्या साहाय्याने ग्रामीण समुदायांसाठी नवीन आर्थिक संधी निर्माण होऊ शकतात; मात्र डिजिटल दरी कमी करणे आवश्यक आहे.

शिफारसी:

१. महाविद्यालयांनी गांधीवादी मूल्यांवर आधारित सामाजिक नवोपक्रम आणि उद्योजकता प्रकल्पांना प्रोत्साहन द्यावे.
२. ग्रामीण युवक व महिलांसाठी डिजिटल साक्षरता, वित्तीय साक्षरता आणि व्यवसाय व्यवस्थापन प्रशिक्षण उपलब्ध करून द्यावे.
३. शेतकरी, कारागीर आणि बचत गटांसाठी सामूहिक प्रक्रिया, पॅकेजिंग आणि विपणन व्यवस्था विकसित करावी.
४. स्थानिक स्वराज्य संस्था, शैक्षणिक संस्था आणि उद्योग यांनी संयुक्तपणे रोजगारनिर्मिती व कौशल्यविकास कार्यक्रम राबवावेत.
५. गांधीवादी विचारांचा आधुनिक संदर्भात वापर करताना वैज्ञानिक पुरावे, मानवी हक्क, तांत्रिक व्यवहार्यता आणि बदलत्या सामाजिक-आर्थिक परिस्थितींचाही विचार करावा.

निष्कर्ष:

महात्मा गांधींचे तत्त्वज्ञान केवळ ऐतिहासिक किंवा राजकीय संदर्भापुरते मर्यादित नाही. स्वावलंबन, स्वदेशी, ग्रामस्वराज्य, सर्वोदय आणि विश्वस्तत्व या संकल्पना आधुनिक सामाजिक व आर्थिक समस्यांचा विचार करण्यासाठी आजही उपयुक्त ठरू शकतात. गांधीवादी दृष्टिकोनातून नवोपक्रमाचा उद्देश केवळ उत्पादनवाढ, नफा किंवा तांत्रिक प्रगती नसून मानवी क्षमता विकसित करणे, स्थानिक अर्थव्यवस्था सक्षम करणे आणि विकासाच्या संधी अधिक व्यापक समाजापर्यंत पोहोचविणे हा असला पाहिजे. डिजिटल तंत्रज्ञान, कृषी मूल्यवर्धन, सामाजिक उद्योजकता आणि कौशल्यविकास यांना गांधीवादी मूल्यांची जोड दिल्यास सर्वसमावेशक विकासाच्या नवीन शक्यता निर्माण होऊ शकतात. त्यामुळे गांधीवादी मूल्ये, आधुनिक नवोपक्रम आणि लोकसहभाग यांचा समन्वय हा आत्मनिर्भर, समताधिष्ठित आणि शाश्वत समाजनिर्मितीसाठी उपयुक्त वैचारिक दृष्टिकोन ठरू शकतो.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Accelerated Fixed-Point Approximation of Nonlinear Abstract Differential Equations via a New Iteration Process

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DOI - 10.5281/zenodo.24339692

Abstract:

In this paper, we employ the accelerated three-step New Iteration Process (NIP) to investigate the existence and uniqueness of the mild solution of a nonlinear Abstract Differential Equations with nonlocal condition. We also deal with the strong convergence, T -stability, and rate-of-convergence, properties of New Iteration Process (NIP) relative to the Picard, Mann, Ishikawa, and S-iteration processes and compare the rate of convergence of NIP with the other iterative approaches.

Keywords: Abstract differential equations; nonlocal condition; fixed-point theory; New iteration process; contraction mappings; mild Solution; iterative schemes; rate of convergence; stability.

MSC (2020): 34G20; 47H10; 47J25;47H09; 54H25;34D20.

1 Introduction

In this paper, we study existence, uniqueness and other properties of mild solutions of a nonlocal problem of the form:

$$x^{'}(t) + Ax(t) = f(t, x(t)), \quad t \in [0, b], \tag{A}$$

with the given nonlocal initial condition

$$x(0) + g(x) = x_0, \tag{B}$$

where $-A$ is the infinitesimal generator of a C_0-semigroup $\mathfrak{T}(t)$, $t \geq 0$, on a Banach space X and X be a Banach space with norm $\|\cdot\|$. Let $B = C[0, b]; X)$ be Banach space of all continuous functions from $[0, b]$ into X,and functions $f : [0, b] \times X \to X$, $g : B \to X$, are continuous and x_0 is a given element of X and $b \leq 1$.

The nonlocal condition, which is a generalization of the classical initial, was motivated by physical problems. The pioneering work on nonlocal conditions is due to Byszewski L. [22]. Existence of mild, strong and classical solutions for differential and integrodifferential equations in abstract spaces with nonlocal conditions has received much attention in recent years. We refer to the papers of , Balachandran and Chandrasekaran S. [27],Balachandran K.[26], Tidke H. L. and Dhakne M. B. [28]

We motivated by work of D. Filali, E. Alshaban, B. Z. Albalawi, F. M. Alamrani, A. Alatawi, F. A. Khan [21] .They developed an accelerated three-step iterative scheme for approximating fixed points of contraction mappings in Banach spaces, with a focus on fractional models. They

proved strong convergence of the proposed iteration under assumptions, and they also establish stability and data dependence results. A refined rate-of-convergence analysis shows that the new iteration process(NIP) has converges faster than several classical two- and three-step methods, including the Picard, Mann, Ishikawa, and S-iteration processes.

Recently,in the interesting paper [25],Tidke H.L. has studied existence and uniqueness of solution of similar type of problem (A)-(B)by Banach fixed point theorem.From the above works, we can see that although abstract differential problems have been investigated by some authors, the abstract differential equation with nonlocal conditions and an infinitesimal generator of operators has, to our knowledge, not been discussed extensively.

Therefore, motivated by all the works above, the aim of this paper is to prove the existence, uniqueness , strong convergence,T-stability, and rate of convergence of abstract Differential Equation with the help of the New Iteration Process (NIP), and also to study the properties of NIP relative to the Picard, Mann, Ishikawa, and S-iteration processes, and to compare the rate of convergence of NIP with that of the other iterative approaches.

The equations of these type or their special forms commonly come across in almost all phases of physics and other areas of applied mathematics. The problems of existence, uniqueness and other properties of solutions of various special forms of (A)-(B) have been studied by using different techniques during last few years and the references given therein(see [23])and also [15, 16, 17, 18, 19, 20]

The nonlinear abstract differential equation (A)-(B) constitutes an appropriate mathematical model for processes in which the initial state cannot be measured directly but must instead be inferred from later observations of the trajectory. Such conditions arise naturally in problems of viscoelasticity, anomalous diffusion, and control systems, and they generalize the classical pointwise condition $u(0) = u_0$ to allow feedback from the entire solution history. As a result, the reduction of (A)-(B) to a fixed-point equation, and the identification of the correct contraction constant governing that equation, requires a dedicated investigation distinct from the classical (local) theory.

In 1922, Banach studied the existence of a unique fixed point for contraction mappings on complete metric spaces, and showed that the associated Picard iteration converges to that fixed point from any starting point. While the Picard iteration always converges under a contraction hypothesis, its rate of convergence can be slow, which motivated a long line of accelerated iterative schemes. In 1953, Mann introduced a one-parameter iterative scheme for approximating fixed points more robustly than Picard iteration. In 1974, Ishikawa proposed a two-step generalization of Mann's scheme. In 2000, Noor introduced a three-step iterative scheme for variational inequalities. In 2007, Agarwal, O'Regan and Sahu introduced the S-iteration process and showed that, for certain classes of operators, it converges faster than both Mann and Ishikawa iteration. Recently, Filali, Alshaban, Albalawi, Alamrani, Alatawi and Khan introduced a new three-step iterative scheme — the New Iteration Process (NIP) (see [[1], [2],[3],[4], [5], [6], [8],[7, 9, 10, 11, 12, 13, 14]). we employ NIP in the present work.(see [21])

The paper is organized as follows. In section 2, we present Preliminaries and Hypotheses. Section 3 deals with main results about Strong Convergence and Existence, Uniqueness Of Solutions Via New Iteration Process , in Section 3.2 We established Stability result and in section 3.3 we study Rate of Convergence Comparison Result and in section 4 we discuss on conclusion.

2 Preliminaries and Hypotheses

Before proceeding to the main results, we shall set forth some preliminaries and hypotheses that will be used in our subsequent discussion.

Let X be a Banach space with norm $\|\cdot\|$ and $-A$ is the infinitesimal generator of a C_0-semigroup $\mathfrak{T}(t),\ t \geq 0$, on a Banach space X. The set of bounded linear operators $\mathfrak{T}(t),\quad t \in \mathbb{R}_+ = [0,\infty)$ is a C_0-semigroup on X if

(i). $\mathfrak{T}(t+s) = \mathfrak{T}(t)\mathfrak{T}(s) = \mathfrak{T}(s)\mathfrak{T}(t), \quad t,s \geq 0,$

(ii). $\mathfrak{T}(0) = I$ the identity operator,

(iii). $\mathfrak{T}(\cdot)$ is strongly continuous in $t \in \mathbb{R}_+$,

(iv). $\|\mathfrak{T}(t)\| \leq Me^{wt}$ for some $M \geq 1$ and real w and $t \in \mathbb{R}_+$

(see, Martin [24], p.276).

Throughout in this paper , X be a Banach space with norm $\|\cdot\|$. Let $B = C[0,b];X)$ be Banach space of all continuous functions from $[0,1]$ into X, endowed with the supremum norm

$$\|x\|_\infty = \sup_{t\in[0,1]} |x(t)|, \quad 0 \leq t \leq b \leq 1.$$

Definition 2.1 ([1])**.** A mapping $T : X \to X$ is a *contraction* if there exists $q \in [0,1)$ such that

$$\|Tu - Tv\|_\infty \leq q\|u - v\|_\infty, \qquad \text{for all } u, v \in X.$$

Theorem 2.2 (Banach contraction principle [1])**.** *If $T : X \to X$ is a contraction, then T has a unique fixed point $u^* \in X$, and the Picard iteration $w_{m+1} = Tw_m$ converges to u^* for every $w_0 \in X$.*

We now recall some iterative processes for control sequences $\{\zeta_m\}, \{\kappa_m\}, \{\eta_m\} \subset (0,1)$ and initial approximation $w_0 \in X$, The classical iterative schemes are as follow:

- *Picard iteration* [2]: $w_{m+1} = Tw_m$.
- *Mann iteration* [3]: $w_{m+1} = (1-\zeta_m)w_m + \zeta_m Tw_m$.
- *Ishikawa iteration* [4]: $v_m = (1-\kappa_m)w_m + \kappa_m Tw_m$, $w_{m+1} = (1-\zeta_m)w_m + \zeta_m Tv_m$.
- *S-iteration* [6]: $v_m = (1-\kappa_m)w_m + \kappa_m Tw_m$, $w_{m+1} = (1-\zeta_m)Tw_m + \zeta_m Tv_m$.

Definition 2.3. Let $-A$ be the infinitesimal generator of a C_0-semigroup $\mathfrak{T}(t),\ t \geq 0$, on a Banach space X. The function $x \in B$ given by

$$x(t) = \mathfrak{T}(t)[x_0 - g(x)] + \int_0^t \mathfrak{T}(t-s)f(s,x(s))ds, \quad t \in [t_0, b], \tag{1}$$

is called the mild solution of the problem (A)-(B).

We recall the NIP scheme of Filali et al. [21] [[1], [2]].

Definition 2.4 (New Iteration Process, [21])**.** Let $T : X \to X$, $\{\zeta_m\}, \{\kappa_m\} \subset (0,1)$, and $w_0 \in X$[[1], [2]].. Define, for $m \geq 0$,

$$\begin{cases} u_m = (1-\zeta_m)w_m + \zeta_m T^2 w_m, \\ v_m = (1-\kappa_m)Tw_m + \kappa_m T^2 u_m, \\ w_{m+1} = Tv_m. \end{cases} \tag{NIP}$$

We call $\{w_m\}$ the new iteration process(NIP).

Definition 2.5 (Rate of convergence, [21]). Let $\{u_m\}$ and $\{v_m\}$ be sequences in X converging to the same limit u^*, and suppose there are real sequences $\{\zeta_m\}, \{\eta_m\}$ such that ,for all $m = 1, 2, 3, \cdots$
with $\|u_m - u^*\|_\infty \leq \zeta_m$ and $\|v_m - u^*\|_\infty \leq \eta_m$ for all m.
Then $\{u_m\}$ *converges faster* than $\{v_m\}$ if
$\lim_{m\to\infty} \frac{\zeta_m}{\eta_m} = 0$.

Definition 2.6 (T-stability, [21]). Let $F_m : X \to X$ define an iteration $w_{m+1} = F_m(w_m)$ converging to a fixed point u^* of T. The iteration is *T-stable* if for every sequence $\{x_m\} \subset X$,

$$\lim_{m\to\infty} \|x_m - F_m(x_m)\|_\infty = 0 \iff \lim_{m\to\infty} x_m = u^*.$$

Remark Let $(X, \|\cdot\|.$ be a Banach space and let $T\colon X \to X$ be a contraction: there exists $q \in (0, 1)$. Let $u^* \in X$ denote the unique fixed point of T. For each $m \geq 0$ define the (one-step) operator $Fm\colon X \to X$ by

$$Fm(w) := T((1 - \kappa_m)T_w + \kappa_m T^2((1 - \zeta_m)w + \zeta_m T^2 w)),$$

so that the scheme can be written $w_{m+1} = F_m(w_m)$.

Let us denote

$$L_1 = \max_{t_0 \leq t \leq b} \|f(t, 0)\|,$$
$$G = \max_{x\in B} \|g(x)\|.$$

We list the following hypotheses for our convenience.

(H_1) $g : B \to X$ and there exists a constant $G_1 > 0$ such that

$$\|g(x_1) - g(x_2)\| \leq G_1\|x_1(t) - x_2(t)\|,$$

for $x_1,\ x_2 \in B$.

(H_2) $f : [t_0, b] \times X \times X \to X$ is continuous and there exists constant $L > 0$ such that

$$\|f(t, x_1) - f(t, x_2)\| \leq L\|x_1 - x_2\|,$$

for $t \in [t_0, b]$ and $x_i,\ y_i \in X,\ i = 1, 2$.

(H_3) $-A$ is the infinitesimal generator of a semigroup of bounded linear operators $T(t)$ in X, which is compact for $t > 0$, and there exist constant $M \geq 1$ such that $\|T(t)\| \leq M, \quad t \geq 0$.

3 Main Results

3.1 Strong Convergence and Existence, Uniqueness Of Solutions Via New Iteration Process

Now, we are in a position to state and prove the main theorem which addresses the existence and uniqueness of solutions of the problem nonlinear abstract differential equation (A)-(B) We first prove the main conclusion.

Theorem 3.1. *Suppose that hypotheses* $(\mathcal{H}_1)$-$(\mathcal{H}_3)$ *come together. Assume* $T : X \to X$ *is a contraction on* X *with constant* $q = M(G_1 + L) < 1$ *.Then the equation* (A)-(B) *has at most one solution* $u^* \in C[0,1]$ *which is the required solution and is achieved by the new iteration process (NIP) starting with any element* $w_0 \in X$ *and* $\{w_m\}$ *converges strongly to fixed point* u^* *in* $C[0,1]$ *Moreover for every* $m \geq 0$*,the following bound holds :*

$$\|w_{m+1} - u^*\|_\infty \leq r_m \|w_m - u^*\|_\infty, \tag{2}$$

where $r_m = q^2(1-\kappa_m) + \kappa_m q^3\big(1 - \zeta_m(1-q^2)\big) \leq q^2$*. In particular,*

$$\|w_m - u^*\|_\infty \leq q^{2m}\|w_0 - u^*\|_\infty \longrightarrow 0 \quad as\ m \to \infty.$$

where

$$q = M(G_1 + L) < 1,$$

and $q < 1$.

Proof. We use the Banach contraction principle to prove existence and uniqueness of mild solution to (A)-(B). Let $B = C([0,1]; X)$ be Banach space with norm $\|.\|$.Let $E_r = \{x \in B : \|x\| \leq r \leq 1\}$, where $r \geq [1-(MLb]^{-1}[M(\|x_0\|+G) + ML_1 b]$ with $[MG_1 + MLb] < 1$,be closed and bounded set and define an operator on the Banach space B by

$$(Tx)(t) = \mathfrak{T}(t)[x_0 - g(x)] + \int_0^t \mathfrak{T}(t-s) f(s, x(s)) ds, \quad t \in [0,1], \tag{1}$$

Firstly, we show that the operator F maps E_r into itself. By using hypotheses, we have

$$\begin{aligned}
&\|(Tx)(t)\| \\
&\leq M[\|x_0\| + G] + \int_0^t M\|f\Big(s, x(s)\Big)\|ds \\
&\leq M[\|x_0\| + G] + \int_0^t M\|f\Big(s, x(s)\Big) - f\Big(s,0\Big) + f\Big(s,0\Big)\|ds \\
&\leq M[\|x_0\| + G] + MLbr + ML_1 b \\
&\leq (M[\|x_0\| + G] + + ML_1 b) + MLbr \\
&\leq [1 - (MLb)]r + (MLb)r = r,
\end{aligned} \tag{2}$$

for $x \in E_r$. The above equation shows that the operator T maps E_r into itself.

Now for every $x_1,\ \ x_2 \in E_r$ and $t \in [t_0, b]$, we obtain

$$\begin{aligned}
&\|(Tx_1)(t) - (Tx_2)(t)\| \\
&\leq \|\mathfrak{T}(t)\|\|g(x_1) - g(x_2)\| + \int_{t_0}^t \|\mathfrak{T}(t-s)\Big[f\big(s, x_1(s)\big) - f\big(s, x_2(s)\big)\Big]\|ds \\
&\leq MG_1\|x_1 - x_2\|_\infty + M\int_0^t L\|x_1 - x_2\|ds \\
&\leq \Big[MG_1 + MLb\Big]\|x_1 - x_2\|_\infty. \\
&\leq \Big[M(G_1 + L)\Big]\|x_1 - x_2\|_\infty.
\end{aligned} \tag{3}$$

If we take $q = M(G_1 + L)$, then

$$\|Tx_1 - Tx_2\|_\infty \leq q\|x_1 - x_2\|_\infty$$

with $0 < q < 1$. This shows that the operator T is a contraction on the complete metric space B.

Taking $\sup_{t\in[0,1]}$,

$$\|Tx - Ty\|_\infty \leq q\,\|x - y\|_\infty\,, \qquad x, y \in X. \tag{3}$$

Applying (3) to the pair (Tx, Ty), and then writing out $T^2x = T(Tx)$, $T^2y = T(Ty)$ explicitly via (3),

$$|(T^2x)(t) - (T^2y)(t)| \leq |[\mathfrak{T}(t)]||g(Tx) - g(Ty)| + \int_0^t \mathfrak{T}(t-s)|f(s,(Tx)(s)) - f(s,(Ty)(s))|\,ds,$$

$$\left\|T^2x - T^2y\right\|_\infty \leq q\,\|Tx - Ty\|_\infty\,, \qquad x, y \in X.$$

where $q = M(G_1 + L)$
by the identical chain of estimates applied to $(Tx, Ty) \in X \times X$; combined with (3),

$$\left\|T^2x - T^2y\right\|_\infty \leq q\,\|Tx - Ty\|_\infty \leq q^2\,\|x - y\|_\infty\,, \qquad x, y \in X.$$

Let u^* be the unique fixed point of T. We estimate the error at each sub-step. Since $Tu^* = u^*$, applying T again gives $T^2u^* = u^*$. we have

$$\left\|T^2w_m - T^2u^*\right\|_\infty \leq q\,\|Tw_m - Tu^*\|_\infty \leq q^2\,\|w_m - u^*\|_\infty\,, \qquad w_m, u^* \in X. \tag{4}$$

Step 1 (estimate for $u_m - u^*$). Since $u^* = (1-\zeta_m)u^* + \zeta_m u^* = (1-\zeta_m)u^* + \zeta_m T^2u^*$, subtracting from the definition of u_m,

$$u_m(t) - u^*(t) = (1-\zeta_m)\big[w_m(t) - u^*(t)\big] + \zeta_m\big[(T^2w_m)(t) - (T^2u^*)(t)\big].$$

By the triangle inequality and (4) with $(x, y) = (w_m, u^*)$,

$$\|u_m - u^*\|_\infty \leq (1-\zeta_m)\,\|w_m - u^*\|_\infty + \zeta_m q^2\,\|w_m - u^*\|_\infty = q_u\,\|w_m - u^*\|_\infty\,,. \tag{5}$$

where $q_u = 1 - \zeta_m(1-q^2) \in [q^2, 1]$.
Step 2 (estimate for $v_m - u^*$). Since $u^* = (1-\kappa_m)Tu^* + \kappa_m T^2u^*$ (as $Tu^* = T^2u^* = u^*$), subtracting from the definition of v_m,

$$v_m(t) - u^*(t) = (1-\kappa_m)\big[(Tw_m)(t) - (Tu^*)(t)\big] + \kappa_m\big[(T^2u_m)(t) - (T^2u^*)(t)\big].$$

By (3) with $(x, y) = (w_m, u^*)$ and (4) with $(x, y) = (u_m, u^*)$,

$$\|v_m - u^*\|_\infty \leq (1-\kappa_m)q\,\|w_m - u^*\|_\infty + \kappa_m q^2\,\|u_m - u^*\|_\infty\,.$$

Substituting (5),

$$\|v_m - u^*\|_\infty \leq \Big[(1-\kappa_m)q + \kappa_m q^2 q_u\Big]\,\|w_m - u^*\|_\infty = \theta_m\,\|w_m - u^*\|_\infty\,. \tag{6}$$

The intermediate parameter θ_m and the sub-step contraction factor q_u are defined respectively as $\theta_m = (1-\kappa_m)q + \kappa_m q^2 q_u$, where $q_u = 1 - \zeta_m(1-q^2)$

Step 3 (estimate for $w_{m+1} - u^*$). Since $Tu^* = u^*$, and directly evaluating $(Tv_m)(t) - (Tu^*)(t)$ via (1),

$$|(Tv_m)(t) - (Tu^*)(t)| \le [\mathfrak{T}(t)]|g(v_m) - g(u^*)| + \int_0^t \mathfrak{T}(t-s)|f(s, v_m(s)) - f(s, u^*(s))|\, ds,$$

$$|(Tv_m)(t) - (Tu^*)(t)| \le q \left\| v_m - u^* \right\|_\infty, \qquad x, y \in X.$$

by the same chain as (3), so, using (6),

$$\left\| w_{m+1} - u^* \right\|_\infty \le q \left\| v_m - u^* \right\|_\infty \le q\theta_m \left\| w_m - u^* \right\|_\infty = r_m \left\| w_m - u^* \right\|_\infty, \tag{7}$$

where $r_m = q\theta_m = q^2(1-\kappa_m) + \kappa_m q^3 q_u$, which is exactly (2) (recalling $q_u = 1 - \zeta_m(1-q^2)$). Since $q_u \le 1$,

$$r_m = q^2(1-\kappa_m) + \kappa_m q^3 q_u \le q^2(1-\kappa_m) + \kappa_m q^3 \le q^2(1-\kappa_m) + \kappa_m q^2 = q^2,$$

using $q < 1 \Rightarrow q^3 \le q^2$. Hence $r_m \le q^2 < 1$ for every $m \ge 0$.

Step 4 (explicit unrolling: $q^2, q^4, q^6, q^8, \ldots$, then formal induction). We now make the geometric decay fully explicit rather than invoking induction in one line, since this is where the acceleration of NIP relative to Picard-type schemes (which only attain a single power of q per step) becomes visible term by term.

At $m = 0$: by (7), $\left\| w_1 - u^* \right\|_\infty \le r_0 \left\| w_0 - u^* \right\|_\infty \le q^2 \left\| w_0 - u^* \right\|_\infty$.

At $m = 1$: applying (7) again, now with w_1 in place of w_0,

$$\left\| w_2 - u^* \right\|_\infty \le r_1 \left\| w_1 - u^* \right\|_\infty \le q^2 \left\| w_1 - u^* \right\|_\infty \le q^2\big(q^2 \left\| w_0 - u^* \right\|_\infty\big) = q^4 \left\| w_0 - u^* \right\|_\infty.$$

At $m = 2$:

$$\left\| w_3 - u^* \right\|_\infty \le r_2 \left\| w_2 - u^* \right\|_\infty \le q^2 \left\| w_2 - u^* \right\|_\infty \le q^2\big(q^4 \left\| w_0 - u^* \right\|_\infty\big) = q^6 \left\| w_0 - u^* \right\|_\infty.$$

At $m = 3$:

$$\left\| w_4 - u^* \right\|_\infty \le r_3 \left\| w_3 - u^* \right\|_\infty \le q^2 \left\| w_3 - u^* \right\|_\infty \le q^2\big(q^6 \left\| w_0 - u^* \right\|_\infty\big) = q^8 \left\| w_0 - u^* \right\|_\infty.$$

At $m = 4$: by exactly the same one-step application of (7),

$$\left\| w_5 - u^* \right\|_\infty \le q^2 \left\| w_4 - u^* \right\|_\infty \le q^2\big(q^8 \left\| w_0 - u^* \right\|_\infty\big) = q^{10} \left\| w_0 - u^* \right\|_\infty.$$

The pattern is now unmistakable: each application of (7) multiplies the previous bound by an additional factor of q^2, so that after m applications the exponent of q has grown by $2m$. We record this as a formal claim and prove it by mathematical induction on m, which is the rigorous justification for the pattern observed above.

Claim. $\left\| w_m - u^* \right\|_\infty \le q^{2m} \left\| w_0 - u^* \right\|_\infty$ for every $m \ge 0$.

Base case ($m = 0$): $\left\| w_0 - u^* \right\|_\infty \le q^0 \left\| w_0 - u^* \right\|_\infty = \left\| w_0 - u^* \right\|_\infty$, trivially true with equality.

Inductive step: Suppose the claim holds for some $m \ge 0$, i.e. $\left\| w_m - u^* \right\|_\infty \le q^{2m} \left\| w_0 - u^* \right\|_\infty$. By (7) and $r_m \le q^2$,

$$\left\| w_{m+1} - u^* \right\|_\infty \le r_m \left\| w_m - u^* \right\|_\infty \le q^2 \cdot \left\| w_m - u^* \right\|_\infty \le q^{2(m+1)} \left\| w_0 - u^* \right\|_\infty.$$

By mathematical induction,

$$\left\| w_m - u^* \right\|_\infty \le q^{2m} \left\| w_0 - u^* \right\|_\infty.$$

Because $q \in (0,1)$, $q^{2m} \to 0$ as $m \to \infty$, proving strong convergence of $\{w_m\}$ to u^*. □

3.2 Stability Result

Stability analysis is essential for understanding how robust iterative algorithms are in the presence of computational errors or perturbations. A stable iteration process guarantees a reliable approximation of fixed points even when numerical inaccuracies occur.

Theorem 3.2 (T-stability)**.** *Consider the Banach space X and the contraction mapping T as defined in Theorem 3.1Under the hypotheses $(\mathcal{H}_1)$-$(\mathcal{H}_3)$ holds ,If w_m denotes the sequence generated by the iterative scheme* (NIP)*, and operator composition $w_{m+1} = F_m(w_m)$ with*

$$F_m(w) = \mathfrak{T}[x_0 - g(v_m(w))] + \int_0^t \mathfrak{T}(t-s) f(s, v_m(w)(s))\, ds,$$

where $v_m(w) = (1-\kappa_m)Tw + \kappa_m T^2((1-\zeta_m)w + \zeta_m T^2 w)$,Then iteration $w_{m+1} = F_m(w_m)$ is T-stable in $C[0,1]$.

Proof. **Step 1 (Lipschitz estimates for F_m).** For any functions $x, y \in C[0,1]$, applying the integral operator bounds from Theorem 3.1 gives

$$|(Tv_m)(t) - (Tu^*)(t)| \le [\mathfrak{T}(t)]|g(v_m) - g(u^*)| + \int_0^t \mathfrak{T}(t-s)|f(s, v_m(s)) - f(s, u^*(s))|\, ds,$$

$$|(Tv_m)(t) - (Tu^*)(t)| \le q \left\| v_m - u^* \right\|_\infty,$$

$$\begin{aligned} |(T_m(x))(t) - (T_m(y))(t)| &\le [\mathfrak{T}(t)]|g(v_m) - g(u^*)| + \int_0^t \mathfrak{T}(t-s)|f(s, v_m(s)) - f(s, u^*(s))|\, ds \\ &\le q \left\| v_m - u^* \right\|_\infty \\ &\le q\|v_m(x) - v_m(y)\|_\infty \le r_m \|x-y\|_\infty \le q^2 \|x-y\|_\infty. \end{aligned}$$

Taking supremum over $t \in [0,1]$ gives $\|F_m(x) - F_m(y)\|_\infty \le r_m \|x-y\|_\infty$. Also, $F_m(u^*) = u^*$.

Step 2 ($\Longrightarrow$). Let $\{x_m\} \subset C[0,1]$ be a sequence such that $\lim_{m\to\infty} \|x_m - F_m(x_m)\|_\infty = 0$. By the triangle inequality,

$$\begin{aligned} \|x_m - u^*\|_\infty &\le \|x_m - F_m(x_m)\|_\infty + \|F_m(x_m) - F_m(u^*)\|_\infty \\ &\le \|x_m - F_m(x_m)\|_\infty + r_m \|x_m - u^*\|_\infty. \end{aligned}$$

Rearranging yields $\|x_m - u^*\|_\infty \le \frac{1}{1-q^2}\|x_m - F_m(x_m)\|_\infty$. Taking $m \to \infty$ gives $x_m \to u^*$.

Step 3 ($\Longleftarrow$). Conversely, if $x_m \to u^*$,

$$\|x_m - F_m(x_m)\|_\infty \le \|x_m - u^*\|_\infty + \|F_m(u^*) - F_m(x_m)\|_\infty \le (1+q^2)\|x_m - u^*\|_\infty \longrightarrow 0$$

as $m \to \infty$, proving T-stability. □

3.3 Rate of Convergence Comparison Result

Theorem 3.3 (Rate Comparison)**.** *Let $T : C[0,1] \to C[0,1]$ be the operator defined in proof of Theorem 3.1 with contraction constant $q \in (0,1)$ and solution u^*. Let $\{\zeta_m\}, \{\kappa_m\} \subset (0,1)$ be sequences bounded away from 0 and 1. there is $\delta \in (0, \frac{1}{2})$ such that*

$$\delta \le \zeta_m, \kappa_m \le 1 - \delta, \qquad \forall m \ge 0.$$

Then the NIP sequence $\{w_m\}$ converges to u^* faster than the Picard, Mann, Ishikawa, and S-iteration sequences generated by T from the same w_0.

Proof. By Theorem 3.1, $\|w_m - u^*\|_\infty \le Aq^{2m}$, $A = \|w_0 - u^*\|_\infty$. We derive, from the defining recursions of Section 2 and the contraction bound (3), an explicit one-step (and hence, by induction exactly as in proof of Theorem 3.1 , an explicit m-step) bound for each classical scheme, then compare exponents.

Picard. $p_{m+1} = Tp_m$, so by (3), $\|p_{m+1} - u^*\|_\infty \le q\,\|p_m - u^*\|_\infty$; by induction (base case trivial, inductive step identical in structure to Theorem 3.1 Step 4 but with a single power of q per step), so by induction

$$\|p_m - u^*\|_\infty \le B\,q^m, \qquad B = \|p_0 - u^*\|_\infty.$$

Hence the comparison ratio is

$$\frac{\|w_m - u^*\|_\infty}{\|p_m - u^*\|_\infty} \le \frac{A}{B}\left(\frac{q^2}{q}\right)^m = \frac{A}{B}\,q^m \;\longrightarrow\; 0,$$

since $q \in (0,1)$. Therefore $\{w_m\}$ converges faster than the Picard sequence $\{p_m\}$.

Mann. $m_{m+1} = (1-\zeta_m)m_m + \zeta_m T m_m$. Since $u^* = (1-\zeta_m)u^* + \zeta_m T u^*$,

$$m_{m+1}(t) - u^*(t) = (1-\zeta_m)\big[m_m(t) - u^*(t)\big] + \zeta_m\big[(Tm_m)(t) - (Tu^*)(t)\big],$$

so, by (3), $\|m_{m+1} - u^*\|_\infty \le (1-\zeta_m)\,\|m_m - u^*\|_\infty + \zeta_m q\,\|m_m - u^*\|_\infty = c_m\,\|m_m - u^*\|_\infty$, $c = 1 - \zeta_m(1-q)$;

$$c_m \le c^* = 1 - \delta(1-q) \qquad \forall m,$$

so by induction

$$\|m_m - u^*\|_\infty \le C\,(c^*)^m, \qquad C = \|m_0 - u^*\|_\infty.$$

Moreover

$$c^* - q = (1-q)(1-\delta) > 0 \implies c^* > q > q^2.$$

Hence the comparison ratio is

$$\frac{\|w_m - u^*\|_\infty}{\|m_m - u^*\|_\infty} \le \frac{A}{C}\left(\frac{q^2}{c^*}\right)^m = \frac{A}{C}\left(\frac{q^2}{1-\delta(1-q)}\right)^m \;\longrightarrow\; 0,$$

because $0 < q^2/c^* < 1$. Therefore $\{w_m\}$ converges faster than the Mann sequence $\{m_m\}$.

S-iteration. $v_m = (1-\kappa_m)w_m + \kappa_m T w_m$, $w_{m+1} = (1-\zeta_m)Tw_m + \zeta_m T v_m$. As above, $\|v_m - u^*\|_\infty \le (1-\kappa_m)\,\|w_m - u^*\|_\infty + \kappa_m q\,\|w_m - u^*\|_\infty = [1 - \kappa_m(1-q)]\,\|w_m - u^*\|_\infty$. Since $u^* = (1-\zeta_m)Tu^* + \zeta_m T u^*$ (as $Tu^* = u^*$),

$$w_{m+1}(t) - u^*(t) = (1-\zeta_m)\big[(Tw_m)(t) - (Tu^*)(t)\big] + \zeta_m\big[(Tv_m)(t) - (Tu^*)(t)\big],$$

so, by (3) applied twice,

$$\begin{aligned}||w_{m+1} - u^*||_\infty &\le (1-\zeta_m)q||w_m - u^*||_\infty + \zeta_m q||v_m - u^*||_\infty \\ &\le q\Big[(1-\zeta_m) + \zeta_m\big(1 - \kappa_m(1-q)\big)\Big]||w_m - u^*||_\infty\end{aligned}$$

$$\|w_{m+1} - u^*\|_\infty \le q\big[1 - \zeta_m\kappa_m(1-q)\big]\|w_m - u^*\|_\infty = s_m\|w_m - u^*\|_\infty.$$

Since s_m is decreasing in $\zeta_m\kappa_m \ge \delta^2$,

$$s_m \le s^* = q\big[1 - \delta^2(1-q)\big] \qquad \forall m,$$

so by induction

$$\|s_m - u^*\|_\infty \le D\,(s^*)^m, \qquad D = \|s_0 - u^*\|_\infty.$$

Moreover

$$s^* - q^2 = q(1-q)(1-\delta^2) > 0 \implies s^* > q^2.$$

Hence the comparison ratio is

$$\frac{\|w_m - u^*\|_\infty}{\|s_m - u^*\|_\infty} \le \frac{A}{D}\left(\frac{q^2}{s^*}\right)^m = \frac{A}{D}\left(\frac{q}{1-\delta^2(1-q)}\right)^m \longrightarrow 0,$$

because $0 < q^2/s^* < 1$. Therefore $\{w_m\}$ converges faster than the S-iteration sequence $\{s_m\}$.

Ishikawa. With $v_m = (1-\kappa_m)x_m + \kappa_m T x_m$ and $x_{m+1} = (1-\zeta_m)x_m + \zeta_m T v_m$, (3) gives

$$\|v_m - u^*\|_\infty \le \big[1 - \kappa_m(1-q)\big]\|x_m - u^*\|_\infty,$$

and since $u^* = (1-\zeta_m)u^* + \zeta_m T u^*$,

$$\|x_{m+1} - u^*\|_\infty \le \big[1 - \zeta_m(1-q)(1+q\kappa_m)\big]\|x_m - u^*\|_\infty = r_{I,m}\|x_m - u^*\|_\infty.$$

Since $\zeta_m(1+q\kappa_m)$ is increasing in both ζ_m and κ_m, it attains its minimum at $\zeta_m = \kappa_m = \delta$, so

$$r_{I,m} \le r_I^* = 1 - \delta(1-q)(1+q\delta) \qquad \forall m,$$

hence by induction

$$\|x_m - u^*\|_\infty \le E\,(r_I^*)^m, \qquad E = \|x_0 - u^*\|_\infty.$$

Moreover, since $\delta < 1$ and $q\delta < 1$ imply $\delta(1+q\delta) < 1+q$,

$$r_I^* - q^2 = (1-q)\big[(1+q) - \delta(1+q\delta)\big] > 0 \implies r_I^* > q^2.$$

Hence the comparison ratio is

$$\frac{\|w_m - u^*\|_\infty}{\|x_m - u^*\|_\infty} \le \frac{A}{E}\left(\frac{q^2}{r_I^*}\right)^m = \frac{A}{E}\left(\frac{q^2}{1-\delta(1-q)(1+q\delta)}\right)^m \longrightarrow 0,$$

because $0 < q^2/r_I^* < 1$. Therefore $\{w_m\}$ converges faster than the Ishikawa sequence $\{x_m\}$.

Result. For each classical scheme with one-step factor $\rho \in \{q, c^*, s^*, r_I^*\}$, we have shown $\rho > q^2$ pointwise for every m; since ζ_m, κ_m are bounded away from $0, 1$, ρ is in fact bounded away from q^2 by a fixed gap independent of m (each of c, s, r_I is a continuous, monotone function of $\zeta_m, \kappa_m \in [\delta, 1-\delta]$, attaining its infimum over this compact range at a value still $> q^2$). Hence there is $\rho_{\min} > q^2$ with $\rho \ge \rho_{\min}$ for every m and every scheme, and

$$\lim_{m\to\infty} \frac{Aq^{2m}}{A\rho^m} \le \lim_{m\to\infty}\left(\frac{q^2}{\rho_{\min}}\right)^m = 0,$$

since $q^2/\rho_{\min} < 1$. By Definition 2.5, $\{w_m\}$ converges faster than each of the four classical schemes. □

Remark 3.4. In the constant-parameter case $\zeta_m \equiv \zeta$, $\kappa_m \equiv \kappa$ (so that δ may be taken equal to $\min(\zeta, \kappa) = \max(\zeta, \kappa)$), the ratios above reduce exactly to those implicit in [21]Theorem 4 : q, q^2/c, q/s, q^2/r_I, with $c = 1 - \zeta(1-q)$, $s = q\big[1 - \zeta\kappa(1-q)\big]$, $r_I = 1 - \zeta(1-q)(1+q\kappa)$.

4 Conclusions

We showed that accelerated three-step New Iteration Process (NIP) applies directly to a nonlinear abstract Differential Equation with nonlocal condition establishing existence, uniqueness.We studied the strong convergence, T-stability, and rate-of-convergence properties of NIP relative to the Picard, Mann, Ishikawa, and S-iteration processes and compare the rate of convergence of NIP with the other iterative approaches.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

कृत्रिम बुद्धिमत्ता आणि मराठी भाषा : संधी, आव्हाने व भविष्यातील दिशा

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DOI - 10.5281/zenodo.24339718

सारांश :

एकविसाव्या शतकात विज्ञान आणि माहिती तंत्रज्ञानाच्या क्षेत्रात झालेल्या प्रगतीमुळे मानवी जीवनाच्या विविध क्षेत्रांमध्ये आमूलाग्र बदल घडून आले आहेत. विशेष कृत्रिम बुद्धिमत्तेच्या विकासामुळे शिक्षण, साहित्य, भाषा, संशोधन, आकलन,संवाद, भाषांतर आणि ज्ञाननिर्मिती या क्षेत्रांना नवीन दिशा प्राप्त झालेली दिसून येते. कृत्रिम बुद्धिमत्ता ही संगणकाला मानवी बुद्धिमत्तेशी संबंधित काही कार्ये करण्यास सक्षम करणारी तंत्रज्ञानाधारित प्रणाली आहे. नैसर्गिक भाषा प्रक्रिया, स्वयंचलित भाषांतर, वाणीचे (बोलण्यातून) लेखनात रूपांतर, मजकुराचे विश्लेषण (विशिष्ट पाठ किंवा धडा)आणि मजकूरनिर्मिती या माध्यमांतून कृत्रिम बुद्धिमत्ता भाषिक व्यवहारांमध्ये अनन्य साधारण महत्व प्राप्त झाले आहे.मराठी ही समृद्ध साहित्यिक परंपरा, स्वतंत्र भाषिक वैशिष्ट्ये आणि व्यापक सामाजिक वापर असलेली भारतीय भाषा आहे. तथापि, डिजिटल तंत्रज्ञानाच्या क्षेत्रात मराठी भाषेसाठी अधिकाधिक दर्जेदार भाषिक माहिती, प्रमाणित डिजिटल साधने, बोलीभाषांचे प्रतिनिधित्व (उपभाषा)आणि अचूक भाषिक प्रक्रिया विकसित करण्याची आवश्यकता आहे. या पार्श्वभूमीवर कृत्रिम बुद्धिमत्ता मराठी भाषेच्या विकासासाठी अनेक संधी उपलब्ध करून देते. मराठी भाषेतील भाषांतर, शुद्धलेखन, लेखनसहायक, साहित्याचे डिजिटल जतन, भाषा शिक्षण, संशोधन आणि ज्ञानाचा प्रसार या क्षेत्रांमध्ये तिचा उपयोग होऊ शकतो.दुसरीकडे, कृत्रिम बुद्धिमत्तेद्वारे निर्माण होणाऱ्या माहितीतील त्रुटी, भाषिक संदर्भांचे अपुरे आकलन, बोलीभाषांकडे होणारे दुर्लक्ष, साहित्यिक मौलिकतेचा प्रश्न, कॉपीराइट, गोपनीयता आणि डिजिटल विषमता ही महत्त्वाची आव्हाने आहेत. प्रस्तुत संशोधनात वर्णनात्मक आणि विश्लेषणात्मक पद्धतीचा वापर करून कृत्रिम बुद्धिमत्ता आणि मराठी भाषा यांच्यातील संबंधांचा अभ्यास करण्यात आला आहे. उपलब्ध संदर्भसाहित्य आणि भाषिक तंत्रज्ञानाशी संबंधित संसाधनांच्या आधारे मराठी भाषेच्या संवर्धनासाठी कृत्रिम बुद्धिमत्तेचा जबाबदार, चिकित्सक आणि मानवी दृष्टिकोनातून वापर करण्याची आवश्यकता अधोरेखित करण्यात आली आहे.

बीजशब्द : कृत्रिम बुद्धिमत्ता, मराठी भाषा, नैसर्गिक भाषा प्रक्रिया, डिजिटल साहित्य, स्वयंचलित भाषांतर, भाषिक संवर्धन, डिजिटल मानवविद्या.

प्रस्तावना:

भाषा हे मानवी समाजाच्या सांस्कृतिक, आर्थिक सामाजिक आणि बौद्धिक विकासाचे महत्त्वपूर्ण साधन आहे. भाषा केवळ विचार व्यक्त करण्याचे माध्यम नसून ती समाजाचा इतिहास, संस्कृती, परंपरा, लोकजीवन, सामूहिक स्मृती आणि ज्ञानपरंपरा यांचे जतन करणारी व्यवस्था आहे. प्रत्येक भाषेमध्ये विशिष्ट समाजाचा अनुभवविश्व, जीवनदृष्टी आणि सांस्कृतिक वारसा सामावलेला असतो. त्यामुळे भाषेचे संवर्धन आणि विकास ही केवळ भाषिक बाब नसून सामाजिक आणि सांस्कृतिक विकासाचीही महत्त्वाची

प्रक्रिया आहे. मराठी भाषेला संतसाहित्य, भक्तिसाहित्य, लोकसाहित्य, शाहिरी परंपरा, आधुनिक कविता, कथा, कादंबरी, नाटक, समीक्षा आणि वैचारिक साहित्य यांची समृद्ध परंपरा लाभली आहे. संत ज्ञानेश्वर, संत नामदेव, संत एकनाथ, संत तुकाराम, महात्मा ज्योतिबा फुले, लोकहितवादी, महात्मा गांधी, डॉ. बाबासाहेब आंबेडकर, कुसुमाग्रज, पु. ल. देशपांडे आणि अनेक साहित्यिक व विचारवंतांनी मराठी भाषेच्या वैचारिक आणि सांस्कृतिक विकासात महत्त्वपूर्ण योगदान दिले आहे. आजच्या डिजिटल युगात भाषेच्या वापराचे स्वरूप बदलत आहे. इंटरनेट, समाजमाध्यमे, ई-पुस्तके, डिजिटल ग्रंथालये, ऑनलाइन शिक्षण आणि कृत्रिम बुद्धिमत्तेवर आधारित साधनांमुळे भाषेचा वापर पारंपरिक मुद्रित माध्यमांपुरता मर्यादित राहिलेला नाही. या बदलत्या परिस्थितीत कृत्रिम बुद्धिमत्ता ही भाषेच्या अभ्यासासाठी आणि वापरासाठी महत्त्वाची तंत्रज्ञानप्रणाली म्हणून पुढे आली आहे. तिच्या साहाय्याने मजकूर तयार करणे, प्रश्नांची उत्तरे मिळवणे, भाषांतर करणे, माहितीचे वर्गीकरण करणे, भाषिक नमुन्यांचे विश्लेषण करणे आणि वाणीचे लेखनात रूपांतर करणे शक्य होते.भारत सरकारच्या भाषिक तंत्रज्ञानविषयक BHASHINI उपक्रमामध्ये विविध भारतीय भाषांमधील भाषिक अडथळे कमी करण्यासाठी भाषांतर, वाणी आणि इतर भाषा-तंत्रज्ञान सेवांचा विकास केला जात आहे. त्यामुळे मराठी भाषेच्या संदर्भात कृत्रिम बुद्धिमत्तेचा अभ्यास करणे आवश्यक ठरते. या तंत्रज्ञानाचा उपयोग मराठी भाषेचा प्रसार, भाषिक ज्ञानाचे जतन, साहित्याचे विश्लेषण आणि अध्यापनाची गुणवत्ता सुधारण्यासाठी कसा करता येईल, याचा चिकित्सक विचार प्रस्तुत संशोधनात करण्यात आला आहे.शिक्षणाच्या क्षेत्रात कृत्रिम बुद्धिमत्ता विद्यार्थ्यांना विषय समजावून सांगणे, सरावासाठी प्रश्न तयार करणे, कठीण संकल्पना सोप्या भाषेत स्पष्ट करणे आणि लेखनाचा प्राथमिक मसुदा तयार करणे यांसाठी उपयोगी ठरू शकते.

संशोधनाची पार्श्वभूमी:

डिजिटल तंत्रज्ञानाच्या प्रारंभीच्या टप्प्यात भारतीय भाषांसाठी संगणकावर मजकूर लिहिणे, साठवणे आणि प्रकाशित करणे ही प्रमुख आव्हाने होती. पुढे युनिकोड, डिजिटल फॉन्ट, ऑनलाइन प्रकाशन आणि स्मार्टफोनच्या प्रसारामुळे भारतीय भाषांचा डिजिटल वापर वाढला.सध्याच्या टप्प्यात कृत्रिम बुद्धिमत्तेवर आधारित प्रणाली भाषेचा अर्थ समजून घेण्याचा, मजकूर तयार करण्याचा आणि विविध भाषांमध्ये माहिती पोहोचवण्याचा प्रयत्न करतात. यामुळे मराठी भाषेच्या विकासासाठी नवीन शक्यता निर्माण झाल्या आहेत.मात्र, इंग्रजीसारख्या भाषांच्या तुलनेत मराठीसाठी उपलब्ध असलेल्या डिजिटल माहितीचे प्रमाण, माहितीची गुणवत्ता, भाषिक विविधता आणि तांत्रिक साधनांची उपयुक्तता यांचा स्वतंत्रपणे अभ्यास करणे आवश्यक आहे. कृत्रिम बुद्धिमत्तेचा वापर वाढत असताना मराठी भाषेची स्वायत्तता, सांस्कृतिक वैशिष्ट्ये आणि साहित्यिक परंपरा जतन करणेही तितकेच महत्त्वाचे आहे .

संशोधनाची उद्दिष्टे:

१. कृत्रिम बुद्धिमत्तेची संकल्पना आणि भाषिक क्षेत्रातील महत्त्व स्पष्ट करण्यात मदत करणे.
२. मराठी भाषेच्या विकासासाठी कृत्रिम बुद्धिमत्तेमुळे निर्माण होणाऱ्या संधींचा अभ्यास करणे.
३. मराठी भाषेतील भाषांतर, लेखन, वाचन आणि भाषा शिक्षणातील कृत्रिम बुद्धिमत्तेच्या उपयोगांचे विश्लेषण करणे.

४. मराठी साहित्याच्या डिजिटल जतनासाठी आणि अभ्यासासाठी कृत्रिम बुद्धिमत्तेची उपयुक्तता स्पष्ट करणे.

५. मराठी भाषेतील कृत्रिम बुद्धिमत्तेच्या वापरासमोरील भाषिक, तांत्रिक, प्रादेशिक आणि सामाजिक आव्हानांचा अभ्यास करणे.

संशोधन पद्धती :

वर्णनात्मक आणि विश्लेषणात्मक संशोधन पद्धती:

एखाद्या विद्यार्थ्याला इंग्रजीतील शैक्षणिक लेख समजून घ्यायचा असल्यास त्याचा मराठीत प्राथमिक अनुवाद करून घेता येतो. त्याचे भाषांतर करताना मानवी भाषिक कौशल्य महत्त्वाचे ठरते.या अभ्यासात कृत्रिम बुद्धिमत्ता, भारतीय भाषांसाठी विकसित होणारी भाषिक तंत्रज्ञाने, मराठी भाषेचा डिजिटल वापर, भाषा शिक्षण आणि साहित्याच्या डिजिटल जतनाशी संबंधित उपलब्ध संदर्भांचा विचार केला आहे. कृत्रिम बुद्धिमत्ता म्हणजे संगणकीय प्रणालींना मानवी बुद्धिमत्तेशी संबंधित काही कार्ये करण्यास सक्षम करणारे तंत्रज्ञान आहे.माहितीचे विश्लेषण, नमुने ओळखणे, भाषेवर प्रक्रिया करणे, प्रश्नांची उत्तरे तयार करणे आणि विशिष्ट उद्दिष्टांसाठी अंदाज किंवा सूचना देणे अशा कामांसाठी तिचा उपयोग केला जातो. मशीन लर्निंग, डीप लर्निंग. मजकुरातील प्रमुख कल्पना ओळखणे. माहितीतील नमुन्यांच्या आधारे नवीन मजकूर, चित्र, किंवा इतर गोष्टीं(सामग्री) निर्माण करू शकणाऱ्या प्रणालींसाठी वापरली जाणारी संज्ञा आहे. अशा प्रणालींचा उपयोग मराठी भाषेत निबंधाचा आराखडा तयार करणे, विषय समजावून सांगणे, भाषांतराचा प्राथमिक मसुदा तयार करणे आणि अभ्यासासाठी प्रश्न तयार करणे यांसाठी करता येतो. मात्र, या प्रणालींचे उत्तर नेहमीच तथ्यात्मकदृष्ट्या अचूक असेल असे नाही.

मराठी साहित्याच्या संशोधनात कृत्रिम बुद्धिमत्ता:

मराठी भाषा शिक्षण: व्याकरणातील संकल्पनांची उदाहरणांसह माहिती तयार करणे.कवितेचा आशय समजून घेण्यासाठी प्रश्न तयार करणे.गद्य उताऱ्यावर आधारित आकलन प्रश्न तयार करणे. विद्यार्थ्यांसाठी भाषिक सराव तयार करणे. निबंधलेखनासाठी मुद्दे आणि आराखडा तयार करणे. विद्यार्थ्यांच्या लेखनातील सामान्य चुका ओळखण्यास मदत घेणे. मराठी भाषेतील कठीण साहित्यिक संकल्पनांचे स्पष्टीकरण मिळवणे.

मराठी साहित्याचे डिजिटल जतन: मराठी पुस्तके, नियतकालिके, हस्तलिखिते, दुर्मीळ ग्रंथ आणि ऐतिहासिक दस्तऐवजांच्या यांपैकी काही साहित्य कालांतराने खराब होण्याची शक्यता असते. त्यामुळे त्याचे डिजिटल स्वरूपात जतन करणे महत्त्वाचे ठरते. जुन्या मराठी ग्रंथाची स्कॅन केलेली प्रत उपलब्ध असल्यास OCR (Optical Character Recognition) तंत्रज्ञानाच्या साहाय्याने त्यातील मजकूर संगणकीय स्वरूपात आणण्याचा प्रयत्न करता येतो.मात्र, जुन्या छपाईतील अक्षरे, मोडी लिपी, खराब झालेली पाने आणि विशेष शब्दरचना यांमुळे चुका होऊ शकतात. त्यामुळे डिजिटल मजकुराचे मानवी परीक्षण आवश्यक आहे.

मराठी बोलीभाषांचे दस्तऐवजीकरण: मराठी भाषेच्या विविध प्रादेशिक रूपांमध्ये खानदेशी, अहिराणी, वऱ्हाडी, मालवणी, आगरी आणि इतर बोलीरूपांचा समावेश होतो. या भाषिक रूपांमध्ये विशिष्ट शब्दसंपत्ती, उच्चार, वाक्प्रचार आणि सांस्कृतिक अनुभव दिसून येतात.बोलीभाषांतील ध्वनिमुद्रणांचे लिप्यंतरण, शब्दसंग्रहाचे संकलन आणि भाषिक वैशिष्ट्यांचे विश्लेषण करण्यास मदत मिळू शकते. खानदेशातील लोकगीते, लोककथा, म्हणी आणि वाक्प्रचार यांचे ध्वनिमुद्रण करून त्यांचे डिजिटल दस्तऐवजीकरण

करता येऊ शकते.यामुळे भाषिक विविधतेचे जतन करण्यासाठी नवीन संधी निर्माण होतात.

मराठी भाषेचा जागतिक प्रसार: डिजिटल माध्यमांमुळे मराठी भाषा महाराष्ट्राबाहेरील आणि परदेशातील वाचकांपर्यंत पोहोचवता येते. मराठीतील लेख, कविता, सांस्कृतिक माहिती आणि साहित्यिक चर्चा डिजिटल माध्यमांवर उपलब्ध करून दिल्यास मराठी भाषेचा प्रसार वाढण्यास मदत होऊ शकते. कृत्रिम बुद्धिमत्तेच्या साहाय्याने मराठीतील निवडक साहित्याचा इतर भाषांमध्ये प्राथमिक अनुवाद करता येतो. त्यामुळे मराठी साहित्याचा परिचय अधिक व्यापक वाचकवर्गाला करून देण्याच्या संधी निर्माण होतात. मात्र, भाषांतरित साहित्यामध्ये मूळ साहित्याचा आशय, भावनिक परिणाम आणि सांस्कृतिक संदर्भ जपणे आवश्यक आहे.

शैक्षणिक संशोधन आणि संदर्भशोध: संशोधन करताना संबंधित पुस्तके, संशोधन लेख, अहवाल आणि आधीच्या अभ्यासांचा आढावा घेणे आवश्यक असते. कृत्रिम बुद्धिमत्तेच्या मदतीने संशोधनाच्या विषयाशी संबंधित संभाव्य उपविषय निश्चित करणे, संशोधन प्रश्न तयार करणे आणि उपलब्ध मजकुराचा प्राथमिक सारांश तयार करणे. मराठी विषयाच्या संशोधकांना पुढील कामांसाठी मदत मिळू शकते. कृत्रिम बुद्धिमत्ता कधीकधी अस्तित्वात नसलेले संदर्भ, चुकीची लेखक नावे किंवा चुकीचे प्रकाशन तपशील देऊ शकते. त्यामुळे प्रत्येक संदर्भ मूळ पुस्तक, नियतकालिक किंवा अधिकृत स्रोतामधून पडताळणे अत्यावश्यक आहे.

मराठी भाषेतील कृत्रिम बुद्धिमत्तेची प्रमुख आव्हाने:

भाषिक माहितीची गुणवत्ता आणि उपलब्धता: कृत्रिम बुद्धिमत्तेच्या अनेक प्रणालींना प्रशिक्षणासाठी मोठ्या प्रमाणातील डिजिटल माहितीची आवश्यकता असते. त्या माहितीचे प्रमाण, गुणवत्ता आणि विविधता या बाबी प्रणालीच्या कामगिरीवर परिणाम करतात. मराठी भाषेसाठी पुस्तके, नियतकालिके, संशोधन लेख, लोकसाहित्य, बोलीभाषा, संवाद आणि विविध विषयांवरील मजकूर यांचे दर्जेदार डिजिटल संकलन विकसित करण्याची गरज आहे.

मराठी व्याकरण आणि भाषिक संदर्भ: एखाद्या म्हणीचा शब्दशः अर्थ आणि प्रत्यक्ष वापरातील अर्थ वेगवेगळे असू शकतात.त्यामुळे मराठीतील व्याकरण आणि सांस्कृतिक संदर्भ समजून घेण्यासाठी भाषिकदृष्ट्या संवेदनशीलता आवश्यक असते.

कृत्रिम बुद्धिमत्तेकडून निर्माण होणाऱ्या चुकीच्या माहितीचा प्रश्न: काही माहिती चुकीची, अपूर्ण किंवा संदर्भहीन असू शकते. मराठी साहित्याच्या अभ्यासात याचे विशेष महत्त्व आहे..एखाद्या कवितेचा कवी, प्रकाशनवर्ष, साहित्यिक प्रवाह किंवा एखाद्या ग्रंथातील संदर्भ चुकीचा दिला गेल्यास संशोधनाच्या निष्कर्षांवर परिणाम होऊ शकतो. दिलेल्या माहितीची प्राथमिक सूचना म्हणून दखल घ्यावी; अंतिम सत्य म्हणून स्वीकार करू नये.

बोलीभाषा आणि भाषिक विविधतेकडे दुर्लक्ष: प्रमाण मराठी आणि बोली मराठी यांच्यात शब्दसंपत्ती, उच्चार, व्याकरण आणि अभिव्यक्तीच्या पद्धतींमध्ये फरक असू शकतो. यामुळे मराठी भाषेच्या विविधतेचे अपुरे प्रतिनिधित्व होण्याची शक्यता असते. म्हणून कृत्रिम बुद्धिमत्तेच्या विकासात प्रादेशिक भाषा, लोकसाहित्य आणि बोलीभाषांमधील माहितीचा समावेश करणे आवश्यक आहे.

साहित्यिक मौलिकतेचा प्रश्न: साहित्यनिर्मिती ही केवळ शब्दांची मांडणी नव्हे. ती लेखकाच्या अनुभवविश्वातून, समाज जागृतीतून कल्पनाशक्तीतून आणि कलात्मक दृष्टिकोनातून आकार घेते. कृत्रिम बुद्धिमत्तेच्या मदतीने

कविता, कथा, निबंध किंवा लेखांचे प्राथमिक मसुदे तयार करता येतात.

निष्कर्ष:

एकविसाव्या शतकातील माहिती आणि तंत्रज्ञानाच्या विकासामुळे मानवी जीवनाच्या विविध क्षेत्रांमध्ये कृत्रिम बुद्धिमत्तेचा वापर वाढत आहे. भाषा, साहित्य, शिक्षण, संशोधन आणि ज्ञाननिर्मिती या नवीन शक्यता निर्माण करत आहे. तथापि, मराठी साहित्याच्या डिजिटल जतनाच्या दृष्टीनेही कृत्रिम बुद्धिमत्तेला महत्त्व आहे. जुन्या ग्रंथांचे डिजिटल स्वरूपात रूपांतर, सामग्रीचे वर्गीकरण आणि मोठे मजकुराचे विश्लेषण या प्रक्रियांना संबंधित तंत्रज्ञानाची मदत मिळू शकते. विशेषता मराठीतील दुर्मीळ ग्रंथ, नियतकालिके, हस्तलिखिते, लोकगीते, लोककथा, यांचे दस्तऐवजीकरण करण्यासाठी डिजिटल तंत्रज्ञानाचा नियोजनबद्ध वापर करता येतो. यामुळे मराठी भाषेच्या साहित्यिक आणि सांस्कृतिक वारशाचे जतन करण्यासाठी नवीन मार्ग उपलब्ध होता मराठी भाषेच्या विकासाचा विचार करताना तिच्या प्रादेशिक आणि सामाजिक विविधतेकडे लक्ष देणे आवश्यक आहे. खानदेशी, अहिराणी, वऱ्हाडी, मालवणी, आगरी आणि इतर बोलीरूपांमध्ये स्थानिक जीवनानुभव, स्वतंत्र शब्दसंपत्ती आणि सांस्कृतिक वैशिष्ट्ये आढळतात. मात्र, या प्रक्रियेत स्थानिक भाषिकांचे ज्ञान, उच्चारांची वैशिष्ट्ये आणि सांस्कृतिक संदर्भ यांचा मानसन्मान राखणे आवश्यक आहे. मराठी व्याकरणाचे आकलन, म्हणी आणि वाक्प्रचारांचे संदर्भाधारित अर्थ, बोलीभाषांचे प्रतिनिधित्व आणि साहित्यिक आशयाचे अचूक आकलन या बाबतीत तांत्रिक प्रणालींकडून चुका होऊ शकतात. . साहित्यनिर्मितीच्या क्षेत्रात कृत्रिम बुद्धिमत्तेचा वापर करताना मानवी कल्पनाशक्ती, लेखकाचा वैयक्तिक अनुभव, भाषिक शैली, साहित्यिक मौलिकता आणि बौद्धिक संपदेचे संरक्षण या बाबींचा विचार करावा लागतो. त्यामुळे शैक्षणिक प्रामाणिकता, संदर्भांचा योग्य वापर आणि तंत्रज्ञानाच्या वापराबाबत पारदर्शकता राखणे महत्त्वाचे आहे. मराठी भाषेच्या तंत्रज्ञानाधारित विकासासाठी दर्जेदार डिजिटल भाषिक माहितीचे संकलन, प्रमाणित शब्दसंग्रहाची निर्मिती, मराठी भाषेसाठी भारत सरकारचा BHASHINI उपक्रम आणि भारतीय भाषांसाठी विकसित केलेली IndicTrans2 सारखी भाषांतर प्रणाली ही भारतीय भाषांमधील भाषिक तंत्रज्ञानाच्या विकासाची महत्त्वपूर्ण उदाहरणे आहेत. तथापि, अशा साधनांची मराठी भाषेतील अचूकता, उपयुक्तता आणि मराठीच्या विविध भाषिक संदर्भांतील कामगिरी यांचे स्वतंत्रपणे परीक्षण करणे गरजेचे आहे. विकासासाठी, प्रसारासाठी, अध्ययनासाठी आणि या तंत्रज्ञानाचा वापर मानवी विचारशक्ती, भाषिक जाण, सांस्कृतिक संवेदनशीलता आणि चिकित्सक दृष्टिकोन यांच्या समन्वयाने केल्यास मराठी भाषेच्या डिजिटल विकासाला चालना मिळू शकते.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Economic and Social Consequences of Unnecessary and Unproductive Expenditure in Rural India

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DOI - 10.5281/zenodo.24339744

Abstract:

India is considered a country of villages. Even though there has been tremendous progress in science and technology, the contribution of the agricultural sector and rural areas has always been important in the rural and overall economy of the country.

In rural areas, along with the increase in income in society over time, the amount of unnecessary non-productive expenditure has also increased significantly. Because instead of investing the income received in the development of the agricultural sector, children's education or health, a large portion of the income is spent on weddings that occur once in a lifetime, religious festivals throughout the year, extravagant gambling and ostentatiousness and addictions. Due to this, the majority of families in rural India are getting trapped in the cycle of debt, which is creating a major obstacle in sustainable social and economic development. Due to many such reasons, the amount of unproductive expenditure is found to have increased in rural areas compared to productive expenditure. Also, instead of creating capital from income, debt or savings, the largest portion of rural family income is spent on meaningless and unproductive social customs, traditions, ostentatiousness and often addictions. For this reason, this research paper has proposed unnecessary financial expenditure, waste of capital in rural areas and its detailed classification, comparative analysis and measures to improve it.

Major Classifications of Unproductive Costs:

In most parts of rural India, the highest unnecessary expenditure is seen in areas related to the following four factors:

1. Various religious festivals, ceremonies and celebrations: People spend more than their means on pilgrimages, religious weeks and religious rituals related to various religions in the village, out of superstition or the feeling that they are doing it for the gods and goddesses.
2. **Various social functions:** In rural areas, different types of social ceremonies are celebrated in a very grand and divine manner according to customs and traditions or to maintain the prestige in the society or to show social dominance. Basically, without considering the original purpose or objective of the social ceremony, a huge amount is spent only on attractive and showy things. This includes the birth anniversary or death anniversary of various great men, various social ceremonies.
3. **Showy and grand wedding ceremonies and receptions:** Nowadays, if there is any part of the country where the most unnecessary and noisy expenses are incurred, then the wedding ceremony is at

the top. This includes wedding decorations, various unnecessary but modern and attractive events, various unnecessary and rich dishes on the plate, various items that show people their pomp and wealth, as well as Lakhs of rupees are unnecessarily spent or wasted on various things like dowry system, extravagant wedding reception, expensive catering, loud bands and DJs, and digital banners that showcase the prestige of the wedding families.

4. **Addictions and bad habits:** In rural areas, many families or heads of families, and during the attack, even young children, are seen to be addicted to various addictions. This includes drinking alcohol, gambling like cards and betting, tobacco and gutkha, which have adverse effects on health. The family has to bear a huge financial burden on the income of these addicted individuals.
5. **Misuse of Loan:** Nowadays, various types of loans are easily available. Due to various government schemes, bank policies, competition among financial institutions and advancement in technology, getting loans has become easier. But in rural areas loans taken for agricultural sector or for agricultural improvement or agricultural gold loan, loans taken for technical matters in the field, for agricultural mechanization or for agricultural development are not used in agriculture but are used for weddings or for household luxuries. Loans taken for employment growth in rural areas, for various micro and small industries or for business are also used for purchasing personal luxuries, wedding ceremonies, religious or social ceremonies or for various inappropriate reasons. Due to this, the burden and stress of debt increases instead of being used for productive work.
6. **Unnecessary house construction:** Like in cities, in rural areas too, when constructing houses, unnecessary extra amenities and facilities are considered. Huge houses are built by taking huge loans. This is accompanied by many reasons like jealous claims, how my house is bigger and better than that of people in our society, and more showiness than necessary. Also, in such sophisticated homes, a huge amount of money is spent on various things such as large amounts of attractive furniture, various types of lighting, and extremely expensive souvenirs.
7. **Imitation of modern urban and foreign culture:** Following the practices developed in the city or in foreign cultures, a large portion of the money is spent on these imitations, even if it is borrowed, out of the belief that each family member should have a separate room in the house, that each room should have modern amenities, that each should have a separate bathroom and toilet, and that each room should have a separate TV.

The comparison between productive and unproductive costs can be clarified on the basis of the following points:

The following table illustrates how both productive and unproductive expenditure impacts the economic performance of rural households in the country:

Table 1 the comparison between productive and unproductive costs

Criteria	Productive Expenditure	Unproductive Expenditure
Main objective	Innovate. Invest in sustainable income generating products, increase knowledge and experience, save and create capital from it.	Grand wedding ceremonies, various social and religious ceremonies, various political banner displays, and events celebrated by competing with each other in the village.
Examples:	Quality modern and higher education, health insurance, modern technology in agriculture, small scale industries.	Ceremonies like Marriage, baby shower, mehndi function, Birthday celebration, festivals etc.
Long-term results:	Productive spending increases income, creates capital, creates employment, raises the economic standard of the family and society, and eliminates poverty by increasing employment in our area.	Due to this, the family is always under mental stress. A large part of the income goes to repaying the debt. Generation after generation, they are pushed into the pit of moneylender or bank loans. Sometimes they even become addicted. Temporary ostentatious social prestige and false prestige and pressure are created.
Financial Return (ROI)	Sustainable income provides continuous financial profit. It can be used to make new investments and generate new income from them.	The economic return is zero. No income is generated from productive expenditure. Debt only increases. Borrowing for various reasons results in another loan being taken to repay one loan. This increases mental stress. And many opportunities for progress cannot be realized simply because of lack of savings.

Socio-Economic Analysis of The Mentality in Rural India:

This unnecessary spending in rural India is not only due to ostentation but also due to certain social and psychological factors, such as:

- **Status Anxiety:** There is a huge competition among ourselves. Out of jealousy, how are we bigger than other people in our society, i.e. neighbors, relatives, friends, various people in the society, how can we show off our wealth and prestige everywhere, how can our program be big, large amounts of debt are taken out and spent in rural areas.
- **Advanced Gazettes:** Like Modern and expensive Smartphones. Their recharges.
- **Cultural customs and traditions:** People have to celebrate certain events even without wanting to, fearing what society will say if they break the various customs and traditions that have been followed since ancient times (Social Exclusion). Often, they have to spend excessively for it. This includes various religious festivals, social customs in the family, various festivals celebrated in the village, and various ceremonies created for fashion. Such expenses increase.
- **Lack of financial literacy:** Lack of planning while making productive expenditure, proper division or planning of income, proper and complete knowledge about the various investment options

available for increasing income, which of them provide fixed income, which options will be profitable in the future has not reached the rural areas of India. Due to this, everyone runs after the same business or in the same field of work. As a result, competition increases.

Solutions and Corrective Approaches:

To pull rural India out of this unnecessary social and economic abyss, the following institutional and social measures are needed:

• **Encouragement of collective ceremonies:** Various types of ceremonies are held in every family and every society or among relatives. Various types of traditional and religious programs are also held. If all such ceremonies are held collectively and economically, the expenditure on regressive customs and traditions in the villages will be greatly reduced, therefore a movement of collective ceremonies should be created.

• **Skill Development for Youth:** It is necessary to divert the attention of the youth in rural areas away from unnecessary politics, political party agendas and policies and addictions and towards higher education, competitive exams, jobs, business and entrepreneurship.

• **Financial literacy campaigns**: Various government initiatives and schemes, banks and social organizations should implement financial literacy programs and activities for women and men in rural areas. Due to this, every rural family can make proper planning regarding family income and production, future provisions, savings and capital formation from it.

Conclusion:

If rural India is to be developed, it will not happen only through various government schemes, government subsidies or loan waivers. For this, by acquiring financial literacy, avoiding unnecessary and unproductive expenditure on various social, religious and family functions, and spending the same money on education, health, trade, business and agricultural development and modernization, the rural Indian economy will not achieve stability. Along with social transformation, financial literacy is the real need of today's rural areas.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

महात्मा गांधी राष्ट्रीय ग्रामीण रोजगार हमी योजना व ग्रामीण विकास : स्थानिक प्रशासनाच्या भूमिकेचा अभ्यास (जळगाव जिल्ह्यातील रावेर तालुक्याच्या संदर्भात)

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DOI - 10.5281/zenodo.24339763

सारांश (Abstract):

महात्मा गांधी राष्ट्रीय ग्रामीण रोजगार हमी योजना ही भारतातील ग्रामीण भागातील आर्थिक व सामाजिक विकासाला चालना देणारी एक महत्त्वपूर्ण योजना आहे. ग्रामीण भागातील बेरोजगारी कमी करणे, ग्रामीण कुटुंबांना रोजगाराची संधी उपलब्ध करून देणे, ग्रामीण मजुरांचे उत्पन्न वाढविणे आणि ग्रामीण पायाभूत सुविधांचा विकास करणे ही या योजनेची प्रमुख उद्दिष्टे आहेत. या योजनेच्या प्रभावी अंमलबजावणीमध्ये स्थानिक प्रशासनाची भूमिका अत्यंत महत्त्वाची असते. ग्रामपंचायत, ग्रामसभा, पंचायत समिती, जिल्हा परिषद आणि संबंधित प्रशासकीय यंत्रणा यांच्या समन्वयातून योजनेची अंमलबजावणी केली जाते.प्रस्तुत संशोधनामध्ये जळगाव जिल्ह्यातील रावेर तालुक्याच्या संदर्भात महात्मा गांधी राष्ट्रीय ग्रामीण रोजगार हमी योजनेचा ग्रामीण विकासावर होणारा परिणाम आणि योजनेच्या अंमलबजावणीतील स्थानिक प्रशासनाची भूमिका अभ्यासण्याचा प्रयत्न करण्यात आला आहे. रोजगार उपलब्धता, ग्रामीण कुटुंबांचे उत्पन्न, महिला सहभाग, स्थलांतर, जलसंधारण, मृदसंधारण आणि ग्रामीण पायाभूत सुविधांचा विकास या घटकांचा अभ्यास या संशोधनात महत्त्वाचा आहे. त्याचबरोबर रोजगाराची मागणी नोंदविणे, कामांचे नियोजन करणे, लाभार्थ्यांची निवड, मजुरीचे वेळेवर वितरण, पारदर्शकता आणि सामाजिक लेखापरीक्षण यांसारख्या बाबींचाही विचार करण्यात आला आहे.या संशोधनात असे गृहीत धरण्यात आले आहे की, स्थानिक प्रशासनाची कार्यक्षमता आणि महात्मा गांधी राष्ट्रीय ग्रामीण रोजगार हमी योजनेची परिणामकारकता यांच्यात सकारात्मक संबंध आहे. योजनेचा अपेक्षित लाभ ग्रामीण कुटुंबांपर्यंत पोहोचविण्यासाठी प्रशासकीय पारदर्शकता, लोकसहभाग, प्रभावी नियोजन आणि उत्तरदायित्व आवश्यक आहे. प्रस्तुत संशोधन ग्रामीण रोजगार हमी योजनेच्या अंमलबजावणीतील समस्या ओळखून ग्रामीण विकास अधिक प्रभावी करण्यासाठी उपाययोजना सुचविण्याचा प्रयत्न करते.

बीजशब्द: महात्मा गांधी राष्ट्रीय ग्रामीण रोजगार हमी योजना, ग्रामीण विकास, स्थानिक प्रशासन, ग्रामपंचायत, रोजगार, लोकसहभाग, रावेर तालुका.

प्रस्तावना (Introduction):

भारत हा कृषिप्रधान देश असून देशातील मोठ्या लोकसंख्येचे जीवनमान ग्रामीण अर्थव्यवस्थेवर अवलंबून आहे. ग्रामीण भागातील रोजगाराच्या मर्यादित संधी, हंगामी बेरोजगारी, अपुरे उत्पन्न, शेतीवरील अवलंबित्व आणि ग्रामीण भागातून शहरी भागाकडे होणारे स्थलांतर या समस्या ग्रामीण विकासाच्या प्रक्रियेत अडथळे निर्माण करतात. या समस्यांवर उपाय म्हणून केंद्र व राज्य शासन

विविध ग्रामीण विकास योजना राबवितात. त्यापैकी महात्मा गांधी राष्ट्रीय ग्रामीण रोजगार हमी योजना ही ग्रामीण कुटुंबांना रोजगाराची हमी देणारी एक महत्त्वाची योजना आहे.राष्ट्रीय ग्रामीण रोजगार हमी कायदा २००५ अंतर्गत ही योजना सुरू करण्यात आली आणि २००६ पासून तिची टप्प्याटप्प्याने अंमलबजावणी करण्यात आली. या कायद्यांतर्गत पात्र ग्रामीण कुटुंबातील प्रौढ सदस्यांनी अकुशल अंगमेहनतीच्या कामाची मागणी केल्यास, संबंधित नियम व अटींनुसार एका आर्थिक वर्षात किमान १०० दिवसांच्या मजुरीच्या रोजगाराची हमी देण्याची तरतूद आहे.या योजनेचा उद्देश केवळ ग्रामीण मजुरांना रोजगार उपलब्ध करून देणे एवढाच मर्यादित नाही. ग्रामीण भागातील नैसर्गिक साधनसंपत्तीचे संवर्धन, जलसंधारण, मृदसंधारण, सिंचन सुविधांचा विकास, ग्रामीण रस्ते आणि सार्वजनिक मालमत्तांची निर्मिती यांनाही या योजनेत महत्त्व दिले जाते. त्यामुळे रोजगारनिर्मितीबरोबरच ग्रामीण अर्थव्यवस्थेची उत्पादकता वाढविण्यासही मदत होऊ शकते.या योजनेची परिणामकारकता मोठ्या प्रमाणात स्थानिक प्रशासनाच्या कार्यक्षमतेवर अवलंबूनअसते.ग्रामपंचायतीकडून कामांचे नियोजन, ग्रामसभेमध्ये प्रस्तावांची चर्चा, रोजगार मागणीची नोंद, कामांचे वाटप, मजुरी देयकांची प्रक्रिया आणि सामाजिक लेखापरीक्षण या बाबी योग्य पद्धतीने पार पडणे आवश्यक असते.जळगाव जिल्ह्यातील रावेर तालुका हा कृषी क्षेत्राच्या दृष्टीने महत्त्वाचा तालुका आहे. या भागातील ग्रामीण कुटुंबांच्या आर्थिक स्थितीचा, रोजगाराच्या संधींचा आणि स्थानिक प्रशासनाच्या कार्यपद्धतीचा विचार करता रोजगार हमी योजनेचा अभ्यास महत्त्वपूर्ण ठरतो. प्रस्तुत संशोधनात रावेर तालुक्याच्या संदर्भात या योजनेची ग्रामीण विकासातील भूमिका आणि स्थानिक प्रशासनाच्या कार्यक्षमतेचा अभ्यास करण्याचा प्रयत्न केला आहे.

संशोधन समस्येचे विधान (Statement of the Research Problem):

ग्रामीण भागातील बेरोजगारी आणि हंगामी रोजगाराची कमतरता ही ग्रामीण विकासासमोरील प्रमुख आव्हाने आहेत. ग्रामीण कुटुंबांना त्यांच्या गावात रोजगार उपलब्ध करून देण्यासाठी महात्मा गांधी राष्ट्रीय ग्रामीण रोजगार हमी योजना राबविण्यात येते. तथापि, योजनेची उद्दिष्टे आणि प्रत्यक्ष अंमलबजावणी यांमध्ये काही ठिकाणी अंतर राहण्याची शक्यता असते.रोजगाराची मागणी नोंदविण्यातील अडचणी, कामे मंजूर होण्यास लागणारा कालावधी, मजुरी वितरणातील विलंब, माहितीचा अभाव, प्रशासकीय समन्वयातील कमतरता आणि सामाजिक लेखापरीक्षणाची मर्यादित प्रभावीता यांमुळे योजनेच्या परिणामकारकतेवर परिणाम होऊ शकतो.या पार्श्वभूमीवर पुढील संशोधन समस्या उपस्थित होतात :रावेर तालुक्यात ग्रामीण रोजगार हमी योजनेची अंमलबजावणी कोणत्या प्रकारे केली जाते?

या योजनेमुळे ग्रामीण रोजगारनिर्मितीला कितपत मदत होते?ग्रामीण कुटुंबांच्या आर्थिक स्थितीवर या योजनेचा काय परिणाम होतो?योजनेच्या अंमलबजावणीत ग्रामपंचायत आणि इतर स्थानिक प्रशासकीय संस्थांची भूमिका काय आहे.योजनेच्या अंमलबजावणीत कोणत्या प्रमुख समस्या उद्भवतात. स्थानिक प्रशासनाची कार्यक्षमता वाढविण्यासाठी कोणत्या उपाययोजना करता येऊ शकतात.या प्रश्नांच्या आधारे रावेर तालुक्यातील रोजगार हमी योजना आणि ग्रामीण विकास यांच्यातील संबंधांचा अभ्यास करणे ही प्रस्तुत संशोधनाची प्रमुख समस्या आहे.

संशोधनाचे महत्त्व (Significance of the Study):

प्रस्तुत संशोधनाचे महत्त्व पुढीलप्रमाणे आहे.

१. ग्रामीण रोजगाराच्या अभ्यासासाठी: ग्रामीण भागातील रोजगारनिर्मिती आणि हंगामी बेरोजगारी कमी करण्यामध्ये रोजगार हमी योजनेची भूमिका समजून घेता येते.

२. ग्रामीण आर्थिक विकासासाठी: रोजगाराच्या माध्यमातून ग्रामीण कुटुंबांच्या उत्पन्नात आणि आर्थिक सुरक्षिततेत होणारे संभाव्य बदल अभ्यासता येतात.

३. स्थानिक प्रशासनाच्या कार्यक्षमतेसाठी: ग्रामपंचायत, पंचायत समिती आणि इतर प्रशासकीय संस्थांच्या कार्यपद्धतीचे मूल्यमापन करता येते.

४. महिला सक्षमीकरणासाठी: ग्रामीण महिलांना रोजगाराच्या संधी उपलब्ध होणे, आर्थिक स्वावलंबन वाढणे आणि कुटुंबाच्या आर्थिक निर्णयप्रक्रियेत सहभाग वाढणे या बाबींचा अभ्यास करता येतो.

५. ग्रामीण पायाभूत सुविधांच्या विकासासाठी: जलसंधारण, मृदसंधारण आणि इतर सार्वजनिक मालमत्तांच्या निर्मितीतील योजनेच्या योगदानाचे विश्लेषण करता येते.

६. धोरणात्मक निर्णयांसाठी: योजनेतील त्रुटी ओळखून प्रशासकीय सुधारणा आणि ग्रामीण विकासासाठी उपाययोजना सुचविता येतात.

संशोधनाची उद्दिष्टे (Objectives of the Study):

१. महात्मा गांधी राष्ट्रीय ग्रामीण रोजगार हमी योजनेची उद्दिष्टे आणि कार्यपद्धती यांचा अभ्यास करणे.

२. जळगाव जिल्ह्यातील रावेर तालुक्यात योजनेच्या अंमलबजावणीचा अभ्यास करणे.

३. रोजगार हमी योजनेचा ग्रामीण कुटुंबांच्या आर्थिक स्थितीवर होणारा परिणाम अभ्यासणे.

४. योजनेच्या अंमलबजावणीत स्थानिक प्रशासनाच्या भूमिकेचे विश्लेषण करणे.

संशोधनाचे स्वरूप:

हे संशोधन ग्रामीण विकासाच्या प्रक्रियेत रोजगार हमी योजनेचे योगदान आणि स्थानिक प्रशासनाची भूमिका यांचा अभ्यास करणारे वर्णनात्मक व विश्लेषणात्मक स्वरूपाचे संशोधन आहे.

1. माहितीचे स्रोत:

अ) प्राथमिक माहिती: प्राथमिक माहिती गोळा करण्यासाठी पुढील साधनांचा वापर करता येईल :रोजगार हमी योजनेतील लाभार्थ्यांच्या मुलाखती.ग्रामपंचायत पदाधिकारी आणि संबंधित कर्मचाऱ्यांच्या मुलाखती.संरचित प्रश्नावलीद्वारे सर्वेक्षण.

ग्रामसभेतील सहभाग आणि उपलब्ध नोंदींचे निरीक्षण.

निवडक गावांमधील रोजगार हमीच्या कामांची पाहणी.

ब) दुय्यम माहिती:

दुय्यम माहिती पुढील स्रोतांमधून गोळा करता येईल:

- केंद्र शासनाच्या ग्रामीण विकास मंत्रालयाचे अहवाल.
- महात्मा गांधी राष्ट्रीय ग्रामीण रोजगार हमी योजनेचे अधिकृत पोर्टल.जळगाव जिल्हा परिषद आणि पंचायत समितीचे उपलब्ध अहवाल.ग्रामपंचायतींच्या उपलब्ध नोंदी.
- शासकीय आर्थिक सर्वेक्षणे.ग्रामीण विकासासंबंधी पुस्तके, संशोधन लेख आणि नियतकालिके.संबंधित कायदे, नियम आणि शासन निर्णय.

स्थलांतरावर परिणाम:

ग्रामीण भागात रोजगार उपलब्ध नसल्यास काही कुटुंबांना कामाच्या शोधात इतर गावांमध्ये किंवा शहरांमध्ये स्थलांतर करावे लागते. गावाजवळ रोजगार उपलब्ध झाल्यास अशा स्थलांतराची गरज काही प्रमाणात कमी होऊ शकते.

तथापि, स्थलांतरावर शेतीतील उत्पन्न, शिक्षण, आरोग्य, औद्योगिक रोजगार आणि इतर आर्थिक घटकांचाही प्रभाव असतो. त्यामुळे स्थलांतरात घट झाल्याचा निष्कर्ष काढण्यासाठी प्रत्यक्ष माहिती आवश्यक आहे

महिला सक्षमीकरण:

रोजगार हमी योजनेत महिलांच्या सहभागाला महत्त्व आहे. महिलांना मजुरीच्या कामांमध्ये सहभागी होण्याची संधी मिळाल्यास त्यांच्या वैयक्तिक उत्पन्नात वाढ होऊ शकते. त्याचबरोबर कुटुंबाच्या आर्थिक निर्णयप्रक्रियेत त्यांचा सहभाग वाढण्यास मदत होऊ शकते.महिलांचा प्रत्यक्ष सहभाग वाढविण्यासाठी कामाच्या ठिकाणी आवश्यक सुविधा, सुरक्षित वातावरण, बालसंगोपनाच्या तरतुदी आणि वेळेवर मजुरी वितरण या बाबी महत्त्वाच्या आहेत.

जलसंधारण आणि मृदसंधारण:

ग्रामीण भागातील शेतीचे उत्पादन पाणी आणि जमिनीच्या गुणवत्तेवर अवलंबून असते. रोजगार हमी योजनेअंतर्गत पात्रतेनुसार जलसंधारण, मृदसंधारण, नाला खोलीकरण, बांधबंदिस्ती आणि इतर नैसर्गिक साधनसंपत्ती संवर्धनाची कामे करता येतात.या कामांमुळे पावसाचे पाणी साठविणे, जमिनीची धूप कमी करणे आणि शेतीसाठी उपलब्ध संसाधनांमध्ये सुधारणा घडवून आणणे शक्य होऊ शकते.

ग्रामीण पायाभूत सुविधांचा विकास:

ग्रामीण भागातील सार्वजनिक मालमत्तांची निर्मिती हा रोजगार हमी योजनेचा महत्त्वाचा भाग आहे. योजनेच्या नियमांनुसार पात्र कामांमधून ग्रामीण रस्ते, जलसंधारण संरचना, शेतीशी संबंधित सुविधा आणि इतर उपयुक्त मालमत्ता निर्माण करता येतात.या मालमत्तांची योग्य निवड, बांधकामाचा दर्जा आणि नियमित देखभाल सुनिश्चित केल्यास त्यांचा दीर्घकालीन फायदा ग्रामीण अर्थव्यवस्थेला होऊ शकतो.

स्थानिक प्रशासनाची भूमिका

महात्मा गांधी राष्ट्रीय ग्रामीण रोजगार हमी योजनेच्या अंमलबजावणीत स्थानिक प्रशासन हा महत्त्वाचा घटक आहे. योजना प्रभावीपणे राबविण्यासाठी विविध प्रशासकीय संस्थांमध्ये समन्वय असणे आवश्यक आहे.

1. ग्रामपंचायतीची भूमिका:

ग्रामपंचायत ही ग्रामीण पातळीवरील महत्त्वाची अंमलबजावणी संस्था आहे. ग्रामपंचायतीच्या माध्यमातून स्थानिक गरजांनुसार कामांचे नियोजन, रोजगार मागणीची नोंद आणि योजनेशी संबंधित प्रशासकीय कार्यवाही केली जाते.ग्रामपंचायतीच्या प्रमुख जबाबदाऱ्यांमध्ये पुढील बाबींचा समावेश होतो :ग्रामसभेच्या सहभागातून कामांची निवड करणे.गावातील गरजांनुसार कामांचे नियोजन करणे.

रोजगार मागणीची नोंद आणि संबंधित प्रक्रिया सुलभ करणे.

पात्र कामगारांना नियमानुसार काम उपलब्ध करून देण्याच्या प्रक्रियेत सहकार्य करणे.कामांची नोंद आणि आवश्यक अभिलेख व्यवस्थित ठेवणे.योजनेविषयी

नागरिकांना माहिती देणे.कामांची गुणवत्ता आणि प्रगती यावर देखरेख ठेवणे.

ग्रामपंचायत कार्यक्षम असल्यास स्थानिक गरजांनुसार रोजगाराची कामे निवडणे आणि योजनेचा लाभ पात्र कुटुंबांपर्यंत पोहोचविणे अधिक सुलभ होऊ शकते.

2. ग्रामसभेची भूमिका:

ग्रामसभा ही लोकसहभाग आणि विकेंद्रित नियोजनासाठी महत्त्वाची संस्था आहे. ग्रामसभेमध्ये गावातील विकासाच्या गरजांवर चर्चा करून रोजगार हमी योजनेअंतर्गत कोणती कामे प्राधान्याने करावीत याबाबत निर्णयप्रक्रियेत सहभाग घेता येतो.ग्रामसभेच्या माध्यमातून पुढील बाबींना प्रोत्साहन मिळू शकते

१. स्थानिक गरजांवर आधारित कामांची निवड.
२. नागरिकांचा निर्णयप्रक्रियेतील सहभाग.
३. विकासकामांबाबत माहितीची उपलब्धता.
४. सार्वजनिक निधीच्या वापराविषयी उत्तरदायित्व.
५. कामांच्या गुणवत्तेबाबत सामूहिक देखरेख.

ग्रामसभा प्रभावीपणे कार्यरत असल्यास योजनेच्या अंमलबजावणीत पारदर्शकता वाढण्यास मदत होऊ शकते

3. पंचायत समितीची भूमिका:

पंचायत समिती ही तालुका स्तरावरील महत्त्वाची प्रशासकीय संस्था आहे. ग्रामीण रोजगार हमी योजनेच्या अंमलबजावणीसाठी पंचायत समिती ग्रामपंचायतींशी समन्वय साधते आणि संबंधित प्रशासकीय कामांमध्ये मदत करते. तिच्या कार्यामध्ये नियोजनाचा समन्वय, कामांच्या प्रगतीचा आढावा, प्रशासकीय मार्गदर्शन, नोंदींची तपासणी आणि अंमलबजावणीतील अडचणी दूर करण्यासाठी प्रयत्न यांचा समावेश होऊ शकतो.रावेर तालुक्याच्या संदर्भात पंचायत समितीची भूमिका महत्त्वाची आहे; मात्र तिच्या प्रत्यक्ष कामगिरीचे मूल्यमापन करण्यासाठी अधिकृत नोंदी आणि संबंधित अधिकाऱ्यांची माहिती आवश्यक आहे.

4. जिल्हा परिषदेची भूमिका:

जिल्हा परिषद आणि संबंधित जिल्हास्तरीय यंत्रणा योजनेच्या नियोजनावर देखरेख ठेवणे, तालुका स्तरावरील कामांचा समन्वय साधणे आणि शासनाच्या मार्गदर्शक सूचनांनुसार अंमलबजावणी होण्यास मदत करणे या बाबींमध्ये भूमिका बजावतात.जिल्हास्तरावरील समन्वय योग्य असल्यास ग्रामीण भागातील विकासकामांची अंमलबजावणी अधिक सुसंगत होऊ शकते.

5. प्रशासकीय पारदर्शकता:

योजनेतील कामांची नोंद, उपस्थिती, खर्च, मजुरी देयके आणि कामांच्या प्रगतीविषयी माहिती उपलब्ध असणे आवश्यक आहे. पारदर्शकता असल्यास नागरिकांना माहिती मिळविणे आणि कामांवर देखरेख ठेवणे सोपे होते.
प्रशासकीय पारदर्शकता वाढविण्यासाठी पुढील उपाय महत्त्वाचे आहेत

1. आवश्यक अभिलेख अद्ययावत ठेवणे.
2. कामांशी संबंधित माहिती नागरिकांना उपलब्ध करून देणे.
3. तक्रार निवारण यंत्रणा प्रभावी करणे.
4. सामाजिक लेखापरीक्षणाला प्रोत्साहन देणे.
5. नियमांनुसार ऑनलाइन नोंदी अद्ययावत करणे.

6. मजुरी वितरण:

रोजगार हमी योजनेतील मजुरांना नियमानुसार मजुरी मिळणे हा योजनेच्या विश्वासार्हतेचा महत्त्वाचा घटक आहे. मजुरी देयकांची प्रक्रिया, उपस्थितीची अचूक नोंद आणि बँक किंवा पोस्ट ऑफिसमार्फत होणारे देयक वितरण यामध्ये योग्य समन्वय आवश्यक असतो.मजुरी वितरणात विलंब झाल्यास ग्रामीण कुटुंबांच्या आर्थिक नियोजनावर परिणाम होऊ शकतो. त्यामुळे संबंधित नोंदींची अचूकता, वेळेवर प्रक्रिया आणि तक्रारींचे निवारण महत्त्वाचे ठरते.

7. सामाजिक लेखापरीक्षण:

सामाजिक लेखापरीक्षण ही सार्वजनिक योजनेतील पारदर्शकता आणि उत्तरदायित्व वाढविण्याची महत्त्वाची प्रक्रिया आहे. त्यामध्ये योजनेशी संबंधित नोंदी, खर्च, रोजगार, मजुरी आणि प्रत्यक्ष कामांची तपासणी केली जाते. सामाजिक लेखापरीक्षण प्रभावी असल्यास अनियमितता ओळखणे, नागरिकांना माहिती मिळवून देणे आणअंमलबजावणीतील त्रुटी दूर करण्यास मदत होऊ शकते.

जळगाव जिल्ह्यातील रावेर तालुक्याच्या संदर्भातील अभ्यास:

जळगाव जिल्ह्यातील रावेर तालुका हा प्रस्तुत संशोधनाचा भौगोलिक अभ्यासविषय आहे. या तालुक्यातील ग्रामीण अर्थव्यवस्था, शेतीवरील अवलंबित्व, रोजगाराच्या संधी आणि स्थानिक प्रशासनाची कार्यपद्धती या बाबींच्या संदर्भात रोजगार हमी योजनेचा अभ्यास करता येतो.रावेर तालुक्याचा अभ्यास करताना केवळ रोजगाराच्या दिवसांची संख्या तपासणे पुरेसे ठरणार नाही. रोजगार हमी योजनेमुळे निर्माण झालेल्या मालमत्तांचा उपयोग, लाभार्थ्यांचे अनुभव, मजुरी मिळण्याची प्रक्रिया आणि ग्रामपंचायतीच्या नियोजनाची गुणवत्ता यांचाही विचार करणे आवश्यक आहे.

1. रोजगाराच्या संधींचा अभ्यास:

रावेर तालुक्यातील निवडक गावांमध्ये किती कुटुंबांनी रोजगाराची मागणी केली, किती कुटुंबांना काम उपलब्ध झाले आणि प्रत्यक्षात किती दिवस रोजगार मिळाला याची माहिती संकलित करणे आवश्यक आहे.यासाठी ग्रामपंचायत नोंदी, अधिकृत रोजगार हमी पोर्टलवरील आकडेवारी आणि लाभार्थ्यांच्या मुलाखती यांचा वापर करता येईल.

2. शेती आणि रोजगार हमी योजनेचा संबंध:

शेतीतील कामे अनेकदा हंगामानुसार बदलतात. अशा परिस्थितीत रोजगार हमी योजना ही ग्रामीण कुटुंबांसाठी पूरक रोजगाराचा स्रोत ठरू शकते.मात्र, योजनेतील कामांची वेळ आणि शेतीतील कामांची वेळ यांचा समन्वय आवश्यक आहे. प्रत्यक्ष अभ्यासामध्ये रोजगार हमी योजनेमुळे मजुरांच्या उत्पन्नात किती बदल झाला आणि शेतीतील रोजगाराशी त्याचा काय संबंध आहे हे तपासता येईल.

3. नैसर्गिक साधनसंपत्तीचे संवर्धन:

रावेर तालुक्यातील निवडक गावांमध्ये जलसंधारण, मृदसंधारण आणि शेतीशी संबंधित पात्र विकासकामांचा अभ्यास करता येईल.या कामांची उपयुक्तता तपासताना.

4. स्थानिक प्रशासनाची कार्यक्षमता:

रावेर तालुक्यातील स्थानिक प्रशासनाच्या कार्यक्षमतेचे मूल्यमापन करण्यासाठी रोजगार मागणीची प्रक्रिया, कामांची निवड, मजुरी देयके, तक्रार निवारण आणि सामाजिक लेखापरीक्षण या घटकांचा अभ्यास करता येईल.प्रशासनाची कार्यक्षमता मोजण्यासाठी निश्चित निर्देशक वापरणे आवश्यक आहे. उदाहरणार्थ, रोजगार मागणीची नोंद वेळेवर होणे, कामांच्या नोंदींची अचूकता, तक्रारींचे निवारण आणि मजुरी देयकांच्या प्रक्रियेची स्थिती यांचा विचार करता येईल.

संशोधनाच्या दृष्टीने महत्त्वाची बाब : रावेर तालुक्यातील रोजगाराचे दिवस, लाभार्थ्यांची संख्या, खर्च आणि प्रत्यक्ष परिणाम यासंबंधी अधिकृत आकडेवारी उपलब्ध नसताना निश्चित संख्यात्मक निष्कर्ष मांडणे योग्य ठरणार नाही. हे निष्कर्ष अधिकृत आकडेवारी किंवा प्रत्यक्ष सर्वेक्षणाच्या आधारे भरावेत.

योजनेच्या अंमलबजावणीतील प्रमुख समस्या:

महात्मा गांधी राष्ट्रीय ग्रामीण रोजगार हमी योजनेच्या प्रभावी अंमलबजावणीमध्ये काही संभाव्य अडचणी उद्भवू शकतात. या अडचणींचे स्वरूप आणि तीव्रता स्थानिक परिस्थितीनुसार बदलू शकते.

1. माहितीचा अभाव:

काही ग्रामीण नागरिकांना रोजगाराची मागणी कशी करावी, कोणती कागदपत्रे आवश्यक आहेत किंवा तक्रार कोठे नोंदवावी याविषयी पुरेशी माहिती नसण्याची शक्यता असते.

यासाठी ग्रामपंचायत स्तरावर माहिती प्रसार आणि मार्गदर्शन व्यवस्था मजबूत करणे आवश्यक आहे.

2. रोजगार मागणीची प्रक्रिया:

रोजगाराची मागणी नोंदविणे आणि तिची पावती मिळणे ही प्रक्रिया सुलभ व पारदर्शक असणे आवश्यक आहे. या प्रक्रियेत अडचणी आल्यास पात्र कुटुंबांना योजनेचा लाभ घेणे कठीण होऊ शकते.

3. मजुरी वितरणातील विलंब:

मजुरी देयकांच्या प्रक्रियेत किंवा संबंधित नोंदींमध्ये त्रुटी असल्यास विलंब होऊ शकतो. यामुळे कामगारांच्या आर्थिक गरजांवर परिणाम होण्याची शक्यता असते.

4. प्रशासकीय मनुष्यबळाची कमतरता:

ग्रामपंचायत आणि इतर स्थानिक संस्थांमध्ये आवश्यक मनुष्यबळ किंवा तांत्रिक सहाय्य अपुरे असल्यास कामांचे नियोजन, नोंदींचे व्यवस्थापन आणि देखरेख यावर परिणाम होऊ शकतो.

5. कामांच्या गुणवत्तेचा प्रश्न:

कामांची निवड करताना स्थानिक गरजा आणि दीर्घकालीन उपयोग यांचा विचार न झाल्यास निर्माण झालेल्या मालमत्तांचा अपेक्षित फायदा मिळणार नाही. त्यामुळे कामांचे तांत्रिक नियोजन आणि गुणवत्तेची तपासणी आवश्यक आहे.

6. लोकसहभागाची मर्यादा:

ग्रामसभा आणि सामाजिक लेखापरीक्षणामध्ये नागरिकांचा पुरेसा सहभाग नसेल तर स्थानिक गरजा आणि प्रत्यक्ष अंमलबजावणी यांच्यात अंतर राहू शकते.

7. डिजिटल प्रक्रियेतील अडचणी:

ऑनलाइन नोंदी, डिजिटल उपस्थिती किंवा बँक खात्यांशी संबंधित प्रक्रियांमध्ये तांत्रिक अडचणी उद्भवल्यास कामगार आणि प्रशासकीय यंत्रणा दोघांनाही अडचणी येऊ शकतात.

या संभाव्य समस्यांची प्रत्यक्ष उपस्थिती आणि परिणाम रावेर तालुक्यातील सर्वेक्षण व अधिकृत नोंदींच्या आधारे तपासणे आवश्यक आहे.

निष्कर्ष (Conclusion):

महात्मा गांधी राष्ट्रीय ग्रामीण रोजगार हमी योजना ही ग्रामीण रोजगारनिर्मिती आणि ग्रामीण विकासाच्या दृष्टीने महत्त्वाची योजना आहे. ग्रामीण भागातील पात्र कुटुंबांना रोजगाराची संधी उपलब्ध करून देणे, ग्रामीण मजुरांच्या आर्थिक सुरक्षिततेत सुधारणा घडविणे आणि सार्वजनिक मालमत्तांची निर्मिती करणे या माध्यमांतून ही योजना ग्रामीण अर्थव्यवस्थेला आधार देऊ शकते.या योजनेची परिणामकारकता केवळ निधीची उपलब्धता किंवा रोजगाराच्या दिवसांच्या संख्येवर अवलंबून नसून स्थानिक प्रशासनाच्या कार्यक्षमतेवरही अवलंबून असते. ग्रामपंचायत, ग्रामसभा, पंचायत समिती आणि जिल्हास्तरीय यंत्रणा यांच्यातील समन्वय, पारदर्शकता, लोकसहभाग आणि उत्तरदायित्व हे योजनेच्या यशाचे महत्त्वाचे घटक आहेत.

जळगाव जिल्ह्यातील रावेर तालुक्याच्या संदर्भात रोजगार हमी योजनेचा अभ्यास करताना ग्रामीण रोजगाराची उपलब्धता, लाभार्थ्यांच्या आर्थिक स्थितीतील बदल, मजुरी वितरणाची प्रक्रिया, जलसंधारणाची कामे आणि स्थानिक प्रशासनाची कार्यपद्धती यांचा एकत्रित विचार करणे आवश्यक आहे.स्थानिक प्रशासन कार्यक्षम असेल, रोजगार मागणीची प्रक्रिया सुलभ असेल, मजुरी वितरण योग्य पद्धतीने होईल आणि ग्रामसभेच्या माध्यमातून नागरिकांचा सहभाग वाढेल, तर योजनेचे अपेक्षित लाभ ग्रामीण कुटुंबांपर्यंत अधिक प्रभावीपणे पोहोचू शकतात. त्याचबरोबर कामांची गुणवत्ता आणि टिकाऊपणा सुनिश्चित केल्यास ग्रामीण भागातील नैसर्गिक साधनसंपत्तीचे संवर्धन आणि पायाभूत सुविधांचा विकास साधता येऊ शकतो.

मात्र, रावेर तालुक्यात या योजनेचा प्रत्यक्ष परिणाम किती झाला आहे आणि स्थानिक प्रशासनाच्या कार्यक्षमतेचा त्याच्याशी किती संबंध आहे हे निश्चित करण्यासाठी अधिकृत आकडेवारी, लाभार्थ्यांचे सर्वेक्षण आणि प्रशासकीय नोंदींचे विश्लेषण आवश्यक आहे.अशा प्रकारे, महात्मा गांधी राष्ट्रीय ग्रामीण रोजगार हमी योजना ही ग्रामीण विकासासाठी महत्त्वाची संधी उपलब्ध करून देते; परंतु तिचे अपेक्षित परिणाम साध्य करण्यासाठी सक्षम स्थानिक प्रशासन, प्रभावी नियोजन, पारदर्शक अंमलबजावणी आणि लोकसहभाग आवश्यक आहे.

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९. रावेर पंचायत समिती व संबंधित ग्रामपंचायती. रोजगार हमी योजनेच्या अंमलबजावणीशी संबंधित उपलब्ध प्रशासकीय नोंदी

International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Synthesis And Scanning Electron Microscopy (SEM) Morphological Study of Iron Oxide

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DOI - 10.5281/zenodo.24339783

Abstract:

Study of nanoparticles is now day is one of the promising fields for researchers. Among them, iron oxide nanoparticles are of particular interest. There are a few important types of iron oxide available for study, such as hematite (α-Fe2O3), magnetite (Fe3O4), and maghemite (γ-FeOOH). There most technique available for Preparation of nanoparticles like co-precipitation, sol-gel, hydrothermal, etc. but co-precipitation is most feasible. Characterization of nanoparticles with Scanning electron microscopy (SEM) shows synthesis nanoparticles shows in in their size in nanometer scale level.

Keywords: Hematite, Co-Precipitation, Magnetite, Sol-Gel.

Introduction:

Nanotechnology plays a vital part in research areas due to its applicability to today's needs in human life and the overall environment. Energy crises all over the world are faced due to limited sources available in nature. There are a number of nanoparticles for study, but out of these, iron oxide nanoparticles have attracted significant research attention due to their applications in energy conversion and storage. Iron oxide nanoparticles are available in several phase forms, such as magnetite (Fe3O4), hematite (α-Fe2O3), and maghemite (γ-Fe2O3 / γ-FeOOH), and have emerged as critical materials across biomedical, environmental, and technological domains due to their tunable magnetic properties, biocompatibility, and chemical stability [1]. However, the performance of iron oxide nanoparticles in applications such as targeted drug delivery, hyperthermia therapy, heavy-metal remediation, water splitting, and catalysis is directly governed by their physical parameters—specifically their size, shape, surface topography, and spatial arrangement [2]. Controlling and evaluating these morphological features is therefore fundamental to optimizing their behavior and functionality.

Scanning Electron Microscopy (SEM) is an indispensable analytical technique for high-resolution surface characterization [3]. By scanning a focused beam of high-energy electrons across the sample surface, SEM generates secondary and backscattered electron signals that reveal topography, surface roughness, grain boundaries, and particle orientation at the nanometer scale [4]. SEM enables simultaneous spatial structural mapping and elemental verification of synthesized iron oxides. Here, we study the synthesis of iron oxide nanoparticles using the co-precipitation method and characterize them by SEM for morphology, surface profiling, and electrochemical application in water splitting.

Experimental Section:

Prepared Fe^{3+}/Fe^{2+} solution as a 1:2 ratio solution. Measured 4.055 g of ferric chloride ($FeCl_3$ (0.5M), 3.475 g ferrous sulphate ($FeSO_4$ $7H_2O$) (0.25M) and 6 g of sodium hydroxide NaOH (3M). make clear solution ferric and ferrous solution using continuous magnetic stirring. When clear solution obtained the mix both the solution. Add precipitation agent i.e. sodium hydroxide solution dropwise till brown colur precipitate obtain with conteneous stirring. After precipitate obtained filter using a Büchner funnel. Wash the precipitate with de-ionized water two times and then with ethanol to remove dissolved impurities. Then dry the precipitate in preheated oven at 90 ^oC for 1 hour. Then calcined the dry product at 500 ^0C for 4 hours. The product is ready for characterisation.

Results and Discussion:

Scanning electron microscopy (SEM) Characterisation:

Instrumentation: Surface morphology and microstructural analysis were carried out using Scanning Electron Microscopy (SEM) operated at an accelerating voltage of 15–20 kV. Digital image analysis (ImageJ software) was employed to extract 3D surface topography reconstructions and 2D cross-sectional line profile intensity maps across a 109.5 nm × 94.0 nm sampling window. The SEM micrograph reveals a highly textured, micro-to-nanostructured morphology comprising irregular, angular grains interspersed with agglomerated nanoscale clusters. Grain size measurements taken across representative particles (labeled 1 through 10) demonstrate a broad size distribution, combining micro-flake aggregates with finer sub-micron particles. The random packing of these polydisperse grains creates an interconnected network of inter-granular voids and pores, which serves as accessible pathways for electrolyte infiltration during energy conversion processes [5]. Figure 1. shows the SEM micrograph reveals a highly heterogeneous, micro-to-nanostructured morphology composed of irregularly shaped, angular micrograins surrounded by smaller nano-grained clusters. Linear grain dimensions measured across ten representative particles indicate a broad grain size distribution ranging from smaller sub-micron fragments to larger agglomerated micro-flakes. The larger micrograins feature sharp edges and rough surface facets, providing a high density of exposed step and ledge sites. The random stacking of these polydisperse grains creates an interconnected network of inter-granular pores and voids, facilitating effective electrolyte penetration. To further quantify the surface texture of the co-precipitated iron oxide nanoparticles, a 3D SEM surface plot (109.5 nm × 94.0 nm) and a corresponding 2D cross-sectional line profile were evaluated shows in figure 2. The 2D cross-sectional intensity profile extracted across a 109.5 nm transect reveals a distinct peak elevation of ~116 gray units located at 59.0 nm and a local valley minimum of ~16 gray units at 29.0 nm. This establishes a peak-to-valley dynamic amplitude (ΔI_max) of 100 gray value units. The steep height gradients ($\Delta I/\Delta x$) confirm the presence of vertical nanostructured channels that facilitate gas bubble detachment (H2 / O2) during water electrolysis. the nanoscale cross-sectional dimensions, surface roughness, and feature heights of the nanostructured catalyst, a 2D line profile plot was extracted across a representative 109.5nm transect of the 3D SEM surface map. Figure 3. shows that the 3D surface plot reconstructed from the SEM micrograph reveals a highly textured, three-dimensional porous architecture dominated by sharp nanoprotrusions and hierarchical vertical features with micro-to-nano height variations.

Figure 1. SEM image

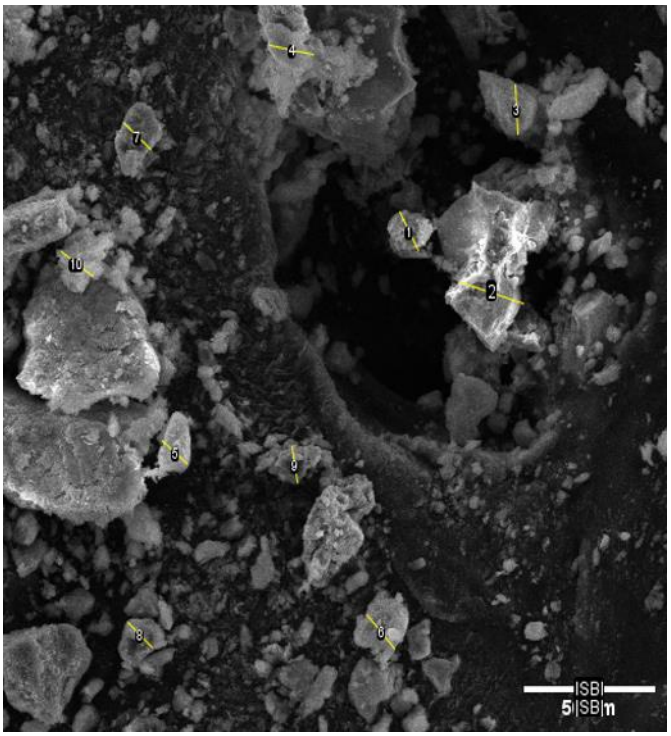
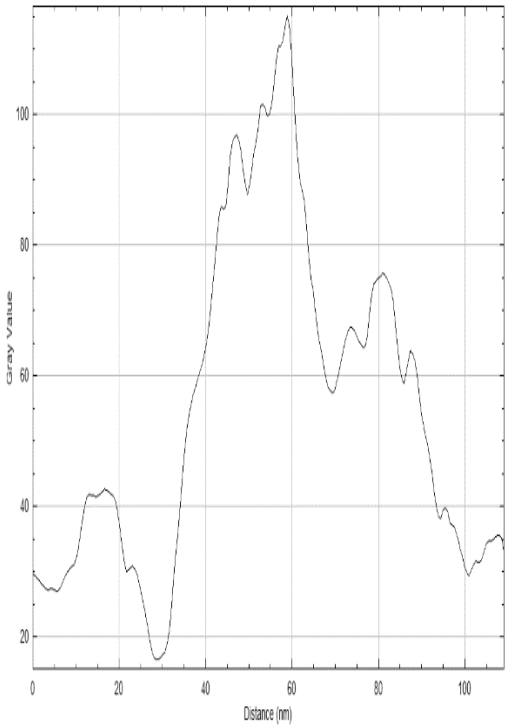


Figure 2. Profile image obtain from SEM image



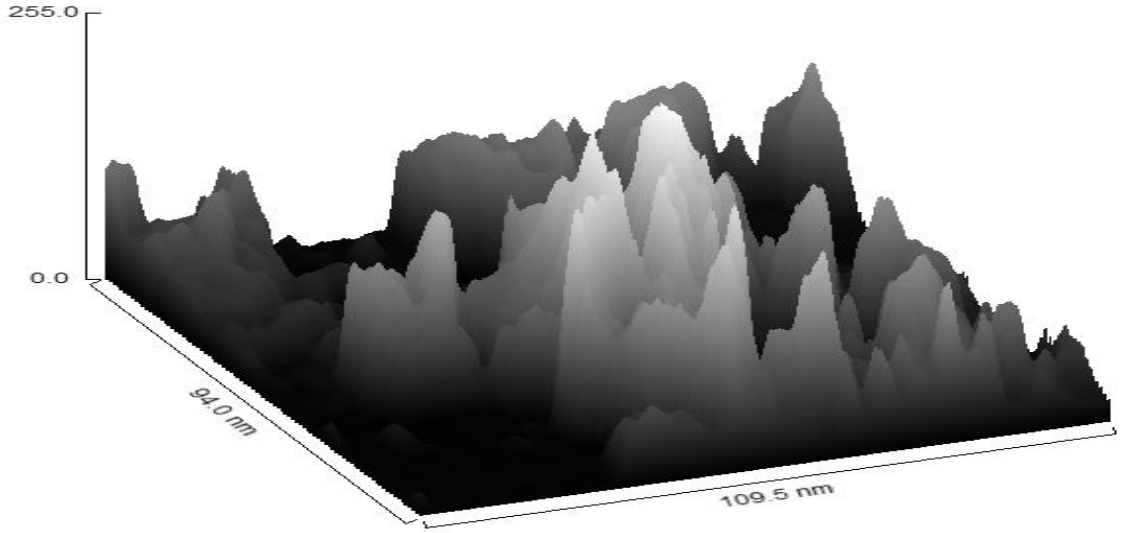


Figure 3. Surface plot obtained from SEM image.

Conclusion:

We successfully prepared nanoparticles and studied the nanoparticles using the SEM technique and different characteristic plots. The prepared nanoparticles can be used for energy storage or energy conversion used electrode in future for water splitting purpose.

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International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.26
Peer Reviewed Bi-Monthly
Vol. 7 No. 56 September - October - 2026

Schiff Bases of Amino Azobenzene Part-III: Synthesis and Biological Applications of Schiff Bases derived from 4-Amino-azobenzene

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DOI - 10.5281/zenodo.24339812

Abstract:

The new 4-Amino azobenzene containing Schiff bases have been synthesized. These synthesized compounds were studied in-vitro for their biological applications.

Keywords: 4-Aminoazobenzene; Schiff bases; Applications: Antibacterial; Antifungal and Antioxidant.

Introduction:

Main objective of medicinal and pharmaceutical researcher to study the disease caused microorganism's prevention and treatment. Some microorganisms effect on human life health as well as surrounding eco system [1-3]. For the treatment of various inflectional diseases effective inhibitory chemicals applied to kill microorganism or complete inactive and prevent their growth. Micro biostatic agents inhibit the growth of inflectional diseases microorganisms. Antimicrobial agent kills harmful microorganisms or stops their growth [4, 5].

Schiff bases were also synthesized from Azo-salicylaldehyde [6] antimicrobial medicines grouped classified according to the microorganisms which are used for the inflectional disease's treatment. For example, antibiotic medicine is used to treat against bacterial infection while and antifungal drug are used against fungal infection. Antimicrobial drugs are used to prevent infection [7, 8]. Schiff bases are recognized as versatile pharmacophores in drug discovery. Their ability to act as privileged ligands has enabled applications as antimicrobial, anticancer, antitumor, anti-inflammatory, antiviral, and antioxidant agents. Literature also highlights their incorporation with functional groups such as –N=N–, –CN, –N=N–OH, and >C=O, which enhance structural diversity and broaden utility.

Antifungal activity is the capability of a give agent or substance to stop the growth and reproduction of fungi responsible for infection. Fungal infection has increased more active significantly of health problem which lead to mortality and morbidity [9]. Aspergillosis infection found into the people with compromised immune systems as well as pre-existing lung conditions such as asthma, cystic fibrosis, chronic pulmonary aspergillosis and cutaneous (skin) aspergillosis [10,11]. Into the body *C. albicans* is found in the gastrointestinal tract, and the development of infections occurs due to immune dysfunction, dysbiosis of the residential microbiota and damage to the muco-intestinal barrier [12]. In this present day, drug chemists develop new and more effective antioxidative agents. The reactive oxygen species causes

oxidative damage of biomolecules such as proteins lipids DNA and RNA, many natural as well as synthetic antioxidants are available in the market for the treatment of oxidative damage diseases [13.14]. azobenzene containing Schiff bases and studied their antibacterial, antifungal and antioxidant activities. In light of these developments, the present work enlightens on the synthesis of Schiff base ligands by reacting amino azobenzene with varied aromatic aldehydes. The in-vitro antifungal, and antioxidant activities of the resulting compounds were systematically investigated in the present work.

Material and Methods:

All organic solvents employed in the present investigation are pure and analytical grade of S D Fine-Chem. and Sigma-Aldrich. The FTIR spectrum was recorded on Brukar ATR FTIR. The ^{1}H-NMR and ^{13}C-NMR spectral data were recorded in DMSO on BRUKER AVANCE NEO for 500 MHz at SAIF, Panjab University. The GC-MS/MS spectrums were recorded on MALDI-TOF/TOF high resolution mass spectrometer from SAIF, Panjab University Chandigarh. The procedure used for antifungal and antioxidant activity screening are as reported earlier. [15,16]

Biological Applications:

Antifungal Activity:

The synthesized compounds were tested against fungi, *Aspergillus Niger* and *Candida albicans.* The antifungal activity of synthesized azo Schiff base compounds gave zone of inhibition (in mm) are recorded in **Table 1**.

Table 1 Data showing the Antifungal activity of synthesized Azo Schiff base compounds screened for different strains.

Compounds	**Zone of inhibition (mm)**	
	Aspergillus Niger	*Candida albicans*
PAB	11.04	16.20
B3C	6.21	9.52
B4C	---	7.13
B5C	6.14	---
B3I	---	12.45
B4V	9.90	6.84
DMSO	---	---
Ampholericin-B	16.58	27.22

--- mean no zone of inhibition

The discs of Whatman No.1 filter paper with a diameter 6 mm each were soaked in test azo schiff base compound solutions of aforesaid concentrations and placed equidistant places in the inoculated large size petri plates. Filter paper disc treated with DMSO served as control and Ampholericin-B was used as standard drug. Finally, Petri plates were incubated at 37 ^{0}C for 48 h. The size of the inhibition zone depends upon the culture medium, diffusion rate, incubation conditions, and concentration of tested compound [17]. The compound PAB contain – NH_2 group in their structural skeleton shows good antifungal activity against *Aspergillus Niger* strain as compared to other compounds [18,19].

Compounds B3I and B4C have no antifungal activity against Aspergillus Niger strain but show antifungal activity against

Candida albicans strain while compounds B5C have no antifungal activity against Candida albicans but show antifungal activity against Aspergillus Niger strain. The azo Schiff base compounds PAB and B3C are active against both Aspergillus Niger and Candida albicans antifungal strain. The compound B3I containing –I group on substituted phenyl ring [20] in their structural skeleton shows good antifungal activity as compared to other active compounds but less the standard drug Ampholericin-B. The *azo* schiff base compounds B4V contain –OH group in their structural skeleton show mild antifungal activity against *Candida albicans* strain. Similarly compound B4C contain Diethylamino groups in their structural skeleton show mild antifungal activity.

The output of antifungal activity (Screening) for the studied azobenzene type of Schiff bases is depicted in fig.1

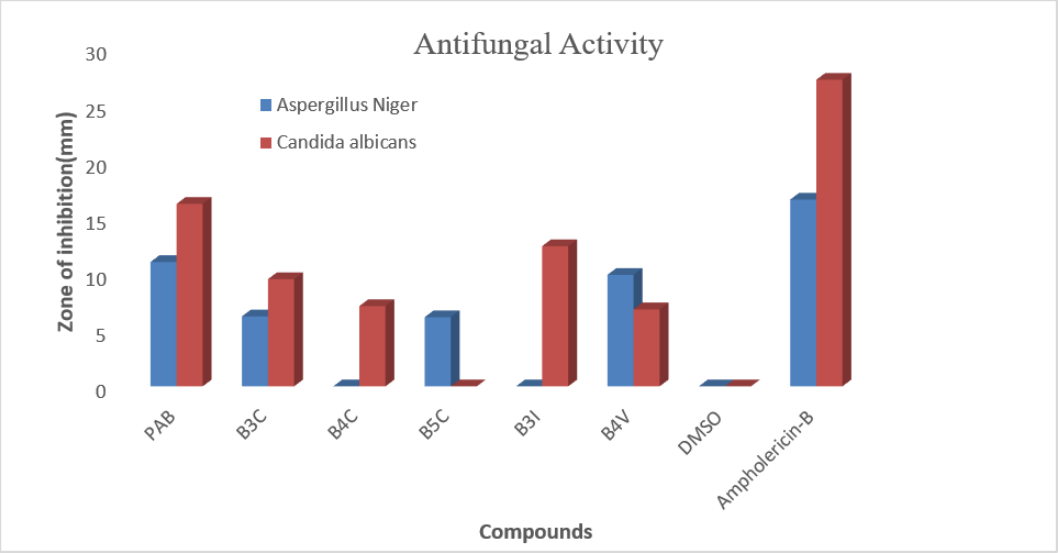

Fig.1. Antifungal activity of synthesize azo Schiff base compounds

Antioxidant Activity:

DPPH Radical Scavenging Assay:

The synthesized compounds of 100 μg/mL concentrations were prepared in DMF and took 1 mL of each compound solution into the test tubes, 4 mL of 0.1 mM methanol solution of DPPH was added and shaken vigorously for a clear solution. The test tubes incubated in the dark place for 30 min. The absorbance at 517 nm was measured using a UV-visible spectrophotometer. Ascorbic acid was used as the internal standard [21-23]. The radical scavenging activity percentage was calculated using following the formula:

Radical scavenging activity (%) = $[(A_o - A_1)/A_o \times 100]$

A_1 is absorbance of synthesized compound.

A_o is the absorbance of the control (blank, without compound)

Table 2 Data showing the Antioxidant activity of synthesized Azobenzene Schiff base compounds screened for different strains.

Compounds	% Inhibition	Ao Absorbance	A1 Absorbance
PAB	32.2	0.723	0.490
B3C	37.6	0.723	0.451
B4C	45.7	0.723	0.392
B5C	31.9	0.723	0.493
B3I	33.6	0.723	0.480
B4V	54.8	0.723	0.327
Ascorbic acid	84.5	0.723	0.112

The output of antioxidant activity (Screening) for the studied azobenzene type of Schiff bases is depicted in fig.2

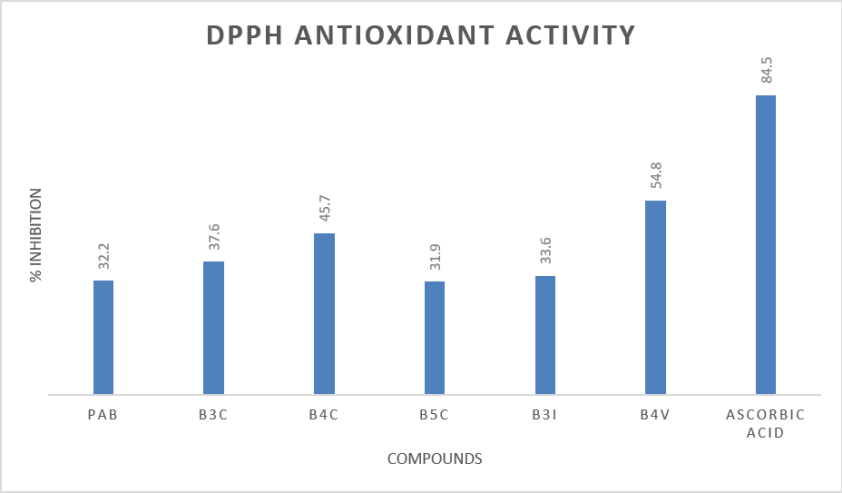

Fig.2. Antioxidant DPPH activity of synthesized azo Schiff base compounds

The increase or decrease in absorbance is mainly depending on more potent antioxidant participated and present in medium. Mainly two step mechanisms in DPPH method to scavenge free radicals [24]. The first mechanism is based on a direct hydrogen abstraction from the antioxidant and second mechanism involves the proton concerned electron transfer process. When any antioxidant component is present in the medium than the molecule is easily quench DPPH free radical, resulting to decrease in absorbance hence rapidly the decrease absorbance result the more potent the antioxidant activity [25, 26]. The DPPH radical scavenging assays resulting data of are recorded in Table2

In this present work, the compounds B5C and B3I shows less radical scavenging activity as compare to other azo Schiff base compounds. The compounds B4C shows good DPPH scavenging activity as compare to B5C and B3I compounds but less as compare to ascorbic acid. The compounds B4V containing –OH groups in their structure slightly exhibited an effective DPPH scavenging activity [27]. Generally, free radical scavenging capacity is mainly attributed to the high reactivity of hydroxyl group [28,29]. Nearly, all the tested azo Schiff base compounds shows less DPPH radical scavenging as comparisons to B4V which is mainly contains electron donating

hydroxyl group on phenyl moiety in their structural skeleton [30,31].

Finally, the resulting data of antimicrobial activity of synthesis azo schiff bases compounds indicated that, the hydroxy (-OH) group present in structure of compound may favors for increase in antioxidant activity [32-34]. These entire compounds have mild to medium antimicrobial activity and antioxidant activity.

Conclusion:

The present work shows the successful synthesis and, antifungal as well as the antioxidant activity of new azobenzene containing Schiff base compounds. These observed activities of all the compounds have been studied which may be attributed to the >C=N- linkage and the electronic nature of the substituents present on the aromatic rings of the Schiff bases. The results of the antifungal and antioxidant activities are compared with that of the standard antibiotic drugs.

Acknowledgement: Authors are thankful to the Management and Principal, MTES', Smt. G. G. Khadse College, Muktainagar as well as Smt. P. K. Kotecha Mahila Mahavidyalaya, Bhusawal and for the continuous encouragement and permission for the present work. Authors are also thankful to SAIF, Panjab University, Chandigarh for recording the ^{1}H-NMR, ^{13}C-NMR and GC-MS/MS spectrums within the stipulated time frame.

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