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Navicating The Digital Frontier: Intersection Of Digital Banking, E-Commerce Ecosystems, Cybersecurity Threats, And Financial Risk Management In The Modern Economy

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Abstract:

The rapid convergence of digital banking infrastructure and global e-commerce enterprise has fundamentally reconstructed the architectural framework of modern financial services and retail commerce. While this systemic shift has unlocked unprecedented transactional speed, reduced operational friction, optimized consumer cross-border commerce, and expanded financial inclusion across emerging markets, it has simultaneously introduced complex structural vulnerabilities. As financial institutions and online commerce platforms transition into interconnected, API-driven ecosystems, the surface area for sophisticated cyber threats—ranging from AI-augmented ransomware and supply-chain exploits to distributed denial-of-service (DDoS) attacks and synthetic identity fraud—has expanded exponentially. This comprehensive research article provides an exhaustively detailed analysis of the dynamic structural synergy between modern digital banking models (including Neo-banks, Open Banking framework, Unified Payments Interface [UPI], and Central Bank Digital Currencies [CBDCs]) and the sprawling e-commerce ecosystem. It rigorously evaluates the contemporary landscape of financial risk management, highlighting liquidity, credit, operational, and systemically interconnected risks generated by digital velocity. Furthermore, the paper investigates state-of-the-art cybersecurity defenses, regulatory architectures (such as the Digital Personal Data Protection Act, RBI Cyber Security Framework, and Basel III operational resilience mandates), and emerging paradigms like Zero Trust Architecture, Machine Learning anomaly detection, and Quantum-Resistant Cryptography. Ultimately, the article establishes an integrated enterprise risk management framework

Keywords: Digital Banking, E-Commerce Ecosystems, Cybersecurity, Financial Risk Management, Open Banking, API Security, Fraud Detection, Operational Resilience, Regulatory Compliance.

Introduction and Theoretical Context:

The global economy is currently experiencing an epochal structural transformation characterized by the hyper-digitization of trade, financial intermediation, and consumer transactions. Over the past two decades, financial institutions have evolved from traditional brick-and-mortar entities anchored by localized branch networks into distributed, software-defined ecosystems. Concurrently, commercial trade has undergone a parallel metamorphosis, shifting from localized physical commerce to globalized, always-on electronic commerce (e-commerce) markets. At the core of this joint evolution lies the seamless operational integration between digital banking infrastructure and e-commerce payment rails.

In contemporary commerce, the boundary separating a commercial transaction from a banking event has effectively dissolved. When a consumer places an order on an e-commerce

platform, a complex sequence of automated financial computations, risk assessments, identity verifications, and cross-institutional settlements is executed within milliseconds. This frictionless integration is enabled by Application Programming Interfaces (APIs), real-time gross settlement architectures, cloud micro services, and specialized payment gateway infrastructure. However, the exact structural characteristics that confer high operational efficiency and consumer convenience—namely, speed, openness, interconnectedness, and systemic automation—also introduce deep structural vulnerabilities.

As financial capital and commercial data circulate through global digital networks at non-zero operational latency, the exposure to malicious cyber actors and systemic financial instabilities has intensified. Cyber threats are no longer isolated perimeter incidents; they are systemic operational hazards capable of halting cross-border commerce, compromising sovereign economic infrastructure, eroding capital adequacy, and destroying institutional value. Consequently, modern financial risk management can no longer operate in silos, isolating traditional balance-sheet credit and liquidity risks from cyber and operational risks.

This research paper develops a holistic, interdisciplinary framework to analyze the quad-dimensional interaction between Digital Banking, E-Commerce, Cybersecurity, and Financial Risk Management. By examining theoretical foundations, empirical technological trends, and emerging regulatory directives, this article provides commercial leaders, financial practitioners, policy makers, and academic researchers with a roadmap for navigating the volatile, uncertain, and highly interconnected digital economy.

Paradigm Shift in Digital Commerce:

The complete operational integration of digital banking and e-commerce has eliminated transactional friction, but in doing so, it has merged financial contagion risk with cyber vulnerability—demanding an integrated, real-time risk management paradigm.

The Evolution of Digital Banking Architectures:

Digital banking has progressed far beyond rudimentary internet banking interfaces that merely rendered online account statements. Today's digital banking ecosystem encompasses a multi-layered spectrum of technological innovation, regulatory enablement, and novel operating models. Understanding these underlying architectural components is crucial for comprehending modern transaction velocity and risk exposure.

1. Neo-Banks and Challenger Bank Paradigms: Neo-banks—digital-native banking institutions operating without physical branch footprints—represent a structural departure from legacy core-banking platforms. Built upon modular cloud-native infrastructure, neo-banks leverage API-first architectures to deliver hyper-personalized financial services. By operating with substantially lower cost-to-income ratios than legacy banks, neo-banks pass cost savings onto consumers through lower transaction fees, higher deposit yields, and seamless embedded financial products. However, their reliance on third-party cloud service providers and vendor-managed middleware creates unique operational dependency risks.

2. Open Banking and Open Finance via Application Programming Interfaces (APIs): Open Banking mandates, such as the European Union's Revised Payment Services Directive (PSD2) and the Account Aggregator framework in India, have legally unbundled banking data and

services. By forcing traditional banks to securely expose customer-permissioned financial data to licensed Third-Party Providers (TPPs) via RESTful APIs, Open Banking has spurred an explosion of FinTech innovation. Open Finance expands this framework beyond deposit accounts to encompass investment portfolios, insurance contracts, mortgages, and credit history, enabling comprehensive real-time financial profiling.

3. Real-Time Retail Payment Systems (e.g., UPI, FedNow, Pix): The global landscape of retail payments has been revolutionized by real-time account-to-account (A2A) payment systems. India's Unified Payments Interface (UPI) serves as a gold standard globally, handling billions of transactions monthly with near-zero transactional latency and negligible cost. Similar real-time rails, such as Brazil's Pix and the US Federal Reserve's FedNow, have drastically altered liquidity velocity. While these systems accelerate commercial activity, they completely remove the traditional 'settlement delay window' during which fraudulent or erroneous transactions could historically be flagged and reversed.

4. Central Bank Digital Currencies (CBDCs) and Programmable Money: Monetary authorities globally are actively piloting Central Bank Digital Currencies (CBDCs)—both retail (rCBDC) and wholesale (wCBDC). CBDCs introduce sovereign programmable digital legal tender, promising to eliminate intermediary processing charges, lower cross-border remittance costs, and optimize liquidity management. Programmable money allows conditional payments (e.g., escrow release upon verified supply chain delivery), redefining smart legal contracts within e-commerce networks.

The Dynamics of The Modern E-Commerce Ecosystem:

The global e-commerce market has expanded beyond centralized digital marketplaces into a multi-channel, omnipresent ecosystem. To sustain high conversion rates, modern digital merchants rely heavily on embedded financial tools, frictionless checkout processes, and cross-border payment facilitators.

1. Embedded Finance and Buy-Now-Pay-Later (BNPL) Models: Embedded finance represents the integration of financial software directly into non-financial e-commerce platforms. A prime example is Buy-Now-Pay-Later (BNPL), which offers instantaneous, algorithmic point-of-sale micro-credit. While BNPL drives higher merchant cart values, it introduces significant credit evaluation challenges. Algorithm-driven credit assessments relying on alternative non-traditional data points often face unproven credit performance during macro-economic downturns.

2. Cross-Border E-Commerce and Foreign Exchange Mechanisms: Cross-border digital trade requires sophisticated automated foreign exchange (FX) settlement mechanisms. Modern merchants must handle multi-currency pricing, international tax compliance, dynamic currency conversion (DCC), and compliance with Anti-Money Laundering (AML) and Countering the Financing of Terrorism (CFT) mandates across multiple jurisdictions. The friction between real-time consumer expectations and complex international regulatory controls remains a primary source of transactional operational risk.

3. The Role of Payment Gateways and Aggregators: Payment gateways and aggregators serve as the critical conduit between e-commerce storefronts, card networks, acquiring banks, and issuing banks. They orchestrate payment routing, tokenization of sensitive cardholder data, 3D Secure multi-factor verification, and chargeback management. Because payment gateways collect immense volumes of personally identifiable information (PII) and card credentials, they represent high-value targets for cyber threat actors.

Cybersecurity Threat Landscape in Digital Financial Services:

As the economic incentives for digital fraud grow, cyber threat actors have transitioned from opportunistic hackers to highly organized, state-sponsored syndicates and enterprise-level Cybercrime-as-a-Service (CaaS) networks. The attack vectors targeted at digital banking and e-commerce systems are increasingly sophisticated, automated, and adaptive.

1. Advanced Persistent Threats (APTs) and Ransomware 2.0: Modern ransomware operations have evolved from simple file-encryption attacks into sophisticated multi-extortion campaigns. Cybercriminals exfiltrate sensitive customer databases, trade secrets, and financial records prior to encrypting core operating servers. If the financial institution or e-commerce merchant refuses to pay the decryption ransom, attackers threaten to publish stolen PII, report compliance breaches to regulatory authorities, or launch secondary Distributed Denial of Service (DDoS) attacks

2. AI-Powered Social Engineering, Phishing, and Deepfakes: The emergence of Generative Artificial Intelligence (GenAI) and Large Language Models (LLMs) has weaponized social engineering. Attackers deploy localized, context-aware phishing emails without grammatical errors, construct convincing voice deepfakes of corporate executives to authorize fraudulent wire transfers (Business Email Compromise - BEC), and execute synthetic identity fraud at scale.

3. API Exploits, Broken Object Level Authorization (BOLA), and Supply Chain Vulnerabilities: Because Open Banking and modern e-commerce architectures rely heavily on APIs, application vulnerabilities have become prime targets. Flaws such as Broken Object Level Authorization (BOLA) allow unauthorized users to manipulate API parameters and access arbitrary customer accounts. Furthermore, attack vectors increasingly target third-party software supply chains—compromising open-source software libraries, vendor SDKs, or cloud configuration scripts to gain access to enterprise banking databases.

4. Distributed Denial of Service (DDoS) and Botnet Threats: High-volumetric and application-layer (Layer 7) DDoS attacks represent an existential threat to digital commerce availability. Targeted botnets exploit thousands of compromised IoT devices to flood payment processing servers during peak shopping periods, causing severe reputational loss, transactional failure, and financial damages.

Critical Vulnerability Analysis:

In the modern digital banking landscape, APIs represent both the primary engine of business innovation and the single largest unmonitored operational attack surface for automated cyber intrusions

Financial Risk Management in The Digital Age:

The digitization of banking and commerce does not eliminate traditional financial risks—such as credit risk, liquidity risk, and operational risk—but radically alters their velocity, distribution, and systemic impact.

1. Liquidity Risk and Real-Time Capital Runoff: Traditional liquidity risk models assumed that bank runs would occur physically, constrained by branch operating hours and human queues. In the contemporary era of mobile banking apps, instant account-to-account transfers, and social-media-driven panic, deposit flight can occur at digital speeds. As demonstrated by high-profile bank failures globally, billions of dollars in deposits can be withdrawn within a matter of hours, presenting unprecedented structural challenges for bank asset-liability management (ALM).

2. Credit Risk and Algorithmic Underwriting Deficiencies: Automated credit scoring models utilize machine learning algorithms to evaluate unconventional data points (e.g., e-commerce transaction histories, mobile app telemetry, social footprint). While this enables instant credit decisioning for underserved populations, these models may exhibit severe algorithmic drift or bias during sudden macroeconomic shifts, leading to unexpected credit losses and rising Non-Performing Assets (NPAs).

3. Operational and Systemic Risk in Interconnected Networks: Operational risk under the Basel framework now heavily focuses on digital resilience. Systemic interconnectedness means that a cyber-outage at a primary cloud infrastructure provider or major payment processing clearinghouse can trigger immediate domino effects, halting thousands of e-commerce platforms and blocking millions of consumer transactions simultaneously.

The Intersection: How Cyber Atacks Translate to Financial Risks:

A critical weakness in conventional risk management is the failure to properly map cyber incidents directly to balance-sheet financial impacts. Cyber threats are direct financial risk multipliers across several primary vectors:

- Direct Asset Losses: Fraudulent wire transfers, unauthorized account drain, and ransom payments represent immediate capital leakage.
- Regulatory Fines & Penalties: Data privacy breaches incur severe statutory penalties under frameworks like GDPR or India's DPDP Act 2023.
- Litigation Costs: Class-action lawsuits filed by affected consumers or commercial partners following data breaches result in immense legal defense costs.
- Reputational Erosion and Customer Churn: Security breaches destroy consumer trust, leading to permanent drop-offs in platform active users and lost revenue.
- Operational Downtime and Restitution: System outages result in unrecoverable lost sales, operational business disruption, and expensive IT remediation fees.

Strategic Cybersecurity Defenses and Mitigation Paradigms

To counter the growing sophistication of cyber threats, financial institutions and e-commerce enterprises must deploy advanced, multi-layered defensive frameworks.

1. Zero Trust Architecture (ZTA): Traditional perimeter-based security models ('castle-and-moat') are completely obsolete in multi-cloud, distributed work environments. Zero Trust Architecture operates on the core dynamic imperative: 'Never Trust, Always Verify.' Every request for access—whether originating inside or outside the corporate network—must be rigorously authenticated, authorized, and continuously encrypted based on contextual identity data.

2. Machine Learning and AI in Real-Time Fraud Detection: Legacy rule-based fraud detection systems are incapable of coping with complex modern fraud patterns. Advanced financial organizations utilize real-time supervised and unsupervised Machine Learning models that analyze thousands of behavioral parameters—such as keystroke dynamics, device fingerprinting, geolocation anomalies, and velocity checks—to score and block fraudulent transactions within milliseconds.

3. Post-Quantum Cryptography (PQC) and Encryption Standards: The rapid advancement of quantum computing poses an existential risk to current public-key encryption infrastructure (such as RSA and ECC). Financial institutions must

begin migrating toward Post-Quantum Cryptography (PQC) standards to protect sensitive long-term transaction data against 'Harvest Now, Decrypt Later' threat vectors.

Regulatory, Legal, And Compliance Frameworks:

Regulatory authorities across the globe have enacted strict guidelines to ensure operational resilience and protect consumer data rights in digital finance.

1. The Digital Personal Data Protection (DPDP) Act, 2023 (India): India's DPDP Act mandates strict legal accountability for Data Fiduciaries handling personal information. Financial entities and e-commerce platforms must obtain explicit, informed consent, maintain absolute data accuracy, implement robust technical safeguards, and notify regulatory authorities and data principals immediately upon the occurrence of any personal data breach, under penalty of severe financial fines.

2. Reserve Bank of India (RBI) Cyber Security Framework and Guidelines: The RBI has mandated comprehensive cybersecurity controls for commercial banks, Urban Co-operative Banks (UCBs), and NBFCs. Key directives require the establishment of continuous Security Operations Centers (SOCs), mandatory Cyber Crisis Management Plans (CCMPs), rigorous third-party risk assessments, and real-time reporting of cyber incidents within strict statutory timeframes.

3. Global Mandates: Basel III Operational Resilience, GDPR, and PCI-DSS 4.0: Internationally, the Basel Committee's Principles for Operational Resilience (POR) require banks to maintain critical operations through severe disruptions. Simultaneously, the Payment Card Industry Data Security Standard (PCI-DSS 4.0) enforces enhanced requirements for multi-factor authentication, continuous monitoring, and cryptographic security for payment card data.

Integrated Enterprise Risk Management (Erm) Framework for Digital Finance:

To successfully navigate these interconnected domain challenges, organizations must break down historical silos between Chief Information Security Officers (CISOs), Chief Risk Officers (CROs), and Chief Financial Officers (CFOs). An Integrated ERM framework links technical cyber telemetry directly to financial risk appetite.

Key structural pillars of an Integrated ERM Framework include:

- Unified Cyber-Risk Quantification (CRQ): Utilizing financial modeling techniques (such as FAIR - Factor Analysis of Information Risk) to express cybersecurity risk in monetary values (Loss Event Frequency x Loss Magnitude).
- Cross-Functional Crisis Governance: Establishing joint cyber-financial incident response committees empowered to execute emergency operational protocols.
- Cyber Insurance Integration: Transferring residual, low-frequency/high-severity cyber risks to commercial cyber insurance markets while maintaining rigorous internal hygiene.
- Continuous Vendor and Third-Party Auditing: Enforcing strict security compliance, SLA performance metrics, and vulnerability testing across all external FinTech software partners.

Future Outlook and Strategic Recommendations:

As we look toward the next decade of digital financial evolution, emerging technologies such as Autonomous AI Agents, Decentralized Finance (DeFi), and Biometric Payment Systems will further reshape commercial trade. Organizations that proactively build resilient frameworks will maintain a distinct competitive advantage.

1. Key Strategic Recommendations for Commerce & Banking Practitioners:

- Adopt a Zero-Trust, API-First Security Posture: Institutionalize continuous identity verification and dynamic API perimeter protection across all internal and public endpoints.
- Automate Real-Time Financial Risk Analytics: Transition from delayed batch-processing risk reports to real-time risk evaluation dashboards integrated into transaction processing pipelines.
- Enhance Employee and Consumer Security Literacy: Conduct regular training on emerging social engineering threats, phishing recognition, and digital hygiene practices.
- Stress-Test Liquidity against Digital Scenarios: Incorporate ultra-rapid digital deposit flight and concurrent severe cyber-attack scenarios into bank asset-liability stress testing models.

Conclusion:

The convergence of digital banking, e-commerce, cybersecurity, and financial risk management represents both a monumental technological opportunity and a profound operational challenge. Frictionless digital commerce has driven unprecedented efficiency, global economic integration, and financial inclusion. However, the operational dependencies created by real-time settlement networks, open API ecosystems, and cloud architectures expose financial platforms to increasingly severe, rapid, and sophisticated cyber threats.

Achieving sustainable economic growth in this hyper-connected environment demands a fundamental shift in institutional mindset. Cyber resilience can no longer be treated as a pure IT concern, nor can financial risk management be confined to traditional accounting metrics. By adopting an Integrated Enterprise Risk Management approach—backed by Zero Trust security architectures, real-time AI fraud detection, proactive regulatory compliance, and cross-functional leadership—institutions can fortify their resilience against systemic shocks while fully capitalizing on the transformative potential of the digital economy.

References:

1. Basel Committee on Banking Supervision. (2021). Principles for Operational Resilience. Bank for International Settlements (BIS).
2. Government of India. (2023). The Digital Personal Data Protection Act, 2023. Gazette of India.
3. Reserve Bank of India. (2021). Master Direction - Digital Payment Security Controls. RBI Guidelines.
4. NIST. (2020). Zero Trust Architecture (NIST Special Publication 800-207). National Institute of Standards and Technology.
5. Payment Card Industry Security Standards Council. (2022). PCI DSS Requirements and Security Assessment Procedures Version 4.0.
6. World Economic Forum. (2024). Global Cybersecurity Outlook 2024. WEF Report Serie

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Start-Ups And The Indian Entrepreneurial Ecosystem

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Abstract:

The Indian entrepreneurial ecosystem has undergone a structural metamorphosis over the past decade, evolving from a localized, service-oriented IT cluster into the third-largest startup ecosystem globally. Driven by proactive government policies, rapid digitization via India Stack, expanded venture capital flows, and a demographic dividend, Indian startups are addressing critical socio-economic challenges across diverse domains such as FinTech, EdTech, AgriTech, HealthTech, and DeepTech. This research paper offers an exhaustive critical evaluation of the dynamics, institutional enablers, financing mechanisms, and structural bottlenecks shaping the Indian startup landscape. Furthermore, it examines the spatial democratization of entrepreneurship into Tier-2 and Tier-3 cities, the rise of women led enterprises, and the imperative transition toward environmental sustainability and climate action. Synthesizing empirical findings and contemporary market trends, the study provides actionable policy recommendations and strategic frameworks to ensure long-term viability, inclusive growth, and global competitiveness for Indian ventures in the coming decade.

Keywords: Startups, Indian Entrepreneurial Ecosystem, Venture Capital, Digital Public Infrastructure, DeepTech, Inclusive Growth, Government Policy, Tier-2/Tier-3 Innovation

Introduction and Background:

In the contemporary global economic landscape, entrepreneurship serves as the fundamental engine of innovation, productivity growth, structural transformation, and employment generation. Over the past two decades, India has emerged as one of the most vibrant and dynamic startup ecosystems in the world, ranking third globally behind only the United States and China. With over 120,000 recognized startups by the Department for Promotion of Industry and Internal Trade (DPIIT) as of recent estimates, and a burgeoning cohort of more than 110 unicorns across diverse sectors, the Indian enterprise narrative has shifted dramatically from legacy, family-owned business conglomerates toward tech-enabled, agile, and high-impact entrepreneurial ventures.

The catalyst for this metamorphosis lies in the convergence of several macro-level structural shifts. First, India's demographic dividend—characterized by a young, educated, and digitally native workforce—has provided a rich talent pool capable of solving complex engineering and business challenges. Second, the unprecedented expansion of telecommunications infrastructure, characterized by low-cost high-speed mobile data and high smartphone penetration, has integrated hundreds of millions of citizens into the digital economy. Third, proactive government initiatives, most notably the launch of the 'Startup India' movement in 2016, along with 'Digital India' and 'Make in India', have fundamentally altered the

regulatory, tax, and institutional landscape in favor of emerging business founders.

However, the rapid expansion of the startup ecosystem has not been without significant structural frictions. Recent global economic headwinds, rising interest rates, macroeconomic volatility, and heightened investor focus on path-to-profitability have ushered in a 'funding winter', exposing operational vulnerabilities across consumer-facing ventures. Issues surrounding corporate governance, regulatory compliance, valuation inflation, and spatial concentration in mega-cities like Bengaluru, Mumbai, and the National Capital Region (NCR) present ongoing hurdles to long-term sustainability. Consequently, a deep academic and empirical inquiry into the structural mechanics, institutional support structures, sectoral trends, and policy frameworks of the Indian startup ecosystem is both timely and essential for commerce scholars, policymakers, and industry practitioners.

Academic Reflection:

The Indian startup journey represents a historic shift from resource-based execution to knowledge-based innovation. Ensuring its long-term impact requires moving beyond valuation-driven growth toward sustainable, governance-first, and societal-value-driven business models.

Historical Evolution and Macroeconomic Phases:

To comprehend the modern architecture of India's startup ecosystem, it is vital to trace its historical trajectory through three distinct evolutionary phases. Each phase reflects distinct macroeconomic circumstances, technological paradigms, and investor sentiments.

1. Phase I: The IT Services Era and Early E-Commerce Pioneers (1990s – 2010): The seeds of modern Indian entrepreneurship were sown during the post-1991 economic liberalization period. The initial wave was dominated by information technology (IT) services and business process outsourcing (BPO) giants such as Infosys, TCS, and Wipro. These firms established India's reputation as a global technology hub and built crucial human capital in software engineering. By the mid-2000s, early internet pioneers began emerging in search, matchmaking, and travel services (e.g., Info Edge, MakeMyTrip). The late 2000s witnessed the inception of foundational e-commerce companies like Flipkart and Snapdeal, which adapted Western business models to the complex, fragmented Indian retail landscape.

2. Phase II: Hyper-Growth, Digital Onboarding, and Venture Capital Inflow (2011 – 2020): The second phase was catalyzed by the rapid deployment of 4G telecommunications, cheap smartphones, and massive inflows of global venture capital from funds such as SoftBank, Tiger Global, Sequoia Capital (now Peak XV Partners), and Accel. This era was characterized by intense market aggregation, customer acquisition strategies powered by deep discounting, and the rapid rise of consumer internet unicorns in mobility, food delivery, logistics, and digital payments (e.g., Paytm, Ola, Swiggy, Zomato). The introduction of the Unified Payments Interface (UPI) in 2016 served as a transformative catalyst, lowering transaction costs and democratizing digital commerce across social strata.

3. Phase III: Maturity, Realignment, and Sustainable Value Creation (2021 – Present): The current phase represents a structural shift from market share expansion at all costs toward fiscal discipline, unit economics, governance, and deep technological innovation. The post-pandemic surge initially drove record capital investments in 2021, followed by a global recalibration known as the 'funding winter'. In this phase, founders and investors are prioritizing

positive cash flows, strong operational governance, IPO readiness, and high-tech domains such as Artificial Intelligence, ClimateTech, Biotech, and Semiconductor Design. Simultaneously, entrepreneurship is decentralizing, moving into Tier-2 and Tier-3 cities across India.

Core Pillars of The Indian Startup Ecosystem:

A robust entrepreneurial ecosystem relies on the synchronized interaction of multiple institutional and structural pillars. In India, five primary pillars sustain startup creation and growth: Human Capital, Financial Capital, Digital Infrastructure, Incubators/Accelerators, and Government Regulatory Support.

1. Human Capital and Talent Pool: India produces over 1.5 million engineering graduates annually, alongside millions of commerce, management, and arts graduates. The presence of premier academic institutions such as the Indian Institutes of Technology (IITs), Indian Institutes of Management (IIMs), National Institutes of Technology (NITs), and leading central/state universities provides a deep repository of technical and managerial talent. Furthermore, returnee NRIs and professionals with experience in Silicon Valley or multinational corporations bring global domain expertise, venture scaling knowledge, and cross-border networks.

2. Financial Capital and Funding Ecosystem: The funding architecture of Indian startups has diversified significantly over the past decade. It spans an integrated capital continuum:

- Angel Investors & Networks: High-net-worth individuals and organized angel groups (e.g., Indian Angel Network, Mumbai Angels) providing pre-seed and seed capital.
- Venture Capital (VC) Funds: Domestic and international VC firms providing Series A through Series C capital for product-market fit and operational scaling.
- Private Equity & Sovereign Wealth Funds: Large institutions (e.g., SoftBank Vision Fund, Temasek, GIC) backing late-stage growth and unicorn-scale operations.
- Debt Financing & Venture Debt: Specialized funds (e.g., Alteria Capital, Stride Ventures) offering non-dilutive capital for working capital and equipment finance.
- Public Markets: Recent legal and market shifts have opened Indian stock exchanges (NSE and BSE) to tech startups, enabling successful IPOs for ventures like Zomato, Nykaa, Policybazaar, and Delhivery.

3. Digital Public Infrastructure (DPI) – The India Stack: Perhaps the most distinctive competitive advantage of the Indian ecosystem is its Digital Public Infrastructure, collectively known as the 'India Stack'. Comprising identity (Aadhaar), payments (UPI), and consent-based data sharing (Account Aggregator system and DigiLocker), DPI has drastically reduced Customer Acquisition Costs (CAC) and Know-Your-Customer (KYC) verification times. Startups can build innovative applications on top of these public rails, achieving rapid scale at a fraction of the cost required in other global jurisdictions.

4. Incubators, Accelerators, and Co-Working Spaces: The physical and institutional support system for early-stage ventures has expanded exponentially. Academic incubators housed within institutions like IIT Madras Incubation Cell, CIIE.CO at IIM Ahmedabad, and T-Hub in Hyderabad offer physical workspace, mentorship, legal guidance, and seed grants. Private accelerators (such as Y Combinator, Surge, and Techstars) alongside modern co-working spaces provide cross-industry collaboration opportunities.

Ecosystem Insight:

Digital Public Infrastructure (India Stack) has effectively reduced friction in identity verification, digital payments, and credit access, allowing Indian startups to achieve scale with unprecedented efficiency

Policy Enablers and Government Initiatives:

Recognizing the transformative potential of startups for employment and economic output, the Government of India has instituted a multi-pronged regulatory and financial support architecture.

1. Startup India Action Plan: Launched in January 2016, the Startup India initiative introduced a comprehensive framework aimed at simplification, handholding, funding support, and incentives. Key provisions include:

- Single Window Clearance: The Startup India Portal provides a unified platform for registration, compliance, and regulatory interactions.
- Tax Exemptions: Income tax exemptions under Section 80-IAC of the Income Tax Act for three consecutive years out of ten for eligible startups, along with exemption from Angel Tax under Section 56(2)(viib) subject to specified conditions.
- Self-Certification: Liberalized labor and environmental law compliance through self-certification for up to 3 to 5 years.
- Fast-Tracking Patents: 80% rebate in patent filing fees and 50% rebate in trademark applications, coupled with panel support for intellectual property protection.

2. Fund of Funds for Startups (FFS) and Credit Guarantee Scheme: To address the early-stage equity funding gap, the Government established the Fund of Funds for Startups (FFS) with a corpus of ₹10,000 Crore, managed by the Small Industries Development Bank of India (SIDBI). FFS does not invest directly in startups; instead, it commits capital to SEBI-registered Alternative Investment Funds (AIFs), which in turn invest in promising Indian ventures. Additionally, the Credit Guarantee Scheme for Startups (CGSS) provides collateral-free venture debt guarantees, encouraging institutional banks and NBFCs to extend credit to innovative enterprises.

3. Sector-Specific Policies: PLI, Atal Innovation Mission, and SAMRIDH: Beyond horizontal policy frameworks, targeted intervention schemes have accelerated innovation in strategic sectors:

- Atal Innovation Mission (AIM): Has established thousands of Atal Tinkering Labs (ATLs) in schools and dozens of Atal Incubation Centres (AICs) in universities to foster entrepreneurial mindsets from an early age.
- Production Linked Incentive (PLI) Schemes: Incentivizes domestic hardware manufacturing, drone manufacturing, electric vehicles, and active pharmaceutical ingredients (APIs), giving rise to hardware startups.
- SAMRIDH and MeitY Schemes: Offer seed funding, acceleration, and commercialization support for software product entities.

Sectoral Analysis: Traditional High-Growth Vs. Emerging Deeptech:

The Indian startup landscape displays remarkable sectoral diversity, spanning both consumer-facing service aggregators and sophisticated research-driven technology enterprises.

1. Financial Technology (FinTech): FinTech remains the largest recipient of venture capital in India. Powered by UPI, open banking, and Aadhaar-based e-KYC, FinTech startups have revolutionized retail payments, micro-lending,

insurtech, wealth management, and neo-banking. Companies like PhonePe, Paytm, Razorpay, and Zerodha have democratized financial services, extending formal financial inclusion to millions of previously unbanked citizens.

2. E-Commerce, Quick-Commerce, and Supply Chain Logistics: Retailing in India has undergone a multi-stage transformation. Following traditional e-commerce, the market saw the rapid emergence of 'Quick Commerce' (10 to 15-minute delivery models) led by platforms such as Blinkit, Zepto, and Instamart. This hyper-fast delivery ecosystem relies on dense networks of micro-warehouses ('dark stores') and real-time algorithmic dispatch systems, fundamentally altering urban consumer behavior.

3. Educational Technology (EdTech): EdTech experienced explosive growth during the COVID-19 pandemic, driven by test preparation, K-12 supplemental learning, and professional upskilling (e.g., Byju's, Unacademy, PhysicsWallah, UpGrad). However, the post-pandemic reopening of physical institutions highlighted operational over-expansion, leading to consolidation, hybrid offline-online models, and an intensified focus on measurable learning outcomes.

4. Agriculture Technology (AgriTech): Given that agriculture employs nearly half of India's workforce, AgriTech ventures (e.g., DeHaat, Ninjacart, WayCool) address deep structural inefficiencies in agricultural supply chains, market linkages, quality assessment, precision farming, and input procurement. By leveraging Internet of Things (IoT) sensors, satellite imagery, and mobile platforms, AgriTech startups are enhancing farm-gate realization and reducing post-harvest losses.

5. DeepTech, ClimateTech, and SpaceTech: The New Frontier: The current frontier of Indian entrepreneurship is moving toward research-intensive technologies:

- DeepTech & AI: Generative AI applications, natural language processing for regional Indian languages, computer vision for industrial automation, and edge computing.
- ClimateTech & Clean Energy: Electric Vehicle (EV) OEMs, battery management systems (BMS), battery swapping networks, solar asset monitoring, and circular economy platforms.
- SpaceTech & DefenceTech: Following the privatization of the space sector through IN-SPACe, startups like Agnikul Cosmos, Skyroot Aerospace, and Pixxel are manufacturing indigenous launch vehicles, small satellites, and hyperspectral imagery platforms.

Sectoral Metamorphosis:

The transition from consumer internet aggregators to DeepTech and SpaceTech ventures demonstrates the increasing scientific complexity and value creation capabilities of Indian entrepreneurs.

Geographical Democratization and Social Inclusivity:

Historically, startup activity in India was heavily concentrated in three major metropolitan hubs: Bengaluru, the National Capital Region (Delhi-NCR), and Mumbai. However, recent empirical trends show a significant spatial and social democratization of entrepreneurship.

1. The Rise of Tier-2 and Tier-3 Startup Hubs: Today, over 45% of DPIIT-recognized startups emerge from Tier-2 and Tier-3 cities such as Jaipur, Ahmedabad, Kochi, Indore, Coimbatore, Chandigarh, Bhubaneswar, and Hubballi-Dharwad. Several factors drive this decentralization: lower operational costs, reduced employee attrition, improving digital

infrastructure, and a deep understanding of local consumer needs ('Bharat' users). Regional innovation clusters are fostered by state-level startup policies, university incubators, and localized angel networks.

2. Women Entrepreneurship and Gender Inclusivity: Promoting women-led enterprises is vital for maximizing socio-economic output. Initiatives such as the Women Entrepreneurship Platform (WEP) by NITI Aayog, specialized bank credit schemes (e.g., Stree Shakti, Mudra Yojana), and dedicated venture funds are supporting female founders. Women-led startups are creating substantial impact across sectors like healthcare, social commerce, artisan aggregation, education, and sustainable consumer goods.

Challenges, Structural Bottlenecks, And Risk Vulnerabilities:

Despite remarkable accomplishments, the Indian entrepreneurial ecosystem faces systemic structural, regulatory, and financial challenges that threaten long-term stability.

1. The Funding Winter and Valuation Realignment: Following the liquidity-fueled boom of 2020–2021, global macroeconomic headwinds, monetary tightening by central banks, and geopolitical conflicts led to a sharp contraction in late-stage venture capital. Investors shifted focus from top-line revenue growth to positive unit economics, EBITDA margins, and sustainable operational cash flows. Many startups faced down-rounds, restructuring, lay-offs, or liquidation.

2. Corporate Governance and Compliance Failures: Rapid scaling without adequate internal controls led to high-profile corporate governance lapses across several prominent ventures. Issues such as financial misstatement, related-party transactions, lack of independent board oversight, and tax non-compliance highlighted the urgent need for professional management, robust audit frameworks, and ethical leadership in growing ventures.

3. Intellectual Property (IP) and R&D Underinvestment: Compared to global innovation leaders like the US, Israel, and China, India's gross expenditure on Research and Development (GERD) remains low at under 0.7% of GDP. Commercialization of academic research remains fragmented, and patent grant cycles, while improving, require further streamlining to protect proprietary deeptech innovations effectively.

4. Regulatory Ambiguity and Exit Bottlenecks: Startups frequently face evolving regulatory landscapes in domains such as fintech, data privacy (Digital Personal Data Protection Act), cryptocurrency, and gaming. Furthermore, exit options for early investors—while improved by public market listings—remain constrained by limited domestic institutional capital participation and complex cross-border merger and acquisition (M&A) regulations.

Sectoral Comparative Matrix:

The following comparative framework outlines key metrics across major sectors within the Indian startup ecosystem:

Sector	Key Growth Drivers	Capital Intensity	Primary Regulatory Body	Ecosystem Maturity
FinTech	UPI, Aadhaar e-KYC, Financial Inclusion	Medium - High	RBI / SEBI / IRDAI	High (Mature)
AgriTech	Supply Chain Inefficiency, IoT, Satellite Data	Medium	Ministry of Agriculture / NABARD	Emerging - High Growth
EdTech	Upskilling, Test Prep, Hybrid Models	High	Ministry of Education / UGC	Consolidating
DeepTech& AI	Generative AI, Regional NLP, Automation	Very High	MeitY / DST / DPIIT	Early Stage - High Potential
ClimateTech	EV Transition, Net-Zero Targets, Battery Tech	High - Very High	Ministry of Power / MoEFCC	Rapid Growth

Strategic Recommendations and Future Roadmap:

To transition from a market-aggregation startup model to an innovation-driven global powerhouse, key stakeholders across government, academia, industry, and venture capital must collaborate on targeted strategic imperatives:

1. Strengthening Corporate Governance and Board Oversight: Early-stage ventures must establish independent advisory boards and implement strict financial reporting, risk management, and compliance standards prior to rapid capital deployment.
2. Expanding Domestic Capital Networks: To reduce dependence on volatile foreign venture capital, policy incentives should encourage domestic institutional investors—such as Indian pension funds, insurance companies, and family offices—to allocate capital into SEBI-registered Alternative Investment Funds (AIFs).
3. Institutionalizing University-Industry R&D Translation: Higher education institutions must upgrade technology transfer offices (TTOs), allow faculty and researchers to commercialize patents, and foster industry-backed research labs focused on deep science, robotics, and clean energy.
4. Deepening Regional Acceleration in Tier-2/3 Clusters: State governments should build specialized incubation facilities tailored to regional economic strengths (e.g., textile-tech in Surat, agri-processing in Dharwad, electronics in Coimbatore), backed by localized seed funds.
5. Streamlining Regulatory and IP Processes: Further simplifying regulatory procedures under the Companies Act, fast-tracking patent grant timelines, and creating clear regulatory sandboxes for emerging technologies will encourage indigenous innovation.

Conclusion:

The Indian entrepreneurial ecosystem stands at a critical juncture. Having rapidly expanded into the world's third-largest startup hub through consumer internet applications and digital payment adoption, the ecosystem is now entering a mature phase defined by technological complexity, financial discipline, and broad geographic reach. The seamless integration of Digital Public Infrastructure (India Stack), strong policy initiatives like Startup India, and an

energetic founder community position India as a key driver of global technology and business innovation.

Overcoming structural challenges—including corporate governance gaps, research funding constraints, and valuation realignments—requires concerted collaboration among founders, institutional investors, academic institutions, and regulatory authorities. By prioritizing sustainable unit economics, deeptech R&D, regional democratization, and environmental stewardship, India's startup ecosystem will not only generate high-quality employment and economic wealth but also engineer sustainable solutions for complex socio-economic challenges across the Global South.

References:

1. Ahluwalia, M. S. (2019). 'Economic Reforms in India: Achievements and the Road Ahead.' Journal of Economic Perspectives, 33(4), 155-172.
2. Bain & Company. (2024). 'India Venture Capital Report 2024: Navigating the Realignment Phase.' Bain & Company Insights.
3. Department for Promotion of Industry and Internal Trade (DPIIT). (2025). 'Startup India Annual Status Report and Ecosystem Overview.' Ministry of Commerce and Industry, Government of India.
4. NITI Aayog. (2023). 'Building India's DeepTech and Innovation Ecosystem: Policy Imperatives and Action Plan.' Government of India, New Delhi.
5. Reserve Bank of India (RBI). (2024). 'Report on Digital Lending, FinTech Evolution, and Financial Stability.' RBI Bulletin.
6. NASSCOM. (2024). 'Indian Tech Startup Ecosystem: Year of Realignment and DeepTech Ascent.' NASSCOM-Zinnov Report.
7. Sharma, A., & Gupta, V. (2023). 'Digital Public Infrastructure as a Growth Catalyst: Lessons from India's Unified Payments Interface.' Journal of Financial Innovation & Commerce, 18(2), 89-104.
8. World Economic Forum. (2024). 'Harnessing Entrepreneurship for Inclusive Growth in Emerging Economies.' WEF Special Report.

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Artificial Intelligence And Emerging Technologies In Commerce Transforming Business, Markets and Consumer Behaviour

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Abstract:

Artificial Intelligence (AI) and emerging digital technologies are fundamentally transforming contemporary commerce. The rapid development of Artificial Intelligence, Generative Artificial Intelligence (GenAI), machine learning, blockchain, Internet of Things (IoT), cloud computing, robotic process automation, big data analytics and digital payment technologies has changed the manner in which businesses create value, interact with customers, manage resources and compete in domestic and international markets. AI has moved beyond traditional automation towards intelligent decision-making, predictive analytics, personalised marketing, conversational commerce and increasingly autonomous business processes. This research paper examines the role and emerging applications of AI and related technologies in commerce, with emphasis on e-commerce, retailing, digital marketing, financial transactions, supply-chain management, customer relationship management and business decision-making. The study adopts a conceptual and descriptive research approach based on a review of secondary literature, institutional reports and research publications. It analyses opportunities created by emerging technologies, including improved operational efficiency, reduction in transaction costs, enhanced customer experience, data-driven decision-making, market expansion and development of innovative business models. At the same time, it examines challenges associated with data privacy, cybersecurity, algorithmic bias, employment displacement, digital inequality, technological dependence and ethical governance. The paper argues that the future of commerce will increasingly involve collaboration between human decision-makers and intelligent technological systems rather than simple replacement of human activities. Businesses that combine AI with appropriate digital infrastructure, skilled human resources, responsible governance and customer-centric strategies can respond more effectively to changing market conditions. The study concludes that responsible adoption of AI and emerging technologies is essential for sustainable, inclusive and innovative growth in the evolving digital economy.

Keywords: Artificial Intelligence; Emerging Technologies; Digital Commerce; Business Transformation

Introduction:

Commerce has continuously evolved with technological development. The transition from physical marketplaces to digital platforms has changed how products and services are produced, marketed, exchanged and consumed. The internet, smartphones, cloud computing, digital payments and social-media platforms created the foundation for modern e-commerce. The present phase of transformation is increasingly characterised by Artificial Intelligence (AI), Generative AI, machine learning, blockchain, Internet of Things (IoT), big data analytics and intelligent digital platforms.

AI is particularly significant because it enables systems to perform activities associated

with human intelligence, including pattern recognition, prediction, language processing, recommendation and decision support. Unlike earlier rule-based automation, modern AI can process large volumes of structured and unstructured information and produce predictions, recommendations and content. OECD research notes that AI adoption has accelerated across firms, although adoption remains uneven by sector, firm size and location. This uneven diffusion is relevant to commerce because technological capability increasingly forms part of competitive capacity.

Generative AI has expanded the commercial role of AI by enabling systems to produce text, images, software code, summaries and other digital outputs. In commerce, these capabilities can support advertising, customer communication, product descriptions, market research and business reporting. Agentic AI is another emerging development: AI systems can perform sequences of tasks, use tools and adapt actions toward defined goals. OECD analysis identifies potential effects on customer engagement, workflow automation, search and market intermediation.

The transformation is not purely technological. It affects organisational structures, employment patterns, consumer behaviour, competition, regulation and business strategy. Understanding AI in commerce therefore requires attention to both opportunities and risks. This paper examines the role of AI and emerging technologies in commerce and their implications for businesses, consumers, employees and the wider digital economy.

Review of Literature:

Recent institutional literature demonstrates that AI is becoming increasingly integrated into commerce and international trade. The OECD's revised 2025 definition of e-commerce explicitly provides guidance on AI-assisted transactions and emerging ordering channels, reflecting changes in the way digital commerce is measured. The OECD also reports that AI adoption varies substantially among firms and regions, with skills shortages, costs, data protection concerns and technological lock-in acting as barriers to diffusion.

The World Trade Organization's World Trade Report 2025 examines AI as a factor in global trade and identifies channels through which AI can reduce trade costs, improve supply-chain visibility, facilitate compliance and support market participation. Its analysis also emphasises that infrastructure, skills and regulatory coordination influence whether the benefits of AI are broadly distributed.

The World Economic Forum's work on consumer industries identifies applications of AI across planning, innovation, customer engagement, operations and supply chains. It highlights generative and agentic AI as developments that may enable process automation, intelligent decision-making and greater personalisation. The report also identifies workforce training, digital infrastructure and responsible governance as important enablers.

OECD work on competitive dynamics indicates that generative and agentic AI can affect market structure by lowering some barriers to entry, supporting product differentiation and changing the minimum efficient scale of operations. At the same time, data access, model restrictions, vertical integration and algorithmic conduct can create new competition concerns. These studies suggest that AI should be examined not only as a productivity technology but also as an institutional and market-structure issue.

The literature therefore points to three broad themes: AI can improve efficiency and innovation; adoption is uneven and dependent on skills, infrastructure and organisational

capabilities; and governance is necessary to address privacy, competition, security, accountability and inclusion.

Objectives of The Study:

1. To examine the role of Artificial Intelligence and emerging technologies in modern commerce.
2. To identify major applications of AI in e-commerce, retail, marketing, finance and supply-chain management.
3. To analyse the impact of emerging technologies on business efficiency and consumer behaviour.
4. To examine opportunities and challenges associated with AI-enabled commerce.
5. To discuss implications of AI for employment, skills and business decision-making.
6. To suggest measures for responsible and sustainable adoption of emerging technologies in commerce.

Research Methodology:

The study adopts a descriptive and conceptual research methodology based on secondary data. Information has been reviewed from publications of the OECD, WTO, World Economic Forum and other relevant institutional and academic sources concerning Artificial Intelligence, digital commerce, international trade and emerging technologies. The approach is qualitative and analytical rather than econometric. The paper synthesises documented developments and identifies their implications for commerce. It does not attempt to estimate the financial performance of individual firms. The limitations of a conceptual study include dependence on the scope and quality of existing secondary literature and the rapid pace at which AI technologies evolve.

Artificial Intelligence in Commerce:

AI is increasingly used in commercial decision-making because businesses generate large amounts of information through transactions, customer interactions, websites, mobile applications, social media and payment systems. AI can process these data to identify patterns and produce commercially useful insights.

Predictive analytics is a major application. Businesses can use AI to forecast demand, identify potential customers, estimate sales and detect unusual transactions. AI-based customer service can answer routine questions, provide product information and support customers beyond conventional business hours. Generative AI can make these interactions more flexible by interpreting natural language and generating context-sensitive responses.

Personalisation is another important application. Online businesses can analyse browsing and purchasing behaviour to recommend products and services. Recommendation systems allow businesses to provide different information to different customers based on relevant data.

AI also supports inventory management. By analysing historical sales, seasonal patterns, consumer behaviour and other variables, businesses can improve forecasts and inventory planning. Better forecasting can reduce stock-outs and excess inventory, although results depend on data quality and the operational context.

Generative AI And Business Transformation:

Generative AI represents a significant expansion of AI capability. Traditional software generally performs defined tasks according to programmed rules, whereas generative systems can create new content based on instructions and context.

In marketing, Generative AI can assist with advertising copy, product descriptions, social-media content and customer communications. In human resource management it can support job descriptions, training material and document preparation. In finance and accounting it can assist with document review, reporting and preliminary analysis. In business research it can summarise large amounts of material and support the preparation of analytical drafts.

However, generated content can contain factual errors, unsupported statements or inappropriate outputs. Human verification is therefore essential, particularly where information affects financial, legal, employment or customer decisions. Generative AI is best understood as a productivity and decision-support tool that requires suitable oversight rather than as an unquestionable source of information.

AI And E-Commerce:

E-commerce is one of the areas most directly affected by AI because digital transactions generate substantial amounts of behavioural and transactional data. Applications include intelligent search, product recommendations, personalised advertising, customer-service chatbots, fraud detection, demand forecasting, inventory optimisation and automated content generation.

AI can improve online shopping by helping customers find products and compare relevant information. The emergence of AI shopping assistants and agents may change the discovery process further. The OECD's 2025 e-commerce definition specifically recognises AI-assisted transactions and emerging ordering channels, illustrating that AI is becoming part of the architecture of digital commerce.

For businesses, this creates both opportunities and adjustment costs. Product information may increasingly need to be structured so that AI systems can interpret it accurately. Companies may also have to consider how consumers encounter products through AI-mediated interfaces rather than through conventional website navigation.

AI In Digital Marketing:

Marketing has traditionally relied on customer research, segmentation and promotional campaigns. AI enables these activities to become increasingly data-driven. Systems can analyse customer interactions across websites, applications and social platforms and identify patterns relevant to segmentation and targeting.

AI can support personalised recommendations and advertising, while Generative AI can produce alternative versions of promotional material for different audiences and channels. Sentiment analysis can also help organisations understand customer feedback.

However, personalisation raises privacy and transparency issues. Customers may not always understand how information about their behaviour is used. Responsible marketing therefore requires appropriate data governance, transparency and compliance with applicable privacy requirements.

AI And Supply-Chain Management:

Supply chains involve suppliers, manufacturers, warehouses, logistics providers, distributors and customers. Disruptions at one point can affect the wider system. AI can support demand forecasting, inventory planning, supplier evaluation, route optimisation, predictive maintenance, warehouse management and risk identification.

IoT complements AI by connecting physical assets and sensors. Sensors can provide information about inventory, vehicle location, temperature, equipment condition and other

operational variables. AI can analyse these data and identify patterns or potential problems.

The World Economic Forum identifies AI applications across planning, operations and supply chains, while the WTO reports that AI can improve supply-chain visibility and facilitate trade-related processes. The combination of AI, IoT and cloud computing can therefore support more responsive and data-driven supply-chain management.

Blockchain And Commerce:

Blockchain is an emerging technology that provides a distributed method of recording transactions. Potential commercial applications include digital payments, supply-chain traceability, smart contracts, digital identity and product authentication.

In supply chains, blockchain can provide records of transactions across multiple stages of a product journey. This may be useful where provenance and authenticity are important. Smart contracts can automate predefined actions when specified conditions are satisfied.

At the same time, blockchain adoption faces challenges involving scalability, technical complexity, governance, interoperability and, for some blockchain architectures, energy consumption. Its commercial value therefore depends on the specific use case rather than on technology adoption alone.

Internet Of Things, Cloud Computing and Big Data:

The Internet of Things connects physical devices that collect and exchange information. In commerce, IoT can support inventory monitoring, store operations, vehicle tracking and equipment management. When IoT data are combined with AI, businesses can move from data collection towards prediction and automated response.

Cloud computing provides scalable computing, storage and software resources. It has reduced the need for many organisations to maintain all computing infrastructure internally. Cloud services can support AI applications, analytics and digital commerce platforms.

Big data analytics provides the information base for many AI applications. Transaction histories, customer interactions, operational records and external market information can be analysed to support commercial decisions. The effectiveness of these systems nevertheless depends on data quality, security and governance.

AI And Digital Payments:

Digital payments have changed the speed and convenience of commercial transactions. Mobile payments, digital wallets, online banking and real-time payment systems have expanded the role of digital financial services.

AI can support payment security through fraud detection and anomaly monitoring. Machine-learning systems can identify unusual transaction patterns and trigger additional verification. AI may also support risk assessment and customer-service processes in financial services.

However, algorithmic financial decisions require careful governance. Poor-quality or biased data can result in inaccurate outcomes. Security systems must also protect sensitive financial information from cyber threats. The commercial value of AI in finance therefore depends on reliability, security and accountability as well as technical capability.

AI and Consumer Behaviour:

Emerging technologies are changing consumer expectations. Customers increasingly seek fast service, personalised recommendations, multiple payment options, convenient digital

transactions, easy product comparison and rapid delivery.

AI can respond to these expectations through personalised interfaces, recommendation systems and automated support. AI shopping agents could further alter behaviour by allowing customers to communicate their requirements in natural language and receive assistance across multiple commercial options.

This development may change the relationship between consumers, brands and digital intermediaries. Businesses may gain new ways to engage customers but may also have less direct control over how products are discovered and compared. Transparency about recommendations and commercial relationships may therefore become increasingly important.

AI and Business Decision-Making:

Business decisions have traditionally relied on managerial experience, financial information and market research. AI adds analytical capability by processing large datasets and identifying patterns. Applications include sales forecasting, market analysis, customer segmentation, risk assessment, inventory planning and scenario analysis.

AI-generated outputs should be evaluated in their business context. Commercial decisions often involve legal, ethical, social and strategic factors that cannot be fully captured by numerical patterns. Effective AI-enabled management therefore requires a combination of machine-supported analysis and human judgement.

AI and Employment in Commerce:

The employment effects of AI are complex. Automation can reduce the time required for repetitive activities such as routine data entry, basic document processing and standard customer enquiries. At the same time, AI can create demand for new skills in data analysis, AI operations, digital marketing, cybersecurity and technology governance.

The likely organisational effect is therefore not limited to simple replacement. Job tasks can be redesigned, with employees spending less time on repetitive work and more on analytical, creative, interpersonal and supervisory activities. OECD research also highlights skills shortages as a barrier to AI adoption. Workforce training and reskilling are consequently central to effective technological transformation.

Opportunities Created by AI And Emerging Technologies:

AI and emerging technologies can create several commercial opportunities. First, automation can improve efficiency and reduce the time required for routine activities. Second, predictive analytics can improve planning and decision support. Third, personalised services can improve customer engagement. Fourth, digital platforms can help firms reach wider markets. Fifth, AI can support innovation in products, services and business models.

The WTO reports that AI can lower trade costs and support firms in navigating trade processes, while its 2025 World Trade Report identifies applications including supply-chain visibility, customs-related processes, market intelligence and regulatory support. Such applications may be particularly relevant to small and medium-sized enterprises if access to infrastructure and skills improves.

Challenges and Risks:

The principal challenges include data privacy, cybersecurity, algorithmic bias, employment disruption, digital inequality, lack of transparency, technology dependence and ethical governance.

Data-intensive commerce increases the importance of protecting personal and

commercial information. Cybersecurity becomes more important as businesses connect more systems and automate more processes. Algorithmic bias can arise from biased or incomplete training data. Smaller firms and regions may face higher adoption barriers because of cost, skills shortages or limited infrastructure. OECD research on emerging AI divides identifies differences across firms and regions and notes that legal, data-protection, skills, cost and technology lock-in concerns can slow adoption.

AI systems can also create accountability questions when decisions are difficult to explain or when multiple technology providers are involved. Responsible adoption therefore requires governance frameworks that address data, security, human oversight, auditability and accountability.

Agentic Commerce:

Agentic commerce refers to commercial processes in which AI agents can perform multiple connected activities toward a defined goal. A consumer might specify product requirements, budget and delivery preferences and receive AI assistance in researching and comparing options.

This could alter the conventional e-commerce journey, in which consumers manually search, compare and purchase. AI-mediated discovery may become an additional layer between consumers and sellers. OECD analysis identifies agentic AI as a developing technology with possible implications for search, workflow automation and customer engagement.

The development also raises questions about consumer choice, market access, transparency, data use and accountability. Because agentic systems remain an evolving technology, further empirical research is required to understand their long-term commercial effects.

Implications For Small and Medium Enterprises:

SMEs can potentially use AI, cloud services, digital marketing, online marketplaces and automated customer service without developing extensive internal infrastructure. This can lower some barriers to participation in digital markets.

However, SMEs may face constraints related to technology costs, employee skills, data quality, cybersecurity and dependence on external providers. Policy and industry support for digital skills, secure infrastructure and accessible technology can therefore influence the extent to which SMEs benefit from AI-enabled commerce.

The WTO and OECD both emphasise that infrastructure and capabilities affect the distribution of AI-related benefits. Inclusive digital transformation therefore requires attention to firms that have fewer financial and technological resources.

Implications For Commerce Education:

Commerce education traditionally emphasises accounting, finance, economics, management, marketing and business law. These disciplines remain fundamental, but commerce graduates increasingly need technological literacy.

Curricula can incorporate AI, data analytics, digital marketing, FinTech, blockchain, cybersecurity, e-commerce, business intelligence and technology ethics. Students do not necessarily need to become computer scientists; rather, they should understand how technologies affect business processes, decisions, risks and opportunities.

Practical exposure to data analysis, AI-assisted research and digital business models can help students connect theoretical commerce knowledge with contemporary business environments.

Future Trends:

Several developments are likely to shape commerce. AI-powered shopping assistants may become more capable; personalisation may become more sophisticated; supply chains may use greater levels of automation; financial services may expand AI-based monitoring; and physical retail may combine sensors, computer vision and analytics.

The rise of agentic AI may increase automation across workflows and customer engagement. At the same time, responsible AI governance is likely to become more important as businesses integrate AI into consequential activities. The World Economic Forum identifies leadership, workforce training, digital infrastructure and responsible governance as important enablers for scaling AI in consumer industries.

Findings of The Study:

The conceptual review produces the following findings:

1. AI is becoming an important component of modern commerce.
2. Generative AI is expanding AI applications into content creation and knowledge work.
3. E-commerce is moving towards more personalised and AI-assisted customer experiences.
4. AI can support demand forecasting, marketing, customer service and supply-chain management.
5. IoT, cloud computing and big data provide important infrastructure for AI-enabled commerce.
6. Blockchain has potential applications in traceability, payments and smart contracts.
7. AI creates opportunities for SMEs but adoption is constrained by skills, costs and infrastructure.
8. AI is changing job tasks and increasing demand for digital and analytical skills.
9. Privacy, cyber security, bias and accountability remain significant concerns.
10. Agentic AI may change digital intermediation and customer engagement, although its long-term effects require further evidence.
11. Responsible governance and human oversight are necessary for sustainable adoption.
12. Commerce education needs greater integration of AI and digital-business capabilities.

Suggestions:

1. Businesses should develop AI strategies linked to specific organisational objectives.
2. Employee training and reskilling should accompany technological adoption.
3. Strong data governance should be established to protect customer and business information.
4. Human oversight should remain part of significant financial, employment and customer decisions.
5. SMEs should receive appropriate support for digital infrastructure and skills development.
6. Commerce curricula should incorporate AI, data analytics and digital business.
7. AI systems should be evaluated for accuracy, security, bias and operational effectiveness.
8. Organisations should establish clear policies covering privacy, accountability and responsible AI use.
9. Consumers should receive appropriate transparency where AI materially affects recommendations or transactions.
10. Future research should use empirical data to examine productivity, employment, consumer behaviour and firm-level outcomes.

Conclusion:

Artificial Intelligence and emerging technologies are reshaping the foundations of modern commerce. Their influence extends beyond e-commerce and digital payments to marketing, customer service, supply-chain management, financial services, analytics and strategic decision-making.

Generative AI and agentic AI represent an important new phase. Generative systems expand the ability of businesses to create and process information, while agentic systems may increasingly perform sequences of commercial activities with limited human intervention. These developments create opportunities for efficiency, innovation, personalisation and market access, but they also introduce challenges involving privacy, cybersecurity, employment, inequality, bias and accountability.

The future of commerce will depend not only on technological capability but also on organisational readiness, skills, infrastructure and governance. AI should therefore be treated as part of a broader commercial transformation rather than simply as an automation tool. Businesses need to combine technology with human expertise, appropriate governance and continuous learning.

For commerce education, this transformation creates a responsibility to integrate technological literacy with established business disciplines. Knowledge of AI, data analytics, FinTech, blockchain, IoT and digital commerce can help future professionals understand changing business environments.

Ultimately, sustainable AI-enabled commerce requires responsible integration of technology into economic and social systems. The key challenge is to capture the benefits of innovation while maintaining security, transparency, accountability and appropriate human oversight.

References:

1. Filippucci, F., Gal, P., Laengle, K., Schief, M., & Yildirim, M. A. (2026). AI meets trade: Global linkages and the cross-country distribution of the gains from AI (OECD Artificial Intelligence Papers No. 57). OECD Publishing. https://doi.org/10.1787/13081644-en
2. Kergroach, S., & Héritier, J. (2025). Emerging divides in the transition to artificial intelligence (OECD Regional Development Papers No. 147). OECD Publishing. https://doi.org/10.1787/7376c776-en
3. OECD. (2025). Artificial intelligence and competitive dynamics in downstream markets (OECD Roundtables on Competition Policy Papers No. 331). OECD Publishing. https://doi.org/10.1787/ccf0624a-en
4. OECD. (2025). The 2025 OECD definition of e-commerce and guidelines for interpretation. OECD Publishing. https://doi.org/10.1787/2254f1de-en
5. OECD. (2022). Artificial intelligence and international trade: Some preliminary implications (OECD Trade Policy Papers No. 260). OECD Publishing. https://doi.org/10.1787/13212d3e-en
6. World Economic Forum. (2025). Transforming consumer industries in the age of AI. World Economic Forum.
7. World Economic Forum. (2025). Artificial intelligence for efficiency, sustainability and inclusivity in TradeTech. World Economic Forum.
8. World Trade Organization. (2025). World Trade Report 2025: Making trade and AI work together to the benefit of all. WTO.
9. World Trade Organization. (2026). AI for trade. WTO.

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India's Changing Tax System: Issues, Reforms, And Challenges A Comprehensive Analysis of Direct and Indirect Tax Policy Dynamics, Digital Modernization, and Fiscal Federalism

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Abstract:

The tax architecture of a nation serves as the primary backbone of its fiscal sovereignty, socio-economic redistribution, and macroeconomic stabilization. Over the past three decades, and with accelerated intensity during the last decade, India's tax system has undergone a paradigm structural shift—transitioning from an opaque, fragmented, high-tariff, physical-scrutiny regime toward a modern, unified, technology-driven, and destination-based framework. This research paper presents a comprehensive academic investigation into India's evolving tax landscape, analyzing major direct and indirect tax reforms, including the landmark introduction of the Goods and Services Tax (GST), corporate rate rationalizations, the dual personal income tax framework, faceless assessment mechanisms, and digital tracking tools like the Annual Information Statement (AIS) and e-Invoicing. The study critically evaluates core structural issues such as tax base narrowness, compliance burdens on MSMEs, persistent tax litigation backlogs, inverted duty structures, and post-compensation fiscal federalism challenges. Furthermore, it examines emerging global tax dimensions including OECD Pillar One and Pillar Two initiatives, digital economy taxation, and green tax frameworks. The paper concludes with actionable strategic recommendations for enacting a simplified Direct Taxes Code (DTC), rationalizing GST into a three-tier structure, expanding alternative dispute resolution, and balancing automated surveillance with taxpayer rights.

Keywords: Tax Reforms, Goods and Services Tax (GST), Direct Taxes Code, Tax Compliance, Faceless Assessment, Fiscal Federalism, Base Erosion and Profit Shifting (BEPS), Input Tax Credit (ITC)

Introduction & Historical Evolution of The Indian Tax Architecture:

Taxation in India is not merely a revenue-raising mechanism; it is a vital instrument of statecraft, socio-economic restructuring, and national development. Article 265 of the Constitution of India provides that "no tax shall be levied or collected except by authority of law." The constitutional schema divides taxing powers between the Union Government and the State Governments under the Seventh Schedule (List I Union List, List II State List, and List III Concurrent List). Historically, this division created a bifurcated taxation structure where direct taxes (income tax, corporate tax) and central indirect taxes (customs, central excise) were administered by the Central Government, while sales tax/VAT, entry tax, and luxury tax fell under state jurisdictions.

To fully comprehend the contemporary changing tax system, it is essential to trace its historical evolution across three distinct economic phases:

1. The Pre-1991 Command Economy Regime: In the post-independence era prior to the 1991 economic liberalization, India's tax regime was

characterized by extreme rate schedules, high tariff walls, administrative discretion, and complex physical controls. Peak marginal personal income tax rates reached an unprecedented 97.75% (including surcharges) in the early 1970s under the misruled assumption that exorbitant tax rates would curtail wealth inequality. In reality, these astronomical rates incentivized rampant tax evasion, fostered a flourishing parallel underground economy, severely narrowed the formal tax base, and penalized honest enterprise.

Concurrently, indirect taxation was plagued by severe cascading effects (tax-on-tax). The Central Excise duty was levied at the manufacturing stage, while State Sales Tax was imposed at subsequent point-of-sale stages without seamless input tax credit mechanisms. This distorted price signals, created inter-state trade barriers, encouraged vertical integration purely for tax avoidance, and undermined the competitiveness of Indian domestic industry in international markets.

2. Post-1991 Liberalization and the Tax Reform Committee (TRC) Era: The balance of payments crisis in 1991 forced a radical reorientation of Indian economic policy. The Tax Reforms Committee (TRC), chaired by Dr. Raja J. Chelliah (1991-1993), laid down the foundation for modern tax policy in India. The Chelliah Committee articulated five key principles that continue to guide Indian tax policy:

- **Lowering Marginal Rates:** Rationalizing high marginal tax rates for both personal income and corporate income to enhance voluntary compliance.
- **Broadening the Tax Base:** Reducing exemptions, concessions, and deductions that created economic distortions and administrative loophole
- **Introduction of Service Tax:** Recognizing the growing contribution of the services sector to GDP, Service Tax was introduced in 1994 under residual entry powers (Article 248) at a nominal rate of 5% on select services.
- **Shift to Value Added Taxation (VAT):** Transitioning from physical excise control to CENVAT at the central level and introducing State VAT in 2005 to replace traditional sales tax, allowing input credit across intra-state trade.

3. The Contemporary Reform Era (2014-Present): Over the past decade, the focus of Indian tax policy has shifted dramatically from incremental procedural adjustments to deep structural, digital, and constitutional transformations. The overarching vision of this contemporary era centers on three cardinal pillars: (a) Ecosystem Unification (GST execution and seamless national market), (b) Administrative Transparency & Non-Adversarial Governance (Faceless assessment, digital footprints, pre-filled returns), and (c) Competitive Base Rates (Corporate rate cuts and flat simplified regimes).

Key Milestones in India's Modern Tax Transformation:

- 1994: Introduction of Service Tax on 3 services at 5% rate.
- 2005: Adoption of State Value Added Tax (VAT) across Indian States.
- 2016: Enactment of 101st Constitutional Amendment Act laying the ground for GST.
- 2017: Launch of Goods and Services Tax (GST) on July 1, unifying 17 indirect taxes.
- 2019: Historic Corporate Tax Rate cut down to 22% (existing) and 15% (new manufacturing).
- 2020: Launch of Faceless Assessment, Faceless Appeals, and Taxpayers' Charter.
- 2023-2026: Adoption of New Personal Tax Regime as default option, automated AIS/TIS integration, and e-Invoicing scale-up.

Landscape Of Direct Tax Reforms:

Direct taxes comprising Income Tax paid by individuals and Hindu Undivided Families (HUFs), and Corporate Tax paid by domestic and foreign corporations—form the bedrock of equitable fiscal revenue. Direct tax revenues have shown remarkable growth, now accounting for over 54% of total central gross tax receipts. This growth has been driven by systemic structural reforms across legislation, policy, and digital administration.

1. Corporate Tax Rate Rationalization: For decades, India maintained relatively high corporate tax rates (30% base rate plus surcharges and cesses, leading to effective tax rates exceeding 34.6%), accompanied by a complex web of sector-specific tax holidays, accelerated depreciation rules, and exemptions. This high rate structure impaired the international competitiveness of Indian enterprises compared to East Asian manufacturing hubs like Vietnam (20%), Thailand (20%), and Indonesia (22%).

In September 2019, through the Taxation Laws (Amendment) Act, the Government executed a historic overhaul of corporate tax rates:

- **Section 115BAA:** Existing domestic companies were offered an option to pay corporate tax at a reduced base rate of 22% (effective tax rate of 25.17% including 10% surcharge and 4% cess), provided they forgo specific tax incentives, deductions under Chapter VI-A, and accelerated depreciation. Crucially, companies opting for this regime were exempted from Minimum Alternate Tax (MAT) under Section 115JB.
- **Section 115BAB:** To incentivize greenfield manufacturing investments under the Make in India initiative, new domestic manufacturing companies incorporated on or after October 1, 2019, were provided an ultra-competitive base tax rate of 15% (effective tax rate of 17.16% with surcharge and cess).

2. Personal Income Tax Framework: Dual Regime Ecosystem: In the domain of personal taxation, the Finance Act 2020 introduced a parallel, simplified tax framework under Section 115BAC, which was subsequently made the default tax regime with enhanced standard deductions and revised slab structures in recent budgets. The contemporary personal tax structure operates as a dual-option system:

Table 1: Comparative Structural Features of Old vs. New Income Tax Regimes

Parameter	Old Tax Regime (With Deductions)	New Tax Regime u/s 115BAC (Default)
Tax Slab Rates	Steep progression (5%, 20%, 30%) with high initial threshold.	Graduated granular slabs (0%, 5%, 10%, 15%, 20%, 30%) with lower rate increments.
Standard Deduction & Rebate	Standard Deduction of ₹50,000 for salaried; Rebate u/s 87A up to taxable income of ₹5 Lakhs.	Enhanced Standard Deduction of ₹75,000; Full Rebate u/s 87A up to ₹7 Lakhs (effective zero tax up to ₹7.75 Lakhs for salaried).
Deductions & Exemptions	Allows Chapter VI-A (80C up to 1.5L, 80D medical, 80CCD NPS), HRA, LTA, Home Loan interest u/s 24(b).	Disallows most major deductions (80C, 80D, HRA, home loan interest on self-occupied property); allows employer NPS contribution u/s 80CCD(2).
Compliance Complexity	High documentation burden (proof of investments, rent receipts, medical bills, loan statements).	Frictionless, zero-documentation filing requiring basic income declaration.

The philosophical shift represented by the New Tax Regime is clear: moving away from a state-directed savings model—where citizens were forced into specific financial instruments (such as tax-saving fixed deposits, traditional insurance policies, and public provident funds) solely to lower tax liabilities—toward an income-choice model that maximizes disposable income and consumption freedom.

3. Technology-Driven Administration and Faceless Ecosystem: Perhaps the most radical disruption in Indian direct taxation is not in the tax rates, but in the complete redesign of tax administration through digital infrastructure. Historically, income tax assessment was characterized by territorial jurisdiction, physical interactions between assessors and assessing officers (AOs), discretionary scrutiny, and rent-seeking vulnerabilities. This has been replaced by a fully automated ecosystem:

A. Faceless Assessment and Appeals System: Launched under the Transparent Taxation – Honoring the Honest platform, the Faceless Assessment Scheme (2020) eliminated geographical jurisdiction. Scrutiny cases are randomly allocated across the country via dynamic automated algorithms. Notice issuance, document submission, response evaluation, draft assessment order creation, and review are conducted entirely electronically through the Income Tax e-filing portal, without any physical contact between the taxpayer and the officer. Similarly, the Faceless Appeal Scheme processes first appeals before Commissioners of Income Tax (Appeals) through anonymous, team-based electronic reviews.

B. Annual Information Statement (AIS) and Taxpayer Information Summary (TIS): The Income Tax Department replaced the rudimentary Form 26AS with comprehensive AIS and TIS tools. By harvesting data from financial institutions, stock exchanges, depositories, Registrar of Properties, GSTN, and credit card issuers, AIS presents taxpayers with a pre-populated, 360-degree view of their financial footprint, including:

- Savings bank interest and term deposit yields.
- Dividend receipts and mutual fund redemptions.
- Equity market purchase and sales transactions (STCG/LTCG).
- Foreign currency remittances under LRS (Liberalized Remittance Scheme).
- High-value credit card expenditures and real estate transactions.

This automated data cross-matching has drastically curtailed tax suppression, facilitated automated pre-filled tax returns (ITR-1, ITR-2, ITR-4), and reduced the necessity for manual scrutiny assessments.

C. Taxpayers' Charter: Codified under Section 119A of the Income Tax Act, the Taxpayers' Charter legally commits the Income Tax Department to 14 specific obligations, including providing fair and impartial treatment, preserving confidentiality, ensuring accountability, holding officers responsible for delays, and maintaining a non-adversarial administrative environment.

Indirect Tax Transformation: The GST Framework:

On July 1, 2017, India enacted its most ambitious economic reform since independence: the implementation of the Goods and Services Tax (GST). By subsuming 17 major central and state indirect taxes (including Central Excise, Service Tax, State Sales Tax/VAT, Entry Tax, Luxury Tax, Octroi, and Entertainment Tax) and 13 cesses, GST realized the constitutional vision of "One Nation, One Tax, One Market."

1. Architecture and Constitutional Framework: GST in India is structured as a concurrent dual model necessitated by India's

federal polity. Every taxable supply of goods or services attracts both Central GST (CGST) and State GST (SGST) for intra-state transactions, or Integrated GST (IGST) for inter-state transactions and imports. IGST is collected by the Union Government and apportioned to the destination State, embodying the principle of GST as a destination-based consumption tax.

The cornerstone of GST governance is the GST Council established under Article 279A of the Constitution. Chaired by the Union Finance Minister and comprising Finance Ministers of all 28 States and 3 Union Territories with legislatures, the GST Council is a unique institutional experiment in cooperative federalism. Decisions are taken by a three-fourths weighted majority, where the Central Government holds one-third of the voting power and all State Governments combined hold two-thirds.

2. Quantitative and Operational Achievements of GST: After initial operational friction, technical glitches in the GST Network (GSTN) portal, and business transition challenges, GST has stabilized into a highly robust revenue generator and supply chain simplifier.

₹1.80L+ Cr Average Monthly Revenue	**14.5 Million** Active Registered Taxpayers	**100 Million+** Monthly e-Way Bills Issued	**₹5 Crore** e-Invoicing Threshold

Key functional achievements of the GST architecture include:

- **Elimination of Cascading Effect:** Seamless flow of Input Tax Credit (ITC) across the entire supply chain—from raw material purchase to final retail—eliminates the compounding tax burden that historically inflated goods pricing.
- **Logistical Efficiency and Checkpost Removal:** The abolition of state border checkposts and inter-state entry taxes, paired with the automated e-Way Bill system (mandatory for movement of goods exceeding ₹50,000 value), has reduced commercial vehicle transit times by 20–30%, resulting in massive logistics cost savings.
- **Electronic Invoicing (e-Invoicing):** Mandatory real-time reporting of B2B invoices to the Invoice Registration Portal (IRP) for businesses with turnover exceeding ₹5 Crore has digitized supply chain verification, automated GST return population (GSTR-1, GSTR-3B), and curbed fake invoice generation.
- **Revenue Buoyancy:** Gross GST revenue collections have risen from an initial monthly average of ~₹90,000 Crore in FY 2017-18 to consistently exceeding ₹1.80 Lakh Crore to ₹2.10 Lakh Crore per month in recent fiscal years, demonstrating sustained compliance widening.

3. Structural Flaws and Systemic Distortions in GST: Despite its transformative trajectory, India's GST model is far from an ideal single-rate tax framework and continues to suffer from structural complexities:

A. Multiple Tax Slabs and Classification Disputes: Unlike international GST/VAT models (e.g., New Zealand's single rate of 15% or Singapore's 9%), India adopted a complex 5-tier rate architecture (0%, 5%, 12%, 18%, and 28%), plus special rates for precious metals (3% on gold) and crude diamonds (0.25%), alongside variable Compensation Cesses on sin and luxury goods. This multiplicity creates persistent tariff classification disputes (e.g., whether a flavored milk drink is dairy or beverage, or whether a foot massager is a medical device or electronic luxury

appliance) and encourages intense lobbying for lower rate placement.

B. Inverted Duty Structure: An inverted duty structure occurs when the tax rate on input raw materials is higher than the tax rate on the finished final product. For example, in specific textile sub-sectors or manufacturing components, inputs are taxed at 18% while finished products are sold at 5%. This leads to massive accumulation of unutilized Input Tax Credit (ITC) with the tax authorities, locking up working capital for businesses and necessitating complex, delay-ridden refund processing systems.

C. Sectoral Exclusions and Supply Chain Breaches: Crucial sectors of the Indian economy remain outside the GST umbrella:

1. Petroleum crude, High-Speed Diesel (HSD), Motor Spirit (Petrol), Natural Gas, and Aviation Turbine Fuel (ATF).
2. Electricity and Power Transmission.
3. Alcoholic liquor for human consumption (constitutionally barred under Entry 54 of State List).
4. Real estate property transactions (stamp duty and registration fees remain under state domain).

Key Issues and Structural Bottlenecks in The Current Tax Architecture:

While legislative policy reforms have modernized the statutory framework, systemic vulnerabilities persist within India's broader fiscal and tax architecture. Addressing these structural issues is essential to raising India's overall tax buoyancy.

1. The Narrow Tax Base and Demographic Asymmetry: India presents a striking macro-fiscal paradox: despite being the world's fifth-largest economy with a population exceeding 1.4 billion, its direct tax base remains exceptionally narrow. Out of 140 crore citizens, only approximately 7.5 to 8.0 crore individuals file Personal Income Tax Returns (ITR), and less than 3% of the total population actually pays net direct personal income tax after accounting for rebates under Section 87A.

Table 2: Comparative Macro-Tax Metrics – India vs. Select Global Peer Economies

Economy	Tax-to-GDP Ratio (%)	Direct Tax Share (%)	Indirect Tax Share (%)	Corporate Tax Rate (%)
India	**11.7%**	**54.5%**	**45.5%**	**22% / 15%**
United States	27.7%	72.1%	27.9%	21%
United Kingdom	35.3%	58.4%	41.6%	25%
China	17.5%	42.0%	58.0%	25%
Brazil	33.5%	38.2%	61.8%	34%
OECD Average	34.0%	60.5%	39.5%	23.6%

Factors driving this persistent tax base narrowness include:

- **Exemption of Agricultural Income:** Under Entry 46 of the State List, agricultural income is exempt from central income tax under Section 10(1). While intended to protect vulnerable smallholder farmers, this exemption is frequently exploited by high-net-worth individuals and corporate entities to declare large non-taxable incomes without adequate verification.
- **Large Informal/Unorganized Economy:** Over 80% of India's workforce operates in the informal sector characterized by cash-intensive transactions, non-accounted trading, and lack of audit trails.

- **High Tax Rebate Thresholds:** The extension of full tax rebates up to ₹7.00–₹7.75 Lakhs of annual income under the new tax regime excludes a vast section of lower-middle-income earners who could otherwise contribute nominal tax amounts to build a culture of universal civic compliance.

2. Tax Compliance Costs and Administrative Friction for MSMEs: Micro, Small, and Medium Enterprises (MSMEs) form the backbone of Indian employment and manufacturing output. However, compliance with the multi-layered GST and direct tax mandates poses disproportionate operational burdens on smaller firms:

- **Complex Return Filing Cadence:** Small businesses must navigate multiple monthly and annual filings (GSTR-1, GSTR-3B, GSTR-9, GSTR-9C, e-Way bills, e-invoicing portals, TDS/TCS returns).
- **Rigid Input Tax Credit (ITC) Matching Rules:** Under Section 16(2)(aa) and Rule 36(4) of CGST Rules, a buyer cannot claim ITC unless the vendor has uploaded the corresponding invoice in GSTR-1 and it reflects in the buyer's GSTR-2B. When small, unorganized vendors fail or delay filing their returns, compliant MSME buyers are penalized through credit lockouts, cash-flow squeezes, and tax demands accompanied by 18% interest penalties.

3. Tax Litigation Backlog and Locked Capital: India suffers from acute, protracted tax litigation. The total tax revenue tied up in dispute across various legal forums—including Commissioner (Appeals), Income Tax Appellate Tribunals (ITAT), Customs Excise and Service Tax Appellate Tribunal (CESTAT), High Courts, and the Supreme Court—exceeds **₹12 Lakh Crore** (equivalent to roughly 4% of GDP).

The key drivers of this dispute backlog are aggressive revenue targets imposed on field officers, leading to high-pitched, ungrounded assessments; frequent retroactive legislative amendments; ambiguity in anti-avoidance rules (such as General Anti-Avoidance Rules - GAAR); and long judicial vacancies in specialized tax tribunals. Although dispute resolution schemes such as SabkaVishwas (2019) for indirect taxes and Vivad se Vishwas (2020 & 2024) for direct taxes recovered substantial revenues, structural litigation generation remains high.

4. Fiscal Federalism and the Post-Compensation Era: When States surrendered their independent legislative powers over sales tax and local duties to enact GST in 2017, the Central Government guaranteed a 14% annual compound growth rate in State GST revenues for a 5-year transition period ending June 30, 2022. To fund this guarantee, a **GST Compensation Cess** was levied on luxury and demerit goods (e.g., motor vehicles, tobacco, aerated drinks).

With the expiry of the 5-year compensation mechanism in June 2022, several States—particularly manufacturing-intensive destination States—faced significant fiscal gaps. While overall GST revenues have grown robustly, the expiration of guaranteed revenue support exposed divergent fiscal capacities across States. Rebalancing State revenue autonomy while maintaining a unified national GST rate structure remains a sensitive political-economy challenge within the GST Council.

Emerging Challenges and Global Dimensions:

1. Taxation of the Digital Economy and International Tax Architecture: Traditional international tax rules, rooted in the 1920s League of Nations framework, relied on the physical presence of an enterprise (Physical Permanent Establishment - PE) to establish taxing rights. In the modern digital age, tech conglomerates (e.g., e-commerce giants, cloud platforms, digital advertising monopolies) generate massive

economic value from Indian consumer data without maintaining physical brick-and-mortar operations in the country.

To address this tax base erosion, India led early unilateral initiatives:

- **Equalisation Levy (2016 & 2020):** Initially introduced at 6% on online advertising payments to non-resident entities, and subsequently expanded to a 2% levy on gross revenues of foreign e-commerce operators supplying goods or services to Indian residents.
- **Significant Economic Presence (SEP):** Codified under Section 9(1)(i) of the Income Tax Act, establishing that economic presence is triggered if foreign digital businesses exceed specified revenue thresholds (₹2 Crore) or user transaction thresholds (300,000 users) in India, irrespective of physical presence.

The OECD/G20 Two-Pillar Global Tax Consensus:

Pillar One: Reallocation of Taxing Rights: Reallocates a portion of residual profits (25% of profit above a 10% margin) of the largest and most profitable multinational enterprises (MNEs) to market jurisdictions where goods or services are consumed, regardless of physical presence. In exchange, participating countries agree to phase out unilateral digital services taxes like the Equalisation Levy.

Pillar Two: Global Minimum Corporate Tax (GloBE Rules): Establishes a global minimum effective corporate tax rate of 15% for MNEs with annual revenues exceeding €750 million. If an MNE pays less than 15% in a low-tax jurisdiction, the home country or market country can impose a "top-up tax." This severely restricts global regulatory tax competition and tax-haven abuse.

2. Virtual Digital Assets (VDA) and Crypto Taxation: The rapid proliferation of cryptocurrencies, non-fungible tokens (NFTs), and decentralization of finance presented significant tax evasion and money laundering threats. In the Finance Act 2022, India enacted a dedicated tax framework for Virtual Digital Assets (VDAs) under Section 115BBH and Section 194S:

- Flat tax rate of 30% (plus applicable surcharge and cess) on net income from the transfer of any VDA, with no deduction allowed for expenses other than the cost of acquisition.
- Prohibition of set-off or carry-forward of losses incurred in VDA transactions against any other taxable income stream.
- TDS of 1% levied under Section 194S on all VDA payment transfers exceeding specified thresholds, creating a transparent digital transaction trail for intelligence monitoring.

3. Green Taxation and Climate-Aligned Fiscal Policies: In alignment with India's COP26 commitments to achieve net-zero carbon emissions by 2070, tax policy is increasingly being mobilized to support environmental sustainability. Key green tax interventions include:

- **Tax Incentives for Sustainable Transport:** Concessional GST rate of 5% on Electric Vehicles (EVs) compared to 28% plus cess on internal combustion engine vehicles, alongside income tax deductions under Section 80EEB for interest paid on EV loans.
- **Carbon and Clean Energy Cesses:** Restructuring coal cesses and introducing variable excise duties on unblended fuels to encourage ethanol and bio-fuel blending.
- **Emerging Carbon Border Adjustments:** Preparing domestic industries for international carbon tariffs, such as the European Union's Carbon Border Adjustment

Mechanism (CBAM), through domestic carbon accounting and green tax alignment.

Comparative Perspectives & Policy Benchmarking:

Benchmarking India's tax performance against structural metrics across key developed and developing economies provides critical insights into ongoing fiscal priorities. Figure 2 illustrates the distribution of direct vs. indirect tax reliance across select peer nations.

Figure 2: Structural Composition of Direct vs. Indirect Tax Revenue Mix (%)

Country	Direct Tax Contribution (%)	Indirect Tax Contribution (%)
USA	72.1%	27.9%
OECD Avg	60.5%	39.5%
India	**54.5%**	**45.5%**
China	42.0%	58.0%
Brazil	38.2%	61.8%

Source: Compiled by Author from OECD Revenue Statistics & RBI State Finances Data.

The comparative analysis demonstrates that mature developed economies lean heavily on progressive direct taxation (income and property taxes), which enhances social equity. Developing economies, conversely, often rely disproportionately on regressive indirect consumption taxes due to administrative ease of collection. India's steady shift toward a 54.5% direct tax share reflects positive structural formalization, though its low overall Tax-to-GDP ratio (11.7%) highlights significant uncaptured fiscal potential compared to the OECD average of 34.0%.

Future Recommendations and Strategic Policy Roadmap:

To support India's economic ambition of becoming a $7 Trillion developed economy by 2030, the tax system requires decisive next-generation structural reforms. Building on the progress made, policy focus must shift toward simplicity, certainty, and administrative efficiency.

1. Comprehensive Enactment of a Modern Direct Taxes Code (DTC): The Income Tax Act of 1961, despite hundreds of piecemeal amendments, remains burdened by archaic wording, redundant sections, and conflicting judicial precedents. India urgently requires a completely rewritten, modern **Direct Taxes Code (DTC)** structured around:

- Plain, unambiguous draft language minimizing judicial interpretations.
- Elimination of all remaining grandfathered exemptions, replaced by simple, flat, low-rate schedules.
- Rationalization of capital gains tax rules across asset classes (holding periods, indexed cost basis, and asset categorization unified into a simple 2-tier framework).
- Formal statutory integration of Advance Pricing Agreements (APA) and Safe Harbour rules to eliminate transfer pricing litigation for foreign investors.

2. GST 2.0 Rationalization and Scope Expansion: The GST Council should execute a comprehensive "GST 2.0" overhaul focused on three structural fixes:

1. Transition to a 3-Tier Rate Structure: Compress the current 5-tier rate structure into three clear tiers:

- **Merit / Essential Rate (5%):** For essential foodstuffs, medicines, and mass-consumption goods.
- **Standard Rate (12%–15%):** Merging the current 12% and 18% slabs into a single unified rate covering over 75% of commercial goods and services.
- **Demerit / Luxury Rate (28%):** Restricted strictly to sin goods, luxury automobiles, and tobacco products, while phasing out special cesses.

2. Phase-wise Inclusion of Excluded Sectors: Progressively bring Natural Gas and Aviation Turbine Fuel (ATF) under GST initially, followed by Petrol, High-Speed Diesel, and Real Estate construction, allowing seamless input tax credit flow across energy and infrastructure sectors.

3. Automated ITC Verification without Buyer Penalty: Modify Rule 36(4) enforcement so compliant buyers are not automatically denied ITC or subjected to harsh recovery notices due to isolated clerical delays by supplier vendors, shifting recovery focus directly onto delinquent suppliers using automated GSTN tracking.

3. Overhauling Dispute Resolution and Judicial Infrastructure: To release ₹12+ Lakh Crore of locked tax revenue and provide investor certainty, administrative dispute mechanisms must be overhauled:

- Operationalize all benches of the **GST Appellate Tribunal (GSTAT)** across every State capital to relieve burden on High Courts.
- Establish mandatory **Alternative Dispute Resolution (ADR)** mechanisms and Binding Advance Rulings for tax disputes exceeding ₹5 Crore, allowing settlement via structured mediation.
- Implement strict administrative accountability and financial penalties on tax departments for raising frivolous assessments that are repeatedly dismissed at tribunal levels.

4. Broadening the Tax Base without Enhancing Rates: Rather than increasing tax rates on existing compliant taxpayers, the tax base must be expanded through non-intrusive data-driven strategies:

- **Gradual Taxation of High-Income Agriculture:** Amend income tax laws to levy tax on agricultural incomes exceeding ₹50 Lakhs per annum accruing to non-farmer corporate entities and high-net-worth individuals, while safeguarding genuine small and marginal farmers.
- **Deep Integration of AI Data Analytics:** Expand the use of Project Insight algorithms to cross-reference lifestyle indicators (e.g., luxury travel, high-value asset purchases, foreign exchange transactions) against declared ITR incomes to detect evasion transparently.

5. Protecting Taxpayer Rights and Data Governance: As tax administration becomes increasingly algorithmic and data-intensive, state power must be balanced with strong taxpayer protections:

- Establish an independent **Taxpayer Ombudsman** to investigate administrative overreach, digital system glitches, and unreasonable refund delays.
- Ensure strict data protection, security, and algorithmic transparency under the Digital Personal Data Protection (DPDP) Act to prevent unauthorized access or misuse of confidential financial data stored in AIS and GSTN databases.

Conclusion:

India's tax system has undergone a remarkable evolution over the past three decades—evolving from an inefficient, fragmented, and discretionary regime into a unified, technology-enabled, and structurally competitive fiscal architecture. The historic execution of the Goods and Services Tax (GST), the rationalization of corporate tax rates to global competitive levels, the implementation of faceless assessment systems, and the integration of automated big-data tracking tools like AIS reflect a decisive commitment toward non-adversarial, transparent fiscal governance.

However, the journey toward a truly mature tax system remains incomplete. Structural bottlenecks—including a narrow direct tax base, multiple GST rate slabs, inverted duty structures, excluded energy sectors, and massive tax litigation backlogs—continue to weigh on economic efficiency. Resolving these challenges requires executing next-generation reforms: enacting a modernized Direct Taxes Code, rationalizing GST into a streamlined 3-tier structure, operationalizing GST Appellate Tribunals, and expanding the tax base through non-intrusive data intelligence.

By balancing progressive revenue generation with taxpayer rights, federal equity, and business simplicity, India can build an agile fiscal framework capable of funding its ambitious infrastructure, social development, and economic expansion goals in the decades ahead.

References & Bibliography:

1. Chelliah, R. J. (1993). Agenda for Comprehensive Tax Reform. Task Force Report, Ministry of Finance, Government of India, New Delhi.
2. Government of India. (2002). Report of the Task Force on Direct & Indirect Taxes (Kelkar Committee Report). Ministry of Finance, New Delhi.
3. Government of India. (2016). The Constitution (One Hundred and First Amendment) Act, 2016. Gazette of India, Ministry of Law and Justice, New Delhi.
4. Government of India. (2019). The Taxation Laws (Amendment) Act, 2019 (No. 37 of 2019). Gazette of India, New Delhi.
5. GST Council Secretariat. (2023). GST Concept & Status Report: Five Years of Unifying Indian Indirect Taxation. New Delhi.
6. Income Tax Department, Government of India. (2020). Taxpayers' Charter and Faceless Assessment Scheme Guidelines. Central Board of Direct Taxes (CBDT), New Delhi.
7. Kelkar, V. L. (2019). Towards India's New Fiscal Federalism. NITI Aayog Policy Paper Series, New Delhi.
8. Ministry of Finance. (2024). Economic Survey 2023-24. Department of Economic Affairs, Government of India, New Delhi.
9. NITI Aayog. (2021). Tax Reforms and Economic Growth in India: An Empirical Appraisal. Policy Research Working Paper No. 4/2021, New Delhi.

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Startup India and the Entrepreneurial Ecosystem in India: An Emerging Framework for Innovation and Inclusive Growth

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Abstract:

Entrepreneurship has become an important part of India's economic development, particularly with the rapid growth of startups in different sectors and regions. The launch of the Startup India initiative in 2016 was an important step towards creating a supportive environment for new businesses, innovation and employment generation. However, the success of a startup does not depend only on government schemes or financial assistance. It also depends on the availability of finance, skilled human resources, technology, mentoring, markets, institutions and a supportive social environment. These interconnected factors together form the entrepreneurial ecosystem.

This paper examines the role of Startup India in developing India's entrepreneurial ecosystem. It reviews selected studies on entrepreneurial ecosystems, Indian startups, incubation, finance and innovation and identifies the major gaps in the existing literature. The paper is conceptual and descriptive in nature and is based mainly on secondary sources, including research articles, government reports and official Startup India documents. The discussion suggests that Startup India has contributed to improving access to recognition, funding, incubation, mentoring and other forms of support. At the same time, challenges such as access to finance, regional differences, lack of mentoring, market competition, skill gaps and the survival of startups continue to exist. The paper argues that the next stage of startup development should focus not only on increasing the number of startups but also on their survival, innovation, employment generation and wider regional and social inclusion.

Keywords: Startup India, Entrepreneurial Ecosystem, Entrepreneurship, Innovation, Startups, Incubation, Finance, India

Introduction:

Entrepreneurship has always been associated with economic development, but its importance in India has increased considerably in recent years. Young entrepreneurs are entering areas such as

ancial services, manufacturing and social enterprises. This growth has also changed the way entrepreneurship is viewed. It is no longer limited to starting a small business for self-employment; it is increasingly connected with innovation, technology, employment generation and solving social and economic problems.

The Government of India launched the Startup India initiative in January 2016 with the objective of creating a stronger environment for innovation and entrepreneurship. The original Startup India Action Plan included measures related to simplification and handholding, funding support and incentives, and industry-academia partnership and incubation. Therefore, Startup India was designed as a broader ecosystem-

building initiative rather than simply a financial assistance programme.

The idea of an entrepreneurial ecosystem is important in understanding this development. A person may have a good business idea, but the idea alone is not sufficient to build a successful enterprise. The entrepreneur may require finance, skilled employees, technology, mentors, customers, infrastructure and support from government and educational institutions. Isenberg (2010) explains the entrepreneurial ecosystem through several interconnected dimensions, including policy, finance, human capital, markets and culture. Similarly, Stam (2015) argues that productive entrepreneurship depends on the interaction of several actors and conditions rather than on the entrepreneur alone.

In India, the development of this ecosystem has taken place alongside the growth of Startup India. The government has introduced startup recognition, funding schemes, incubation support, mentoring platforms and initiatives for connecting startups with investors and markets. The Startup India portal currently lists initiatives such as the Seed Fund Scheme, MAARG, Investor Connect, National Startup Awards and the State Startup Ranking Framework.

At the same time, the growing number of startups does not automatically mean that the entrepreneurial ecosystem is equally strong everywhere. Startups in metropolitan cities may have easier access to investors, incubators, skilled workers and markets than entrepreneurs in smaller cities and rural areas. Therefore, it is necessary to look beyond startup numbers and examine the wider conditions that determine whether entrepreneurs can establish and sustain their businesses.

Objectives of the Study:

The study has the following objectives:

1. To understand the concept and major elements of the entrepreneurial ecosystem in India.
2. To examine the role of Startup India in supporting entrepreneurship and innovation.
3. To review existing research on India's startup ecosystem, funding, incubation and innovation.
4. To identify the major challenges faced by startups within the existing ecosystem.
5. To identify the research gap and suggest areas for strengthening India's entrepreneurial ecosystem.

Review of Literature:

The concept of an entrepreneurial ecosystem has received considerable attention in entrepreneurship research. Isenberg (2010) suggested that entrepreneurship develops within an ecosystem involving government, finance, human capital, markets, culture and institutional support. This perspective is useful because it shifts attention from the individual entrepreneur to the environment in which entrepreneurial activity takes place.

Stam (2015) further developed the ecosystem approach and argued that entrepreneurial ecosystems consist of interdependent actors and factors that influence productive entrepreneurship. His work also pointed out that simply increasing the number of entrepreneurs is not sufficient. The quality and productivity of entrepreneurship need to be considered. Stam and van de Ven (2021) later developed a more systematic framework for examining ecosystem elements and their relationship with entrepreneurial activity.

Indian studies provide a more specific understanding of these issues. Bhagavatula, Mudambi and Murmann (2019) examined the

development of innovation and entrepreneurship in India and observed that the Indian ecosystem had moved beyond its earlier concentration around the information technology sector. The authors highlighted the importance of finance, human capital, institutions and interaction among different ecosystem participants.

The role of incubation has also been examined in the Indian context. Narayanan and Shin (2019), in their study of academic incubators in India, showed that the institutional environment in which incubators operate influences their functioning. This suggests that merely establishing an incubator does not guarantee effective support to entrepreneurs. The quality of institutional linkages and the surrounding environment also matter.

Subrahmanya (2020) studied the entrepreneurial ecosystem for technology startups in Bangalore. His research, based on inputs from ecosystem stakeholders, identified gaps between the existing ecosystem and the conditions required for a stronger startup environment. Areas such as education and research institutions, market maturity and mentoring were among the issues requiring attention. The study is particularly relevant because Bangalore is one of India's most developed startup locations, yet ecosystem gaps were still identified.

Dinesh and Sushil (2019) examined strategic innovation factors in Indian startups through a cross-case study. Their findings indicate that innovation-related strategic factors are important for startup stability and survival. This supports the view that startup policies should not concentrate only on the creation of new businesses but should also consider their ability to remain competitive.

Bhatt, Saurabh and Verma (2022) reviewed India's technology startup ecosystem and discussed the role of policy, education, finance and incubators. Their study points towards the need for a more connected ecosystem in which different forms of support work together rather than operating independently.

Research focusing directly on government intervention has also grown. Singh (2020), in an Asian Development Bank Institute working paper, examined policy and regulatory changes associated with India's Startup Action Plan. The study discussed the three broad areas of handholding and simplification, funding and incentives, and incubation and industry-academia partnerships. Jain (2022) specifically examined the Startup India Seed Fund Scheme and Fund of Funds and highlighted the importance of early-stage finance for startups.

Recent literature has started to question whether ecosystem growth should be measured mainly through startup numbers and funding. Gowda et al. (2026), in a recent review of India's startup ecosystem, observed that although the ecosystem has become more institutionally supported and interconnected, questions remain regarding long-term productivity, quality employment, equitable access to capital and sustained startup survival.

Overall, the literature shows that India's startup ecosystem has developed considerably, but it is still uneven. Existing studies have examined different aspects such as finance, incubation, innovation and regional ecosystems. However, there is scope for bringing these dimensions together while also paying greater attention to smaller cities, women entrepreneurs and entrepreneurs who do not have easy access to the traditional metropolitan startup network.

Research Gap:

The review of literature indicates that considerable research has been conducted on India's startup ecosystem. However, some gaps remain.

First, several studies focus on individual components such as funding, incubation or innovation. There is relatively less integrated discussion of how these factors interact with one another in determining startup outcomes.

Second, a significant part of the literature is concentrated on technology-based startups and major startup centres such as Bangalore. This leaves scope for studying the ecosystem in Tier-II and Tier-III cities, where entrepreneurs may face different problems related to finance, skilled manpower, mentoring and market access.

Third, the availability of government schemes does not necessarily mean that all eligible entrepreneurs are able to use them effectively. There is therefore a need to understand the gap between policy availability and actual accessibility.

Finally, greater attention is required towards startup survival and sustainability. Startup numbers, registrations and funding announcements provide useful information, but they do not fully explain whether enterprises survive, create stable employment, innovate continuously and contribute to regional development.

The present paper attempts to address these gaps by looking at Startup India from a broader entrepreneurial ecosystem perspective.

Research Methodology:

The study is **descriptive and conceptual in nature** and is based entirely on secondary data. Information has been collected from research articles, academic publications, government reports, Startup India and DPIIT documents and other relevant published sources.

The literature was reviewed thematically under areas such as entrepreneurial ecosystem, government policy, finance, incubation, innovation, education, digital entrepreneurship and regional inclusion. The findings from different studies were then compared to understand the common issues affecting the Indian startup ecosystem.

The study does not involve primary data collection or statistical testing. Therefore, its findings should be understood as a synthesis of existing research and policy information rather than as evidence from a new field survey.

Startup India and the Entrepreneurial Ecosystem:

Startup India has gradually become an important part of the institutional environment for entrepreneurship in India. The initiative was launched on 16 January 2016 and its original Action Plan covered 19 action areas. The broad intention was to simplify procedures, improve access to funding and strengthen industry-academia connections.

One of the important developments under the initiative is the DPIIT startup recognition system. Recognition gives eligible startups access to various benefits related to compliance, intellectual property, public procurement and taxation, subject to the relevant conditions. Under the current framework, a non-DeepTech startup can generally remain within the startup definition for up to ten years and must meet the prescribed turnover criteria.

This type of formal recognition is important because it provides startups with an institutional identity and connects them with various government support mechanisms.

1. Financial Support: Finance is one of the most common problems faced by new entrepreneurs. A business may have a promising idea but still fail to develop because the entrepreneur cannot obtain sufficient funds during the early stages.

Startup India has therefore introduced different mechanisms to improve access to finance. The Startup India Seed Fund Scheme provides assistance for activities such as proof of

concept, prototype development, product trials, market entry and commercialisation. Such support is particularly relevant during the early stage when conventional bank finance or private investment may not be easily available.

The Fund of Funds approach is another important intervention. Instead of investing directly in individual startups, the government supports alternative investment funds that subsequently invest in startups. This approach attempts to bring more private capital into the startup ecosystem.

However, availability of funding does not mean that every entrepreneur has equal access to it. Investors often prefer businesses with strong growth potential, technology advantages and established market opportunities. Entrepreneurs in smaller cities or traditional sectors may therefore find it more difficult to attract investment.

2. Incubation and Mentoring: A startup needs more than money. Many first-generation entrepreneurs require guidance on preparing a business model, managing finances, protecting intellectual property, understanding customers and entering markets.

Incubators and accelerators can help fill this gap. Academic institutions have also become important in this area. The research by Narayanan and Shin (2019) demonstrates that the institutional environment surrounding academic incubators matters for their effectiveness.

Startup India's mentoring initiatives, including MAARG, are intended to connect entrepreneurs with experienced mentors. Such initiatives can be particularly useful for young entrepreneurs who have technical knowledge but limited business experience.

The challenge is to ensure that mentoring is practical and continuous. A one-time interaction with a mentor may not be enough for an entrepreneur who is facing difficulties in production, marketing or financial management.

3. Role of Educational Institutions: Universities and colleges can contribute significantly to the entrepreneurial ecosystem. They provide students with knowledge, technical skills, research facilities and opportunities to experiment with business ideas.

Entrepreneurship education can also change the attitude of students towards self-employment and innovation. However, entrepreneurship education should not remain limited to classroom lectures. Students need opportunities for developing prototypes, participating in competitions, interacting with entrepreneurs and understanding actual market conditions.

Research institutions can also contribute through technology transfer and commercialisation of research. Stronger collaboration between colleges, universities, industries and startups can therefore make the ecosystem more productive.

4. Digital Entrepreneurship: Digital technology has reduced some of the traditional barriers faced by entrepreneurs. A small business can now reach customers through social media, e-commerce platforms and digital payment systems without maintaining a large physical presence.

For startups, digital platforms can also provide access to information, customers, mentors and investors. Startup India's digital initiatives have expanded the ways in which ecosystem participants can connect.

However, digital access is not equal across all regions. Differences in digital skills, internet access, language and awareness can still limit participation. Therefore, digital entrepreneurship policies should be accompanied by appropriate training and support.

5. Regional and Inclusive Entrepreneurship: One of the important questions for the future of Startup India is whether the benefits of the

ecosystem are reaching entrepreneurs beyond major metropolitan centres.

Bangalore, Delhi, Mumbai and Hyderabad have developed strong networks of investors, incubators, technology companies and skilled professionals. Smaller cities may not have the same level of ecosystem support.

This does not mean that smaller cities lack entrepreneurial potential. In fact, they may offer opportunities in agriculture, food processing, manufacturing, tourism, handicrafts, services and other locally relevant sectors. What is often missing is the network required to convert these opportunities into scalable enterprises.

Women entrepreneurs also require greater attention. Although women's participation in entrepreneurship has increased, they may face additional barriers relating to finance, networks, mobility, family responsibilities and access to business information.

An inclusive entrepreneurial ecosystem therefore needs to consider the different circumstances of entrepreneurs rather than assuming that all startups face the same conditions.

Major Challenges:

Despite the progress made through Startup India, several challenges continue to affect the entrepreneurial ecosystem.

Access to finance: Early-stage entrepreneurs may find it difficult to obtain external finance because they often lack collateral, credit history or a proven revenue model.

Uneven regional development: Startup support is stronger in some cities and states than in others. Smaller towns may have fewer incubators, investors and experienced mentors.

Skill gaps: Entrepreneurs require financial, managerial, marketing and technological skills in addition to technical knowledge.

Market access: Developing a product is only one part of the process. Startups need customers and sustainable revenue. Competing with established businesses can be difficult.

Mentoring limitations: Mentoring programmes are useful, but the quality and continuity of mentoring can vary.

Startup survival: The creation of a startup is relatively easy to measure, but long-term survival and growth are more difficult to achieve. This is an important area that deserves greater research attention.

Awareness of schemes: Government schemes may not benefit entrepreneurs fully if they are unaware of eligibility conditions or do not know how to access the available support.

Suggestions:

Based on the literature reviewed, the following measures may help strengthen India's entrepreneurial ecosystem.

1. **Increase support in Tier-II and Tier-III cities:** More incubators, entrepreneurship centres and mentoring networks can be developed outside major metropolitan centres.
2. **Improve awareness of government schemes:** Simple information in regional languages can help first-generation entrepreneurs understand available programmes.
3. **Strengthen entrepreneurship education:** Colleges should provide practical exposure through startup projects, business competitions, internships and interaction with entrepreneurs.
4. **Improve early-stage finance:** Greater attention should be given to entrepreneurs who are at the idea, prototype and early-revenue stages.
5. **Build stronger industry-academia links:** Universities and industries should work

together on research commercialisation, internships and startup development.

6. **Focus on startup survival:** Government evaluation should consider indicators such as business survival, employment quality, innovation and revenue growth rather than only the number of startups recognised.
7. **Support women and local entrepreneurs:** Special mentoring, networking and financial support can help entrepreneurs who have traditionally had less access to formal startup networks.

Conclusion:

Startup India has contributed to a significant change in the entrepreneurial environment in India. It has brought greater attention to innovation, startup finance, incubation, mentoring, intellectual property and entrepreneurship education. More importantly, it has helped entrepreneurship become a visible part of India's economic development discussion.

However, the development of a strong entrepreneurial ecosystem is a continuing process. Government schemes alone cannot create successful businesses. Entrepreneurs need access to finance, markets, skills, technology, mentors and supportive institutions. These elements must work together.

The existing literature also suggests that the next stage of India's startup development should move beyond simply counting startups and measuring funding. Greater attention needs to be given to startup survival, innovation, employment quality, regional development and inclusion. Smaller cities, women entrepreneurs and businesses outside the traditional technology sectors should form an important part of this discussion.

Thus, the future of Startup India depends not only on how many new enterprises are created but also on how effectively the wider ecosystem helps those enterprises survive, grow and contribute to economic and social development.

References:

1. Bhagavatula, S., Mudambi, R., &Murmann, J. P. (2019). Innovation and entrepreneurship in India: An overview. *Management and Organization Review, 15*(3), 467–493. https://doi.org/10.1017/MOR.2019.52
2. Bhatt, N., Saurabh, P., & Verma, R. K. (2022). Technology startup ecosystem in India. *International Journal of Business Innovation and Research, 27*(4), 413–430. https://doi.org/10.1504/IJBIR.2022.122491
3. Dinesh, K. K., & Sushil. (2019). Strategic innovation factors in startups: Results of a cross-case analysis of Indian startups. *Journal for Global Business Advancement, 12*(3), 449–470. https://doi.org/10.1504/JGBA.2019.101387
4. Gowda, A. S., Hanumanthappa, R., Raveesha, S., Shashibhushan, M., & Sangeetha, B. (2026). India's startup ecosystem in transition: A critical narrative review of policy, innovation and socio-economic transformation. *Archives of Current Research International, 26*(9), 72–89. https://doi.org/10.9734/acri/2026/v26i92112
5. Isenberg, D. J. (2010). How to start an entrepreneurial revolution. *Harvard Business Review, 88*(6), 40–50.
6. Jain, M. (2022). The role of Startup India Seed Fund Scheme (SISFS) & Fund of Funds for Startups (FFS) in startups in India. *SMS Journal of Entrepreneurship & Innovation, 9*(1).
7. Narayanan, V. K., & Shin, J. N. (2019). The institutional context of incubation: The case of academic incubators in India. *Management and Organization Review, 15*(3), 563–593. https://doi.org/10.1017/MOR.2018.52

8. Singh, V. K. (2020). *Policy and regulatory changes for a successful startup revolution: Experiences from the Startup Action Plan in India*. Asian Development Bank Institute Working Paper No. 1146.
9. Stam, E. (2015). Entrepreneurial ecosystems and regional policy: A sympathetic critique. *European Planning Studies, 23*(9), 1759–1769. https://doi.org/10.1080/09654313.2015.1061484
10. Stam, E., & van de Ven, A. (2021). Entrepreneurial ecosystem elements. *Small Business Economics, 56*(2), 809–832.
11. Subrahmanya, M. H. B. (2020). Entrepreneurial ecosystem for tech start-ups in Bangalore: An exploration of structure and gap. *Journal of Small Business and Enterprise Development, 27*(7), 1167–1185. https://doi.org/10.1108/JSBED-07-2019-0233
12. Vanara, M. (2025). Fostering innovation through policy: A study on the Startup India initiative. *International Education and Research Journal, 11*(6).
13. Department for Promotion of Industry and Internal Trade (DPIIT). (2016). *Startup India Action Plan*. Government of India.
14. Department for Promotion of Industry and Internal Trade (DPIIT). (2026). *Startup India Portal and Startup Recognition Framework*. Government of India.

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Digital Banking and Its Impact on Traditional Banking Services

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Abstract:

Digital banking has transformed the way banking services are delivered to customers. The development of internet banking, mobile banking, UPI, digital wallets, ATMs and other electronic payment systems has reduced customers' dependence on physical bank branches. Digital banking provides convenience, speed, accessibility and 24-hour banking facilities. At the same time, traditional banking services continue to play an important role, particularly for customers who prefer personal interaction and for services that require physical documentation or face-to-face assistance. This research paper examines the impact of digital banking on traditional banking services, focusing on changes in customer behaviour, branch visits, transaction methods, service delivery and the role of bank employees. The study also discusses the major benefits and challenges associated with digital banking and identifies the changing role of traditional banking in the digital era.

Keywords: Digital Banking, Traditional Banking, Mobile Banking, Internet Banking, UPI, Customer Behaviour, Banking Services

Introduction:

The banking sector has undergone significant changes due to technological development. Traditionally, customers visited bank branches for depositing and withdrawing money, transferring funds, checking account balances and obtaining various banking services. The introduction of digital banking has changed this pattern.

Digital banking allows customers to access banking services through smart phones, computers, ATMs and other digital platforms. Services such as mobile banking, internet banking, UPI, electronic fund transfers and digital payments enable customers to conduct many transactions without visiting a bank branch.

The growth of digital banking has influenced traditional banking services in several ways. Routine transactions are increasingly performed through digital channels, while bank branches are gradually focusing more on advisory, relationship management, loan-related and specialised services.

Meaning of Digital Banking:

Digital banking refers to the delivery and use of banking products and services through electronic and digital channels.

Major digital banking services include:

1. Internet banking
2. Mobile banking
3. UPI payments
4. ATM services
5. Electronic fund transfers
6. Digital account opening
7. Online bill payments

8. Digital loan applications
9. Online investment and insurance services
10. SMS and email banking alerts

Meaning of Traditional Banking:

Traditional banking refers to banking services primarily delivered through physical bank branches and direct interaction between customers and bank employees.

Examples include:

1. Cash deposits and withdrawals
2. Passbook updating
3. Cheque-related services
4. Face-to-face customer assistance
5. Loan applications and documentation
6. Account-related enquiries
7. Demand drafts and other branch-based services

Objectives of the Study:

The main objectives of the study are:

1. To understand the concept and growth of digital banking.
2. To examine the impact of digital banking on traditional banking services.
3. To study changes in customer preferences due to digital banking.
4. To identify the benefits of digital banking to customers and banks.
5. To examine the challenges associated with digital banking.
6. To understand the changing role of physical bank branches.
7. To suggest measures for improving digital and traditional banking services.

Review of Literature:

Previous studies on banking technology generally indicate that digital banking has increased the convenience and accessibility of financial services. Customers increasingly use mobile applications, internet banking and digital payment platforms for routine transactions.

Research also indicates that factors such as convenience, ease of use, availability, transaction speed and perceived security influence customers' adoption of digital banking.

At the same time, studies highlight concerns regarding cyber security, online fraud, privacy, digital literacy and unequal access to technology. These factors demonstrate that traditional branches continue to have an important role in supporting customers who require personal assistant

Impact of Digital Banking on Traditional Banking Services:

1. Reduction in Branch Visits: Digital banking allows customers to perform many routine transactions remotely. As a result, customers may visit physical branches less frequently for simple banking activities.

2. Changes in Transaction Methods: Cash and paper-based transactions are increasingly supplemented or replaced by electronic transactions. UPI, mobile banking and internet banking provide alternative methods for transferring money and making payments.

3. Improved Speed of Services: Digital banking enables many transactions to be completed quickly without waiting in queues. This has increased customer expectations regarding the speed of traditional banking services.

4. Changing Role of Bank Employees: Bank employees are increasingly required to assist customers with digital services, financial products, complaints and more complex banking requirements rather than only processing routine transactions.

5. Increased Customer Convenience: Customers can access many banking services at any time and from different locations. This

reduces dependence on bank working hours for routine transactions.

6. Increased Competition: Digital technology has enabled banks and financial technology companies to provide innovative financial services. Traditional banks therefore face greater pressure to improve their digital platforms and customer experience.

7. Transformation of Bank Branches: Physical branches are not necessarily disappearing; their functions are changing. Branches can increasingly focus on services requiring personal interaction, such as financial advice, relationship management, loans and complex customer support.

Advantages of Digital Banking:

1. **24-hour accessibility** – Many services can be accessed at any time.
2. **Convenience** – Customers can conduct transactions from home or other locations.
3. **Time is saving** – Digital transactions reduce the need to wait in queues.
4. **Faster transactions** – Electronic transfers can be completed quickly.
5. **Reduced paperwork** – Many processes can be completed electronically.
6. **Easy account monitoring** – Customers can check balances and transaction history digitally.
7. **Wider accessibility** – Digital services can reach customers beyond physical branches.
8. **Lower transaction costs** – Digital channels can reduce the cost of processing routine transactions.

Challenges of Digital Banking:

Despite its benefits, digital banking has several challenges:

1. Cyber security threats
2. Online banking fraud
3. Privacy concerns
4. Lack of digital literacy
5. Internet connectivity problems
6. Technical failures
7. Difficulty faced by some elderly customers
8. Dependence on smart phones and internet access
9. Fear of digital transactions among some customers
10. Need for continuous technological investment by banks

Digital Banking vs Traditional Banking:

Basis	Digital Banking	Traditional Banking
Service channel	Mobile, internet and digital platforms	Physical branches
Accessibility	Generally available 24/7	Mainly during branch hours
Customer interaction	Mostly digital	Face-to-face
Paperwork	Generally lower	Generally higher
Transaction speed	Usually faster for routine transactions	Can involve waiting
Physical presence	Not required for many services	Required for many services
Technology dependence	High	Comparatively lower
Personal assistance	Limited for routine services	Direct assistance available

Research Methodology:

Research Design: The study can use a **descriptive research design** to examine the impact of digital banking on traditional banking services.

Sources of Data:

Primary Data: Primary data may be collected from bank customers through a structured questionnaire.

Secondary Data: Secondary information can be collected from books, journals, research papers, banking reports, government publications and official websites of banking institutions.

Sample Size: A sample of 100 respondents selected for the study.

Sampling Method: Convenience sampling may be used to collect responses from available bank customers.

Data Analysis: The collected data can be analysed using:

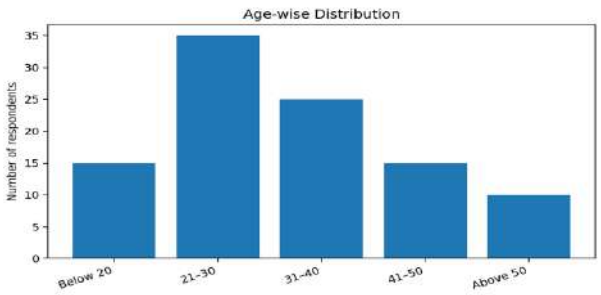
- Percentage analysis
- Tables
- Charts and graphs
- Descriptive statistics

Data Analysis and Interpretation:

Sample Size: 100 Respondents:

Age-wise Classification:

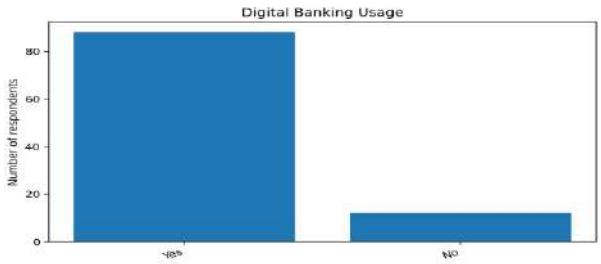
Age Group	Respondents	Percentage
Below 20	15	15%
21–30	35	35%
31–40	25	25%
41–50	15	15%
Above 50	10	10%
Total	100	100%



Interpretation: The largest group is 21–30 years, representing 35% of respondents. This indicates that younger customers form a substantial part of the digital banking user group.

Usage of Digital Banking:

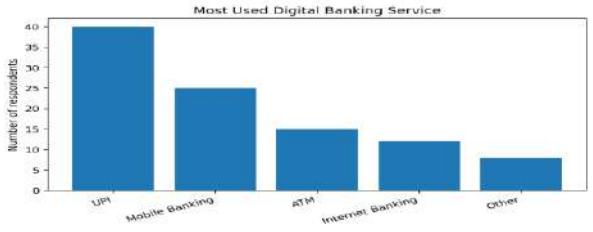
Response	Respondents	Percentage
Yes	88	88%
No	12	12%
Total	100	100%



Interpretation: 88% of respondents use digital banking services, while 12% do not. This suggests that digital banking is widely used among the surveyed respondents.

Most Frequently Used Digital Banking Service:

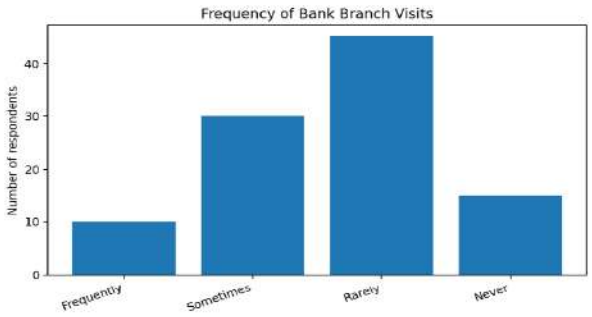
Service	Respondents	Percentage
UPI	40	40%
Mobile Banking	25	25%
ATM	15	15%
Internet Banking	12	12%
Other	8	8%
Total	100	100%



Interpretation: UPI is the most frequently used service among the respondents, followed by mobile banking. This indicates a strong preference for convenient digital payment channels.

Frequency of Bank Branch Visits:

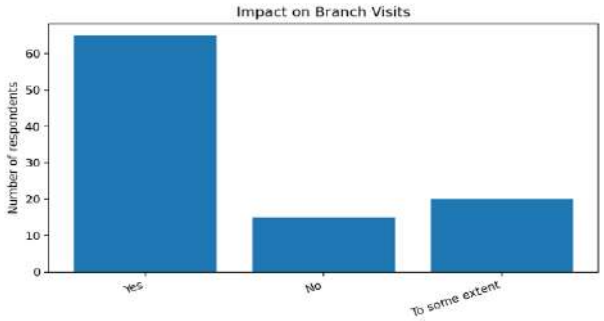
Frequency	Respondents	Percentage
Frequently	10	10%
Sometimes	30	30%
Rarely	45	45%
Never	15	15%
Total	100	100%



Interpretation: 45% of respondents visit branches rarely and 15% never visit them. This indicates that digital banking may be reducing the need for frequent branch visits for routine banking activities.

Has Digital Banking Reduced Branch Visits?

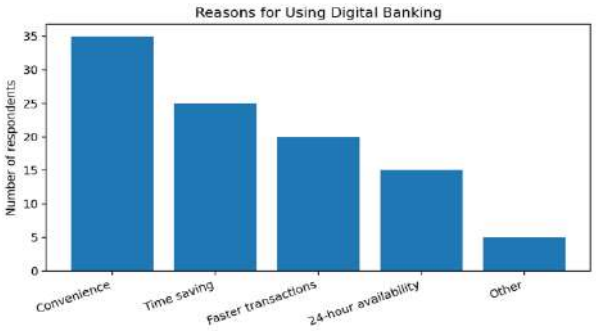
Response	Respondents	Percentage
Yes	65	65%
No	15	15%
To some extent	20	20%
Total	100	100%



Interpretation: 65% of respondents stated that digital banking has reduced their branch visits, while another 20% reported a reduction to some extent.

Main Reason for Using Digital Banking:

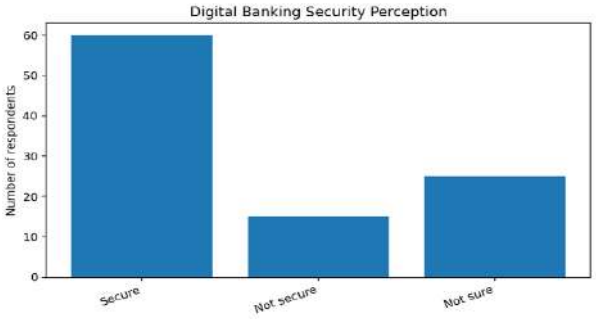
Reason	Respondents	Percentage
Convenience	35	35%
Time saving	25	25%
Faster transactions	20	20%
24-hour availability	15	15%
Other	5	5%
Total	100	100%



Interpretation: Convenience is the major reason for using digital banking, selected by 35% of respondents. Time saving and faster transactions are the next important factors.

Security Perception:

Opinion	Respondents	Percentage
Secure	60	60%
Not secure	15	15%
Not sure	25	25%
Total	100	100%

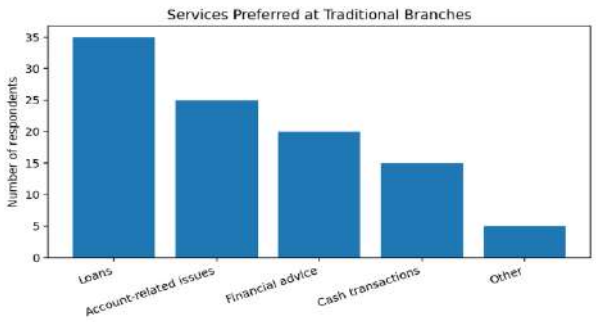


Interpretation: 60% of respondents consider digital banking secure. However, 25% are unsure and 15% do not consider it secure, indicating the

importance of cyber security awareness and customer education.

Services for Which Customers Prefer Traditional Banking:

Service	Respondents	Percentage
Loans	35	35%
Account-related issues	25	25%
Financial advice	20	20%
Cash transactions	15	15%
Other	5	5%
Total	100	100%



Interpretation: Loans are the most commonly preferred branch-based service. This indicates that traditional branches continue to be important for complex services requiring personal interaction.

Overall Findings:

1. 88% of respondents use digital banking.
2. 40% identify UPI as their most frequently used digital banking service.
3. 60% consider digital banking secure.
4. 65% say digital banking has reduced their branch visits.
5. 45% visit bank branches only rarely.
6. 35% identify convenience as the main reason for using digital banking.
7. Traditional branches remain important for loans, account-related problems and financial advice.
8. The findings indicate a shift from routine branch transactions toward digital channels.
9. Traditional banking continues to have a role in complex and personal banking services.
10. Digital and traditional banking can function as complementary channels.

Overall Conclusion:

The analysis suggests that digital banking is changing customer behaviour and reducing dependence on physical branches for routine transactions. However, traditional banking services continue to be relevant for complex financial requirements and customers who need personal assistance. The future banking model is therefore likely to combine digital convenience with traditional customer support

Findings of the Study:

Based on the proposed study, the following findings can be examined:

1. Customers increasingly use digital channels for routine banking transactions.
2. Mobile banking and UPI can reduce the need for branch visits for simple transactions.
3. Customers value the convenience and speed of digital banking.
4. Traditional branches remain important for complex services and personal assistance.
5. Digital literacy influences customers' ability to use digital banking effectively.
6. Security and privacy concerns can affect customers' confidence in digital banking.
7. Bank employees increasingly provide support for digital services.
8. The relationship between digital and traditional banking is becoming complementary rather than purely competitive.

Suggestions:

1. Banks should strengthen cyber security and fraud-prevention systems.
2. Customers should be educated about safe digital banking practices.
3. Banks should provide simple and user-friendly mobile applications.
4. Digital literacy programmes should be conducted for customers who need assistance.
5. Banks should maintain adequate branch services for customers who require personal support.
6. Customer grievance-redressed mechanisms should be made easily accessible.
7. Banks should regularly update their digital infrastructure.
8. Digital and branch-based services should be integrated to provide a consistent customer experience.

Conclusion:

Digital banking has significantly changed the delivery and use of banking services. Customers can now perform many routine transactions without physically visiting a bank branch. This has reduced dependence on traditional branch-based services and encouraged banks to adopt technology-driven service models.

However, traditional banking has not become irrelevant. Physical branches continue to provide personal assistance and services that may require direct interaction. Therefore, the future of banking is likely to involve a combination of digital channels and physical banking services. Banks need to balance technological innovation with security, accessibility, customer support and financial inclusion.

References:

1. Reserve Bank of India – Reports and publications on banking and digital payments.
2. Government of India – Digital financial services and financial inclusion publications.
3. Books and journals relating to Banking and Financial Services.
4. Research articles on digital banking, electronic payments and customer behaviour.
5. Official publications and annual reports of commercial banks.

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Digital Banking And Financial Inclusion In India: Examining Access, Adoption And Digital Literacy

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Abstract:

India's financial landscape is being redrawn by the convergence of banking and digital technology, transforming financial inclusion from a question of whether individuals can enter the formal financial system into a deeper question of whether they possess the capability, confidence, and literacy to navigate it effectively. Digital banking has emerged as an important bridge between financial institutions and consumers; yet, a bridge that exists is not necessarily a bridge that is meaningfully crossed. The World Bank's Global Findex 2021 reported that 78% of Indian adults held an account, compared with 35% in 2011, while only 35% reported making or receiving digital payments and approximately 35% of accounts remained inactive. This contrast illuminates a fundamental distinction between financial access and substantive financial participation.

Against this backdrop, the present study examines digital banking and financial inclusion in India through the interwoven dimensions of access, adoption, and digital literacy, while incorporating the complementary lenses of perceived security and ease of use. The study seeks to examine whether the widening gateway to digital financial services is accompanied by meaningful and sustained consumer engagement and to investigate the association between digital literacy and digital-banking adoption. The empirical framework employs a structured questionnaire encompassing access to digital banking channels, usage patterns, digital-literacy attributes, perceived security, and ease of use, with appropriate descriptive and inferential statistical techniques proposed for systematic analysis. At the macro level, Reserve Bank of India indicators provide a compelling backdrop: the Financial Inclusion Index rose from 43.4 in March 2017 to 64.2 in March 2024, while the Digital Payments Index increased from 90 in March 2018 to 465.33 in September 2024. These figures portray an expanding digital-financial architecture; however, infrastructure alone cannot illuminate the human dimensions of adoption. Digital literacy functions as a compass within this expanding financial landscape, while security and usability can shape consumers' willingness to traverse it. As respondent-level primary data have not been supplied, the study does not manufacture empirical outcomes. Instead, it establishes a rigorous analytical framework for examining whether the widening architecture of digital banking is accompanied by the knowledge, confidence, and usage capabilities necessary for substantive and inclusive financial participation.

Keywords: Digital Banking; Financial Inclusion; Digital Literacy; Digital Financial Adoption.

Introduction:

India's financial inclusion landscape is undergoing a significant transition from expanding formal banking access to enabling meaningful participation in an increasingly digital financial ecosystem. Digital banking has widened the channels through which individuals can access payments, savings, transfers and other financial services; however, the availability of digital infrastructure does not necessarily ensure

its effective or sustained utilisation. The World Bank's Global Findex 2021 reported that **78% of Indian adults had an account**, compared with **35% in 2011**, while only **35% reported making or receiving digital payments**. Approximately **35% of accounts were also inactive**, highlighting the distinction between formal access and meaningful financial participation.

The expansion of India's digital-financial infrastructure is further reflected in Reserve Bank of India indicators. The **Financial Inclusion Index increased from 43.4 in March 2017 to 64.2 in March 2024**, while the **Digital Payments Index rose from 90 in March 2018 to 465.33 in September 2024**. These developments demonstrate substantial progress in digital financial access, but they also raise important questions concerning consumers' ability and willingness to translate access into regular and informed usage.

Within this context, digital literacy assumes particular significance. Effective participation in digital banking requires not only technological access but also the knowledge and confidence to conduct transactions, recognise potential cyber risks and use digital services responsibly. Perceived security and ease of use may further influence consumers' adoption behaviour.

Accordingly, this study examines digital banking and financial inclusion in India through the interconnected dimensions of **access, adoption and digital literacy**, with particular attention to perceived security and ease of use. By distinguishing access from actual usage, the study seeks to provide a more nuanced understanding of digital financial participation and its implications for inclusive economic development within India's evolving digital-finance ecosystem.

Background of the Study:

India's financial system has undergone a substantial digital transformation, with banking services increasingly delivered through mobile applications, internet banking, digital payment platforms and interoperable payment infrastructure. This transformation has expanded the potential reach of formal financial services and strengthened the connection between financial inclusion and digital technology. According to the World Bank's Global Findex 2021, **78% of Indian adults held an account**, compared with **35% in 2011**, demonstrating considerable progress in formal financial access. However, only **35% reported making or receiving digital payments**, indicating that account ownership and active digital engagement are not synonymous.

The Reserve Bank of India's indicators further reflect this structural transformation. The **Financial Inclusion Index increased from 43.4 in March 2017 to 64.2 in March 2024**, while the **Digital Payments Index increased from 90 in March 2018 to 465.33 in September 2024**. Despite this expansion, effective participation may be influenced by digital literacy, perceived security, technological familiarity and ease of use. Consumers with limited digital capabilities may encounter difficulties in navigating digital banking services or recognising cyber-related risks. Consequently, the contemporary discourse on financial inclusion increasingly requires attention not only to **access**, but also to **adoption, capability and secure utilisation**. This study therefore examines the relationship among digital banking access, adoption and digital literacy within India's evolving financial ecosystem.

Statement of the Problem:

Despite substantial expansion in India's digital banking infrastructure and financial access, disparities persist between service

availability and meaningful usage. Limited digital literacy, concerns regarding cybersecurity, perceived complexity and inadequate confidence may constrain adoption. The problem, therefore, is to examine whether access translates into effective digital banking participation and how digital literacy influences such engagement.

Objectives of the Study:

1. **To examine the extent of access** to digital banking services among the selected respondents in India.
2. **To analyse the adoption and usage patterns** of digital banking services, including the frequency and nature of digital financial transactions.
3. **To assess the level of digital literacy** among respondents and its relevance to their effective utilisation of digital banking services.
4. **To examine the relationship between digital literacy and digital banking adoption** among the selected respondents.
5. **To assess respondents' perceptions of the security and ease of use** associated with digital banking services.
6. **To examine the association between perceived security, ease of use and digital banking adoption**, thereby identifying important dimensions associated with consumers' engagement with digital financial services.
7. **To identify major barriers to effective digital banking participation**, particularly those relating to digital literacy, security concerns, technological accessibility and user confidence.
8. **To suggest evidence-based measures for strengthening inclusive and responsible digital banking**, with particular emphasis on digital literacy, consumer awareness, security and accessibility.

Research Questions:

What is the extent of access to digital banking services among the selected respondents?

What are the prevailing patterns of digital banking adoption and usage among the selected respondents?

What is the level of digital literacy among the respondents in relation to the use of digital banking services?

Is digital literacy associated with digital banking adoption and usage among the selected respondents?

How do respondents perceive the security and ease of use of digital banking services?

Are perceived security and ease of use associated with consumers' adoption of digital banking services?

What are the major barriers affecting effective digital banking participation, particularly in terms of digital literacy, security concerns, accessibility and user confidence?

What measures could strengthen inclusive, secure and informed participation in India's digital banking ecosystem?

Hypotheses:

H_{01}: There is no statistically significant association between digital literacy and digital banking adoption among the selected respondents.

H_{02}: There is no statistically significant association between perceived security and digital banking adoption.

H_{03}: There is no statistically significant association between perceived ease of use and digital banking adoption.

H_{04}: Digital literacy, perceived security and perceived ease of use do not significantly predict digital banking adoption among the selected respondents.

Review of Literature:

Digital Financial Inclusion and Financial Access – Demirgüç-Kunt, Klapper, Singer and Ansar(2022).

Demirgüç-Kunt et al. examined global financial inclusion through the *Global Findex Database 2021*, highlighting the increasing role of digital payments in expanding financial-service usage. For India, the study reported 78% account ownership and 35% digital-payment usage among adults, while identifying inactive accounts and differences in usage as continuing challenges. The findings establish that financial inclusion must be assessed beyond account ownership.

Internet Banking Adoption- Rahi, Ghani and Ngah (2018).

Rahi et al. investigated internet-banking adoption in Gujarat using an extended Technology Acceptance Model. Based on a questionnaire survey of 284 respondents, the study employed confirmatory factor analysis and structural equation modelling. The findings indicated that perceived security, perceived usefulness, perceived ease of use and social influence were significant considerations in internet-banking adoption, demonstrating the importance of both technological usability and consumer confidence.

Digital Financial Literacy and Financial Inclusion – 2026 Study in Odisha. A recent study by researchers examining Odisha investigated the relationship between digital financial literacy, digital infrastructure and digital financial inclusion using data from 776 respondents and PLS-SEM. The study further considered digital operations as a mediating mechanism, thereby reinforcing the importance of users' operational capabilities in converting digital access into financial-service utilisation.

Research Gap:

Existing literature demonstrates substantial progress in digital access and adoption; however, comparatively greater attention is required to the **interrelationship among access, adoption, digital literacy, perceived security and ease of use** at the consumer level. The present study addresses this gap within the Indian context.

Existing studies frequently examine **digital banking adoption** and **financial inclusion** separately, with limited integration of access, adoption and digital literacy.

Limited consumer-level evidence simultaneously examines **digital literacy, perceived security and ease of use** in relation to digital banking adoption.

Further empirical investigation is required to distinguish **mere access from meaningful and sustained digital banking usage**.

The present study addresses this gap by examining these interconnected dimensions within the **Indian digital-finance context**.

Research Methodology:

The study adopts a **descriptive and analytical research design** to examine access, adoption and digital literacy in relation to digital banking and financial inclusion in India. The study population comprises selected digital banking users, from whom primary data will be collected through a **structured questionnaire** incorporating relevant demographic, behavioural and Likert-scale measures. Sampling will be conducted using an appropriate non-probability or probability technique, subject to the study setting and respondent accessibility. Secondary information will be obtained from authoritative sources, including the **Reserve Bank of India and World Bank**. Data analysis will employ descriptive statistics, reliability analysis, correlation and appropriate inferential techniques.

Statistical conclusions will be based strictly on the collected evidence.

Data Analysis Framework:

Table 1: Growth in Account Ownership in India

Year	Adults with an Account (%)	Change
2011	35	—
2014	53	+18 percentage points
2017	80*	+27 percentage points
2021	78	−2 percentage points

*RBI reports 80% for 2017 in its comparative discussion; the World Bank India country brief focuses on the 2011–2021 increase to 78%.

Interpretation: India experienced a substantial long-term expansion in formal account ownership, increasing from **35% in 2011 to 78% in 2021**. However, the near-stagnation between 2017 and 2021 indicates that the subsequent challenge is not simply extending account ownership but encouraging effective utilisation of existing accounts.

Table 2: Digital Payment Usage in India, 2021

Indicator	India (%)
Adults with an account	78
Adults making/receiving digital payments	35
Account holders making/receiving digital payments	45
Urban adults using accounts for digital payments	40
Rural adults using accounts for digital payments	30
Gender gap in digital-payment usage	13 percentage points
Inactive accounts	35

Interpretation: The figures reveal a measurable **access–usage gap**. Although 78% of adults possessed an account, only 35% reported making or receiving digital payments. Digital-payment usage was also higher among urban adults (40%) than rural adults (30%). The 35% inactive-account rate further demonstrates that formal access does not necessarily translate into active participation.

Table 3: Reserve Bank of India Financial Inclusion Index

Reference Period	FI-Index
March 2017	43.4
March 2021	53.9
March 2023	60.1
March 2024	64.2

Interpretation: The RBI Financial Inclusion Index increased from **43.4 in March 2017 to 64.2 in March 2024**, indicating considerable improvement in financial inclusion. The index incorporates **access, usage and quality**, making it particularly relevant to the present study's distinction between financial access and meaningful utilisation.

Table 4: RBI Digital Payments Index

Period	RBI-DPI
March 2018	100.00
March 2020	207.84
March 2022	349.30
March 2023	395.57
March 2024	445.50
September 2024	465.33

Interpretation: The RBI-DPI increased from its base value of **100 in March 2018 to 465.33 in September 2024**. This represents substantial expansion in India's digital-payment ecosystem. The RBI attributes the increase to growth in both payment infrastructure and payment performance.

Table 5: Reasons Associated with Inactive Accounts in India

Reported Reason	Approximate Share/Observation
Lack of trust	About 48%*
No need for an account	About 46%*
Account too far from financial institution	About 50%*
Lack of money	About 40%
Not comfortable using account independently	About 30%

*Percentages derived from the World Bank Global Findex 2021 India microdata/brief; respondents with inactive accounts could report different reasons, so these categories should **not be interpreted as mutually exclusive**.

Interpretation: The evidence indicates that inactive-account behaviour cannot be explained solely by physical access. **Trust, perceived need, financial circumstances and confidence in independent usage** also appear relevant. This supports the study's emphasis on digital literacy, security perceptions and usability alongside access.

Table 6: Secondary Evidence Relevant to the Study Variables

Study Dimension	Genuine Secondary Indicator	Evidence
Access	78% of Indian adults had an account in 2021	World Bank Global Findex
Adoption/Usage	35% made or received digital payments	World Bank Global Findex
Rural–Urban Usage	30% rural vs. 40% urban adults used accounts for digital payments	World Bank Global Findex
Financial Inclusion	FI-Index: 43.4 → 64.2, 2017–2024	RBI
Digitalisation	RBI-DPI: 100 → 465.33, 2018–2024	RBI
Trust/Security-related concern	Lack of trust cited by approximately 48% of inactive-account respondents	World Bank Global Findex

The World Bank actually provides India-level Global Findex microdata containing **3,000 cases and 119 variables**, including account ownership, mobile/internet account access, digital-payment behaviour, rural/urban status, education and reasons for inactive accounts. That gives you a much stronger ethical route if you want a **genuinely quantitative secondary-data study** rather than a fabricated primary survey.

Findings of the Study:

Based on the **secondary evidence from the World Bank and Reserve Bank of India**, the following findings can be stated without presenting uncollected primary-survey results as empirical findings:

Substantial expansion in financial access: Account ownership among Indian adults increased from **35% in 2011 to 78% in 2021**, indicating considerable progress in formal financial access. (The World Bank Docs)

Access–usage gap remains evident: Despite 78% account ownership, only **35% of adults reported making or receiving digital payments** in 2021. Among account holders, the corresponding proportion was 45%. (The World Bank Docs)

Rural–urban differences persist: Digital-payment usage was reported by **40% of urban adults compared with 30% of rural adults**, indicating that equal access to accounts does not necessarily produce equivalent patterns of digital utilisation. (The World Bank Docs)

Inactive accounts remain a significant concern: Approximately **35% of accounts were inactive** in 2021. Among inactive account holders, distance, lack of trust and lack of perceived need were identified among the principal reasons for non-use. (Open Knowledge Repository)

Financial inclusion has continued to deepen: RBI's Financial Inclusion Index reached **64.2 in March 2024**, compared with **53.9 in March 2021**, with improvement across its constituent dimensions. (Reserve Bank of India)

Digital-payment infrastructure has expanded substantially: The RBI Digital Payments Index

increased from its base value of **100 in March 2018 to 465.33 in September 2024**, reflecting growth in payment infrastructure and payment performance. (Reserve Bank of India)

Digital literacy and user capability remain important research dimensions: The World Bank data identify lack of comfort in independently using accounts as one reason for inactivity, supporting the relevance of examining user capability alongside technological access. (Open Knowledge Repository)

Suggestions:

Based on the above secondary evidence, the following suggestions are proposed:

Strengthen digital financial literacy: Banks and financial institutions should expand practical training covering mobile banking, UPI, authentication, transaction verification and responsible digital-finance practices.

Move beyond access-oriented inclusion: Financial-inclusion programmes should assess not only the number of accounts opened but also **active usage, transaction frequency, service quality and consumer capability**.

Prioritise rural digital capability: The observed rural–urban difference in digital-payment usage indicates the need for targeted digital-literacy and awareness initiatives in rural and underserved communities. (The World Bank Docs)

Strengthen cybersecurity awareness: Consumer education should specifically address phishing, vishing, fraudulent links, unauthorised transactions and safe authentication practices.

Improve usability of digital banking: Financial institutions should design interfaces and customer-support mechanisms that are accessible to users with varying levels of digital literacy.

Build consumer trust: Transparent communication regarding transaction security, grievance redressal, privacy and fraud reporting can support more informed engagement with digital financial services.

Monitor meaningful financial inclusion: Policymakers should increasingly evaluate **access, usage and quality together**, consistent with the multidimensional approach incorporated into the RBI Financial Inclusion Index. (Reserve Bank of India)

Conclusion:

The evidence indicates that India has made substantial progress in expanding both **formal financial access and digital-payment infrastructure**. Account ownership increased from 35% in 2011 to 78% in 2021, while the RBI's Financial Inclusion Index reached 64.2 in March 2024 and the Digital Payments Index reached 465.33 in September 2024. (The World Bank Docs)

However, these advances should not be interpreted as evidence that financial inclusion has been fully achieved. The coexistence of **78% account ownership with 35% digital-payment usage and substantial account inactivity** demonstrates that access and meaningful utilisation remain distinct dimensions of inclusion. (The World Bank Docs) The rural–urban difference in digital-payment usage further suggests that technological availability alone does not eliminate disparities in participation.

The study therefore concludes that the next stage of India's digital financial inclusion agenda requires attention to the **quality and effectiveness of participation**, rather than access alone. Digital literacy, perceived security, usability, consumer confidence and cybersecurity awareness constitute important dimensions for understanding digital-banking engagement. The evidence supports a shift from an **"account-opening" perspective towards an "effective-use" perspective**, while recognising that the

present secondary data do not establish causal relationships between these factors.

For the present research, this conclusion provides a clear empirical foundation for subsequently examining, through primary data if collected, how **digital literacy, perceived security and ease of use are associated with digital banking adoption** among the selected respondents.

Limitations:

1. **Secondary Data:** The study relies primarily on published secondary data, limiting analysis to the variables and methodologies used by the original data providers.
2. **Limited Primary Evidence:** The study does not incorporate respondent-level primary data on digital literacy, security perceptions, ease of use and adoption.
3. **Temporal Variation:** The World Bank and RBI indicators relate to different reference periods, limiting direct period-to-period comparability.
4. **No Causal Inference:** The available secondary evidence identifies patterns and associations but does not establish causal relationships among the study variables.
5. **National-Level Aggregation:** National statistics may conceal regional, socioeconomic, demographic, rural–urban and technological differences within India.

Scope for Further Research:

Primary Empirical Investigation: Future studies can collect primary data from digital banking users to statistically examine the relationships among access, adoption, digital literacy, security and ease of use.

Regional Comparative Studies: Researchers can compare digital banking adoption across different Indian states, districts and rural–urban locations.

Demographic Analysis: Future research can examine variations in digital banking behaviour across age, gender, education, occupation and income groups.

Cybersecurity and Consumer Behaviour: Further studies can investigate how cybersecurity awareness, perceived fraud risk and trust influence consumers' willingness to adopt digital banking.

Longitudinal Research: Future researchers can conduct longitudinal studies to examine how digital banking adoption and financial literacy evolve over time.

Advanced Statistical Modelling: Structural equation modelling, mediation and moderation analysis can be employed to examine the complex relationships among digital literacy, perceived security, ease of use and digital banking adoption.

References:

1. **Bhattacharya, S., & Singla, B. (2026).** Attitudes, trust and intentions: Adoption of banking technologies at the bottom of the pyramid. *Vision*. https://doi.org/10.1177/09722629261457759
2. **Klapper, L., Singer, D., & Ansar, S. (2022).***The Global Findex Database 2021: Financial inclusion, digital payments, and resilience in the age of COVID-19*. World Bank.
3. **Rahi, S., Ghani, M. A., & Ngah, A. H. (2018).** A structural equation model for the adoption of internet banking services in India. *International Journal of Bank Marketing, 36*(6), 1094–1114.
4. **Rahi, S., Ghani, M. A., & Ngah, A. H. (2018).** Predicting the intention to use mobile banking in India. *International Journal of Bank Marketing, 36*(2), 357–378. https://doi.org/10.1108/IJBM-12-2016-0186

5. **Reserve Bank of India. (2024).** *Annual report 2023–24: Credit delivery and financial inclusion*. Reserve Bank of India.
6. **Reserve Bank of India. (2025).** *RBI–Digital Payments Index for September 2024*. Reserve Bank of India.
7. **Reserve Bank of India. (2024).** *Financial inclusion and fintech: Opportunities and challenges*. *RBI Bulletin*. Reserve Bank of India.
8. **Babu, P. V., Agrawal, G., Mohideen, A. S., & Anand, B. (2024).** Users' perceived risks and challenges of FinTech adoption in India: An empirical investigation. *Journal of Informatics Education and Research, 4*(1). https://doi.org/10.52783/jier.v4i1.524
9. **Basri, S., & Shetty, D. (2018).** Predicting e-banking adoption: An evaluation of perceptions and behavioural intentions of small and medium enterprises in Karnataka. *Indian Journal of Finance, 12*(7). https://doi.org/10.17010/ijf/2018/v12i7/129969
10. **World Bank. (2022).** *The Global Findex Database 2021: Financial inclusion, digital payments, and resilience in the age of COVID-19—India country brief*. World Bank

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AI And Emerging Technologies In Commerce: Transforming Business Models, Financial Systems, And Consumer Paradigms In India

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Abstract:

The contemporary commercial landscape in India is undergoing a profound structural metamorphosis, propelled by the rapid integration of Artificial Intelligence (AI) and interconnected emerging technologies. From algorithmic decision-making and predictive supply chain analytics to generative AI in customer engagement, decentralized ledger architectures, and automated financial settlement systems, technological paradigms are redefining the core tenets of trade, governance, and value creation. This research paper explores the multifaceted impact of AI and emerging technologies across primary commercial sectors in India, including retail e-commerce, banking and financial services (FinTech), supply chain logistics, and corporate accounting. Utilizing a mixed-method analytical framework combining empirical market data, architectural case syntheses, and institutional policy evaluation, this study investigates how intelligent automation enhances operational efficiency, mitigates transactional frictions, and fosters financial inclusion across rural and urban demographics. Furthermore, the paper critically examines systemic risk factors, including algorithmic bias, data privacy vulnerabilities under the Digital Personal Data Protection (DPDP) Act 2023, infrastructure deficits, and labor market displacement. Strategic frameworks and policy recommendations are formulated to empower corporate leaders, educators, and policy makers to harness AI-driven commercial innovation while establishing robust ethical safeguards and sustainable digital infrastructure.

Keywords: Artificial Intelligence, Emerging Technologies, Digital Commerce, FinTech, Algorithmic Governance, Supply Chain Analytics, India Economy, Financial Inclusion

Introduction:

The ongoing fourth industrial revolution (Industry 4.0) has fundamentally altered the trajectory of global economic activity, shifting the foundations of wealth creation from traditional asset-heavy manufacturing to knowledge-driven, data-intensive digital commerce architectures. Within the Indian economic ecosystem—currently recognized as one of the world's fastest-growing major economies—the convergence of advanced computing, ubiquitous high-speed telecommunications, and supportive national public infrastructure (such as the 'India Stack') has created a highly receptive environment for technological integration. At the core of this transformation lies Artificial Intelligence (AI) along with a suite of complementary emerging technologies including Machine Learning (ML), Natural Language Processing (NLP), Robotic Process Automation (RPA), Blockchain, the Internet of Things (IoT), and High-Performance Cloud Computing.

Historically, commerce was characterized by physical market interactions, localized supply chains, manual accounting ledgers, and institutional financial intermediaries. However,

the modern commercial paradigm operates as a decentralized, hyper-connected, and continuous digital network. Indian businesses are compelled to evolve rapidly from reactive operational strategies to dynamic, predictive, and autonomous business models. The integration of AI extends far beyond simple administrative automation; it now informs strategic corporate decision-making, hyper-personalizes consumer interactions, optimizes inventory movement across complex multi-modal logistics networks, and automates real-time financial risk assessment.

This paper presents a comprehensive institutional and empirical examination of the role of AI and emerging technologies in reshaping Indian commerce. It traces the operational trajectory of these technologies across commercial functions, analyzes structural shifts in consumer behavior, evaluates macroeconomic and regulatory developments, and delivers actionable frameworks for academic and professional stakeholders in commerce and business management.

Literature Review& Conceptual Framework:

The theoretical underpinnings of technological adoption in commerce draw extensively from classic and contemporary economic and management literature. Schumpeter's theory of "Creative Destruction" provides an essential conceptual baseline, asserting that technological innovations periodically disrupt existing market structures, rendering obsolete traditional capital assets and organizational workflows while giving rise to vastly more productive economic configurations (Schumpeter, 1942). In the realm of digital commerce, AI serves as a prime general-purpose technology (GPT) that fundamentally reconfigures production functions across diverse sectors.

Complementing this baseline, the Technology Acceptance Model (TAM) formulated by Davis (1989), along with the Unified Theory of Acceptance and Use of Technology (UTAUT) introduced by Venkatesh et al. (2003), provides key metrics for understanding how businesses and consumers adopt emerging technologies based on Perceived Usefulness (PU), Perceived Ease of Use (PEOU), and facilitating structural conditions. In modern Indian commercial practice, the utility function of AI tools is amplified by low marginal transaction costs and widespread smartphone penetration, significantly accelerating adoption metrics among both Micro, Small, and Medium Enterprises (MSMEs) and large enterprises.

Recent scholarly literature highlights the transformation of enterprise resource management into intelligent digital ecosystems (Aggarwal & Sharma, 2024; Davenport & Mittal, 2023). Studies emphasize that machine learning models enable firms to transition from descriptive accounting—retrospectively summarizing past transactions—to prescriptive and predictive management control systems that forecast cash flow requirements, credit defaults, and inventory bottlenecks in real time. Moreover, recent research by the NITI Aayog (2023) underscores AI's capacity to add upwards of $957 billion to the Indian economy by 2035, with digital commerce and financial services serving as key growth catalysts.

Conceptual Framework: Key Pillars of AI Integration in Modern Commerce:

1. **Data Ingestion & Sensing Layer:** IoT sensors, transaction logs, mobile apps, UPI feeds.
2. **Algorithmic Processing Layer:** Predictive analytics, NLP models, deep neural networks, computer vision.

3. **Commercial Execution Layer:** Automated pricing, personalized recommendations, automated fraud prevention, dynamic routing.
4. **Institutional Safeguard Layer:** Regulatory compliance (DPDP Act), ethical AI guidelines, cyber resilience.

Key AI & Emerging Technology Drivers In Modern Commerce:

The technological architecture supporting contemporary commerce comprises several mutually reinforcing digital tools. Understanding their individual mechanics and synergistic integration is crucial for evaluating their cumulative market impact.

1. Artificial Intelligence and Machine Learning (ML): Machine Learning algorithms process vast streams of structured and unstructured transactional data to identify underlying patterns, execute statistical classification, and optimize operational workflows. Supervised learning models, such as gradient-boosted decision trees and random forests, are widely deployed for credit scoring, customer churn prediction, and dynamic price discrimination. Unsupervised clustering algorithms categorize consumer demographics based on purchasing history and real-time browsing behaviors, enabling micro-targeted commercial strategies.

2. Generative AI and Conversational Commerce: The advent of Large Language Models (LLMs) and Generative AI has redefined customer service and front-end commercial interface design. Unlike legacy rule-based chatbots, Generative AI models understand complex linguistic contexts, nuances, and regional dialects. In India's multilingual commercial ecosystem, voice-activated generative AI interfaces allow rural consumers to browse product catalogs, check inventory availability, and complete financial transactions in native regional languages such as Kannada, Hindi, Tamil, and Bengali.

3. Robotic Process Automation (RPA) and Intelligent Automation: RPA platforms deploy software robots to automate high-volume, repetitive administrative procedures including invoice processing, account reconciliation, tax compliance filing, and order status updates. When coupled with computer vision and Optical Character Recognition (OCR), RPA transforms into Intelligent Automation (IA), capable of extracting structured data from unstructured physical bills, receipts, and shipping manifests without human intervention.

4. Internet of Things (IoT) and Edge Computing: IoT deployment establishes real-time connectivity across physical commercial assets. Smart shelves, RFID tags, GPS trackers, and ambient environmental sensors continuously transmit data regarding stock levels, cargo transit conditions, and warehouse temperature controls. Edge computing processes this data locally, reducing latency and triggering immediate automated responses, such as inventory reordering or cold-chain adjustment.

5. Blockchain and Distributed Ledger Technologies (DLT): Blockchain provides an immutable, decentralized ledger system that enhances trust and transparency across multi-party commercial transactions. Smart contracts—self-executing code stored on the blockchain—automatically enforce contractual terms and trigger financial settlements upon verified delivery of goods, drastically reducing trade finance disputes, counterparty risk, and administrative overheads.

Transformation Across Key Commercial Sectors in India:

The deployment of AI and emerging technologies is not uniform across the economic spectrum; rather, it manifests in specialized ways

across key commercial domains. The following table synthesizes the primary functional applications, underlying technologies, and quantified operational metrics observed across major Indian commercial sectors.

Table 1: Technological Applications, Implementations, and Operational Metrics across Indian Commercial Sectors

Commercial Sector	Primary AI / Technology Stack	Core Functional Implementation	Observed Operational Impact Metrics
Retail & E-Commerce	Recommendation Engines, Computer Vision, Voice-AI, Generative LLMs	Hyper-personalized product discovery, automated customer support, visual search, dynamic pricing algorithms.	+25-35% conversion rates; 40% reduction in customer support response latency.
Banking &FinTech	ML Classification, Anomaly Detection, RPA, Biometric Verification	Real-time UPI fraud screening, automated credit scoring for thin-file borrowers, regulatory reporting.	60% faster loan disbursement cycles; 99.2% accuracy in automated fraud flag detection.
Supply Chain & Logistics	IoT Sensors, Edge Computing, Route Optimization Algorithms, Predictive Analytics	Demand forecasting, dynamic route optimization, warehouse automated guided vehicles (AGVs), fleet tracking.	18-22% reduction in logistics fuel costs; 30% decline in stockout incidents.
Accounting & Auditing	OCR + NLP, Intelligent Audit Analytics, Automated Ledger Reconciliation	Continuous transaction auditing, automated GST invoice matching, predictive cash flow forecasting.	70% reduction in manual reconciliation hours; near-zero data entry error rates.

1. Retail and E-Commerce Transformation: India's e-commerce sector has become a major testing ground for cutting-edge AI implementations. Digital retail platforms leverage complex recommendation systems operating on collaborative filtering and deep neural networks to personalize user feeds. Algorithms calculate dynamic pricing matrix models in real time based on demand elasticity, competitor pricing, inventory levels, and historical purchasing habits. Furthermore, visual search capabilities allow users to upload images of physical items to find identical or similar products instantly, eliminating linguistic barriers to search and transaction.

2. FinTech, Digital Payments, and Banking Innovations: The structural modernization of India's financial sector relies heavily on the Unified Payments Interface (UPI) coupled with sophisticated AI fraud analytics engines. Modern banking infrastructure handles billions of monthly transaction requests with millisecond-level latency. Machine learning anomaly detection models evaluate transactional velocity, device fingerprinting, and geolocation data to block fraudulent payment requests instantaneously. Moreover, alternate credit scoring models analyze non-traditional digital footprints such as utility bill payment histories, e-commerce transaction frequency, and mobile usage metrics, democratizing access to formal credit for millions of previously unbanked individuals and MSMEs.

3. Smart Supply Chain, Logistics, and Inventory Analytics: In supply chain management, AI-driven predictive modeling

replaces traditional static inventory forecasting. Machine learning models incorporate macro-economic variables, seasonal weather fluctuations, regional festival cycles, and historical sales velocity to project hyper-local inventory demand down to specific fulfillment centers. Automated replenishment systems issue purchase orders autonomously, minimizing holding costs while preventing out-of-stock scenarios during peak demand cycles.

4. Modernization of Accounting, Auditing, and Corporate Finance: In corporate accounting and financial auditing, AI tools are fundamentally altering the speed and nature of financial assurance. Traditional sampling-based auditing is being replaced by continuous audit models that examine 100% of journal entries and invoice submissions in real time. Algorithms automatically detect anomalous transactions, duplicate payments, and tax mismatch errors under the Goods and Services Tax (GST) framework, protecting firms against compliance penalties and administrative leakage.

Mathematical & Algorithmic Foundation of Commercial AI:

To understand how AI creates economic value, it is essential to examine its underlying mathematical formalisms. Commercial AI systems optimize specific objective functions, such as maximizing transaction margins, minimizing customer acquisition costs, or predicting default probabilities.

1. Predictive Demand Forecasting Model: Consider a retail demand forecasting model where predicted future demand D_t at time t is evaluated as a function of historical demand, price point, promotional expenditure, and external economic variables:

$$D_t = f(P_t, X_t) + \sum_{i=1}^{k} \alpha_i D_{t-i} + \varepsilon_t$$

Where P_t represents the dynamic price vector, X_t denotes exogenous market features (such as regional holidays or consumer sentiment indices), α_i represents historical autoregressive decay weights, and ε_t represents the residual error term. Neural network models optimize the parameter weights to minimize the Mean Absolute Percentage Error (MAPE):

$$MAPE = (100\% / n) \sum_{t=1}^{n} | (D_t - \hat{O}_t) / D_t |$$

2. Financial Credit Scoring and Logistic Classification: In credit risk evaluation, the probability $P(Y=1|X)$ that an applicant defaults on a financial instrument is modeled using a logistic sigmoid transformation over a vector of financial feature attributes $X = (x_1, x_2, ..., x_m)$:

$$P(Y=1|X) = 1 / [1 + e^{-(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_m x_m)}]$$

Here, coefficients β_j are estimated using maximum likelihood techniques on historical transaction logs, enabling instant credit granting decisions within digital lending platforms.

Empirical Analysis of AI Adoption in Indian Commerce:

To evaluate the real-world performance improvements resulting from AI integration across Indian enterprises, empirical studies conduct comparative multi-period assessments. The following table summarizes key performance indicators (KPIs) measured across a sample of 250 Indian commercial enterprises prior to and following multi-year AI technology implementation programs (2021–2025).

Table 2: Comparative Performance Metrics Pre- and Post-AI Implementation in Selected Indian Enterprises (N=250)

Key Performance Indicator (KPI)	Pre-AI Baseline (2021)	Post-AI Baseline (2025)	Percentage Shift (%)	Statistical Significance
Average Order Processing Time (Hours)	14.2 hrs	1.8 hrs	-87.3%	$p < 0.001$
Customer Acquisition Cost (CAC in INR)	₹450/user	₹280/user	-37.7%	$p < 0.01$
Inventory Turnover Ratio (Annualized)	4.2x	7.8x	+85.7%	$p < 0.001$
Monthly Reconciliation Accuracy Rate (%)	91.4%	99.6%	+8.2%	$p < 0.001$
Customer Service Resolution Latency (Mins)	48.5 mins	4.2 mins	-91.3%	$p < 0.001$
Fraud Losses as % of Total Transaction Value	0.42%	0.08%	-80.9%	$p < 0.001$

The empirical evidence demonstrates statistically significant enhancements across all observed operational metrics. The drastic reduction in customer service resolution latency (-91.3%) and order processing time (-87.3%) illustrates how intelligent automation alleviates operational bottlenecks. Similarly, the 85.7% increase in inventory turnover ratio underlines the economic benefits of predictive inventory management in optimizing working capital.

Structural Challenges, Ethical Risks, And Policy Deficits:

Despite its transformational benefits, the rapid integration of AI and emerging technologies in Indian commerce presents structural, socio-economic, and regulatory challenges. Mitigating these systemic risks is essential for ensuring equitable and sustainable economic growth.

1. Algorithmic Bias and Exclusionary Practices: AI models are inherently trained on historical data. If historical datasets contain systemic biases—such as reduced credit extension to specific demographic groups or underdeveloped geographic postal codes—the algorithm codifies and amplifies these historical inequities. In credit scoring and digital insurance underwriting, opaque black-box machine learning models risk automatically denying services to vulnerable populations without offering clear explanations or recourse options.

2. Data Privacy and Regulatory Compliance (DPDP Act 2023): The deployment of predictive analytics relies on the continuous aggregation of consumer data, including geolocation traces, transaction histories, and communication records. The enactment of India's Digital Personal Data Protection (DPDP) Act 2023 establishes strict legal obligations for commercial entities designated as Data Fiduciaries. Organizations face stringent constraints regarding purpose limitation, explicit consent mechanisms, and data minimization protocols. Non-compliance carries severe financial penalties of up to ₹250 crore, requiring firms to rebuild their customer data architecture around privacy-by-design principles.

3. Cyber Security Threats and Digital Vulnerabilities: As commercial networks become increasingly digital, the threat landscape expands. Cyber adversaries deploy sophisticated tactics, including AI-driven phishing, ransomware targeting financial ledgers, and API endpoint exploitation. Compromised commercial databases

lead to intellectual property theft, customer financial fraud, and loss of institutional trust.

4. Infrastructure Disparities and the Digital Divide: While urban centers enjoy tier-1 data center infrastructure, high-speed 5G connectivity, and tech-literate workforces, semi-urban and rural commercial ecosystems (Tier-3 and Tier-4 towns) often face infrastructure deficits. Intermittent power supply, variable bandwidth, and lower digital literacy among local traders (Kirana store operators) threaten to widen the economic divide between digitally integrated enterprises and traditional small businesses.

5. Labor Market Displacements and Reskilling Imperatives: Automation driven by RPA, Generative AI, and autonomous systems poses a structural challenge to traditional entry-level commercial roles, such as manual data entry, routine bookkeeping, tele-sales, and basic customer support. Without structured nationwide reskilling initiatives, rapid technology adoption risks exacerbating structural unemployment among low- and mid-skilled workers.

Future Trajectory & Strategic Recommendations:

To maximize the economic potential of AI and emerging technologies while safeguarding socio-economic interests, strategic intervention is required across public policy, corporate governance, and academic curricula.

1. Public Policy and Institutional Recommendations:

- **Strengthening Digital Public Infrastructure (DPI):** Government initiatives should prioritize extending robust digital connectivity and edge computing hubs to Tier-3, Tier-4, and rural commercial centers. Expanding open frameworks like the Open Network for Digital Commerce (ONDC) will democratize access for smaller merchants, preventing market monopolization by dominant digital platforms.
- **Regulatory Frameworks for Responsible AI:** Regulatory bodies (such as the Reserve Bank of India, SEBI, and the Competition Commission of India) should establish standardized guidelines requiring algorithmic auditability, explainability (XAI), and regular fairness testing for automated financial and commercial systems.
- **Targeted Incentive Schemes for MSME AI Adoption:** Tax incentives, technological subsidies, and public-private consultancy grants should be created to assist small and medium enterprises in adopting digital accounting, inventory management, and cybersecurity capabilities.

2. Strategic Framework for Business Enterprises:

- **Adopting Privacy-Preserving AI Architectures:** Enterprises must invest in privacy-enhancing technologies, such as federated learning and differential privacy, enabling AI models to learn from decentralized data without compromising individual customer privacy under the DPDP Act.
- **Building Agile, Hybrid Human-AI Workflows:** Organizations should frame AI as an augmenting tool rather than a complete replacement for human judgment. Complex strategic planning, ethical evaluations, and relationship management should remain centered on human expertise.
- **Continuous Employee Upskilling Investments:** Corporate strategy must allocate dedicated capital toward continuous learning and reskilling programs, training traditional finance and sales personnel in data analytics, prompt engineering, and digital risk management.

3. Recommendations for Commerce Education Institutions:

- **Curriculum Re-engineering:** Higher education institutions, such as PU colleges and university commerce departments, must modernize standard commerce syllabi. Traditional accounting instruction must be integrated with modules on business analytics, Python for financial modeling, fintech structures, and digital auditing.
- **Industry-Academia Collaboration Hubs:** Institutions should establish specialized technology incubators and practical skill labs in collaboration with technology firms, providing students with hands-on experience in enterprise resource planning (ERP) platforms, analytics tools, and AI tools prior to entering the workforce.

Conclusion:

The integration of Artificial Intelligence and emerging technologies marks a decisive paradigm shift in the history of Indian commerce. Intelligent systems are fundamentally altering how value is produced, exchanged, recorded, and safeguarded across retail, financial, supply chain, and corporate accounting domains. As demonstrated in this study, the economic benefits measured in operational efficiency, cost reduction, accuracy, and market accessibility are substantial and backed by empirical evidence.

However, realizing the full potential of this technological transformation requires proactively addressing its accompanying risks. Algorithmic bias, data privacy concerns under the DPDP Act, cybersecurity threats, digital divide disparities, and workforce disruption require a balanced approach to innovation. By establishing robust ethical governance, investing in digital infrastructure, and modernizing commercial education, India can build a technologically advanced, inclusive, and globally competitive commercial ecosystem. Academic researchers, educators, industry leaders, and policy makers must collaborate to ensure that technological progress serves as a catalyst for sustainable economic growth and broad social upliftment.

References:

1. Aggarwal, R., & Sharma, P. (2024). Artificial Intelligence in Indian Financial Services: Transformation, Inclusion, and Risk Paradigms. Journal of Digital Banking & Commerce, 18(2), 112-135.
2. Davenport, T. H., & Mittal, N. (2023). All-in On AI: How Smart Companies Win Big with Artificial Intelligence. Harvard Business Review Press.
3. Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319-340.
4. Government of India. (2023). The Digital Personal Data Protection Act, 2023 (No. 22 of 2023). Ministry of Law and Justice, Gazette of India.
5. KLE Society's S.V.S. Bellubbi Arts & Commerce College. (2026). Brochure for One Day National Level Conference on Contemporary Issues in India: Research Perspective in Literature, Social Sciences and Commerce. Saundatti, Belagavi. [Submission Guidelines Reference: Commerce Track klesvscommerce@gmail.com].
6. NITI Aayog. (2023). National Strategy for Artificial Intelligence #AIforAll: Economic Impact Assessment for Commercial Transformation. Government of India, New Delhi.
7. Schumpeter, J. A. (1942). Capitalism, Socialism and Democracy. Harper & Brothers.
8. Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. MIS Quarterly, 27(3), 425-478.

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Leveraging AI in Commerce: Driving Innovation, Sustainability, and Digital Transformation

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Abstract:

Artificial Intelligence (AI) is rapidly transforming the commerce sector by enabling intelligent decision-making, personalized customer experiences, operational automation, and data-driven business strategies. This article examines how organizations can leverage AI to drive innovation, promote sustainability, and accelerate digital transformation in commerce. The study explores the role of AI technologies, including machine learning, generative AI, predictive analytics, and intelligent automation, in improving business processes and creating new sources of competitive advantage. It further examines how AI can contribute to sustainable commerce through efficient resource utilization, demand forecasting, waste reduction, sustainable supply-chain management, and improved energy efficiency. The article proposes a conceptual framework linking AI adoption with innovation capability, digital transformation, sustainable commerce performance, and overall business performance. At the same time, challenges related to data privacy, algorithmic bias, cybersecurity, workforce displacement, and ethical AI governance are considered. The study argues that successful AI adoption requires not only technological investment but also organizational readiness, employee capabilities, responsible governance, and a sustainability-oriented strategic vision. By integrating AI with innovation and digital transformation strategies, commerce organizations can enhance operational efficiency, strengthen customer engagement, develop resilient business models, and contribute to long-term environmental and economic sustainability. The study provides useful insights for researchers, policymakers, and business leaders seeking to understand and implement responsible AI-driven transformation in the evolving commerce landscape.

Keywords: Artificial Intelligence, Commerce, Innovation, Sustainability, Digital Transformation, AI Adoption, Business Performance, Sustainable Supply Chain, Generative AI

Introduction:

The rapid advancement of Artificial Intelligence (AI) has emerged as one of the most significant technological developments shaping the contemporary business environment. In the commerce sector, AI is increasingly being adopted to transform traditional business practices, improve decision-making, enhance customer experiences, and create new opportunities for growth. Technologies such as machine learning, natural language processing, predictive analytics, computer vision, robotic process automation, and generative AI are enabling organizations to analyse large volumes of data and respond more effectively to changing customer expectations and market conditions. As commerce becomes increasingly digital and interconnected, leveraging AI has shifted from being a technological advantage to becoming an important component of long-term business strategy.

The integration of AI into commerce is particularly important because consumer behavior and competitive conditions are changing rapidly. Customers increasingly expect personalized products, faster services, seamless digital interactions, and convenient purchasing experiences across multiple channels. AI enables businesses to understand customer preferences through data analytics, provide personalized recommendations, forecast demand, optimize pricing, automate customer service, and improve inventory management. These capabilities allow organizations to develop innovative products and services while simultaneously improving operational efficiency. Consequently, AI has become an important driver of innovation by supporting organizations in developing new business models, redesigning processes, and creating greater customer value.

Beyond innovation, AI has considerable potential to support sustainability in commerce. Businesses are facing growing pressure to reduce resource consumption, minimize waste, manage supply-chain risks, and respond to environmental concerns. AI-based forecasting and optimization can help organizations match supply with demand, reduce excess inventory, optimize transportation routes, improve energy utilization, and identify inefficiencies throughout the supply chain. In retail and e-commerce, for example, accurate demand forecasting can reduce overproduction and product waste, while intelligent logistics systems can improve delivery efficiency and reduce unnecessary transportation. Thus, AI can contribute to the development of more resource-efficient and environmentally responsible commercial practices.

AI is also a major enabler of digital transformation. Digital transformation involves more than simply adopting new technologies; it requires organizations to redesign business processes, organizational structures, customer interactions, and decision-making systems around digital capabilities. AI strengthens this transformation by converting large amounts of structured and unstructured data into actionable insights. AI-powered systems can automate routine activities, support strategic decision-making, identify emerging market trends, and enable real-time responses to customer and operational requirements. When integrated with cloud computing, Internet of Things (IoT), big data analytics, blockchain, and digital platforms, AI can create an interconnected business environment capable of continuous learning and adaptation.

However, the adoption of AI also creates significant challenges. Concerns regarding data privacy, cybersecurity, algorithmic bias, transparency, ethical decision-making, and workforce displacement can affect the responsible implementation of AI in commerce. Organizations may also face difficulties related to high implementation costs, lack of skilled employees, inadequate digital infrastructure, and resistance to organizational change. Therefore, successful AI-driven transformation requires more than technological investment. It requires appropriate governance mechanisms, employee development, organizational readiness, responsible data management, and a clear alignment between AI strategies and broader business and sustainability objectives.

Despite the growing importance of AI in commerce, there remains a need for a comprehensive understanding of how AI adoption simultaneously contributes to innovation, sustainability, and digital transformation. Many organizations focus primarily on improving efficiency or customer experience, while the broader relationship between AI-enabled innovation, sustainable practices, and organizational transformation requires further attention. Examining these dimensions together

can provide a more holistic perspective on how businesses can use AI to achieve both short-term operational benefits and long-term strategic value.

Against this background, the present study focuses on **leveraging AI in commerce to drive innovation, sustainability, and digital transformation.** It examines the ways in which AI adoption can strengthen innovation capabilities, improve digital business processes, promote sustainable commercial practices, and ultimately enhance organizational performance. The study also considers the challenges and ethical implications associated with AI adoption and emphasizes the importance of responsible and strategic implementation. By connecting technological advancement with economic, environmental, and organizational objectives, the study aims to provide a conceptual foundation for understanding how AI can contribute to the future of sustainable and digitally transformed commerce.

The Role of Artificial Intelligence in Modern Business:

Artificial Intelligence (AI) has become a transformative force in modern business, influencing how organizations operate, compete, make decisions, and interact with customers. The increasing availability of large datasets, advanced computing infrastructure, cloud technologies, and sophisticated AI algorithms has enabled businesses to integrate intelligent systems into a wide range of organizational functions. AI allows organizations to process and interpret large volumes of information, identify patterns, predict future outcomes, and automate routine activities. As a result, businesses are increasingly using AI not only as an operational tool but also as a strategic capability for creating value and achieving sustainable competitive advantage.

One of the most important roles of AI in modern business is **improving decision-making**. Traditional business decisions often depend on historical information, managerial experience, and periodic market analysis. AI-based systems can analyze real-time and historical data to identify trends, detect risks, forecast demand, and generate predictive insights. In areas such as finance, marketing, sales, and supply-chain management, these capabilities can help managers make faster and more informed decisions. Predictive analytics can, for example, assist organizations in forecasting customer demand, identifying potential market opportunities, and anticipating operational disruptions.

AI also plays a significant role in **enhancing customer experience**. Modern consumers increasingly expect personalized, convenient, and responsive interactions with businesses. AI enables organizations to analyse customer preferences, purchasing behaviour, browsing patterns, and feedback to provide customized recommendations and services. Chatbots and virtual assistants can provide customer support around the clock, while recommendation systems can help customers discover products and services relevant to their needs. Such applications can strengthen customer engagement, improve service quality, and contribute to customer retention.

Another important contribution of AI is **operational efficiency and automation**. Businesses can use AI to automate repetitive and time-consuming activities such as data entry, document processing, inventory monitoring, fraud detection, quality inspection, and routine customer inquiries. Intelligent automation allows employees to focus on higher-value activities that require creativity, critical thinking, and interpersonal skills. AI can therefore contribute to productivity improvements while reducing errors and enabling organizations to respond more quickly to changing business conditions.

AI is also increasingly associated with **innovation and new business models**. Generative AI, machine learning, computer vision, and natural language processing can support organizations in developing new products, services, and processes. AI can assist with product design, market research, content generation, software development, and experimentation. Businesses can use these capabilities to identify unmet customer needs, accelerate innovation cycles, and develop digitally enabled business models. Consequently, AI is shifting from a technology used primarily for automation toward a broader platform for organizational innovation.

In addition, AI has an important role in **supply-chain and resource management**. Intelligent forecasting systems can improve demand planning, inventory control, procurement, logistics, and distribution. By predicting demand more accurately and optimizing resource allocation, businesses can reduce excess inventory, minimize waste, improve delivery performance, and strengthen supply-chain resilience. These applications are particularly relevant to organizations seeking to integrate sustainability into their business strategies.

AI can further support **sustainability and environmental responsibility**. Organizations can employ AI to monitor energy consumption, optimize production processes, reduce material waste, improve transportation efficiency, and identify opportunities for more sustainable resource utilization. In combination with Internet of Things (IoT) devices and real-time analytics, AI can help businesses monitor environmental performance and make data-driven improvements. This creates opportunities to align operational efficiency with environmental objectives.

However, the increasing role of AI also introduces several challenges. Data privacy, cybersecurity, algorithmic bias, lack of transparency, ethical concerns, and potential workforce displacement require careful consideration. Organizations must establish appropriate governance frameworks to ensure that AI systems are developed and used responsibly. Investment in employee training and digital skills is equally important because successful AI adoption depends on the ability of employees and managers to understand, manage, and effectively use AI technologies.

Overall, Artificial Intelligence is reshaping modern business by combining automation, analytics, personalization, innovation, and intelligent decision-making. Its significance extends beyond individual business functions because AI can influence the entire organizational ecosystem, from customer engagement and product development to supply-chain management and strategic planning. Organizations that strategically integrate AI with human capabilities, responsible governance, and sustainability objectives are better positioned to improve efficiency, encourage innovation, and remain competitive in an increasingly digital business environment.

AI-driven Sustainable Practices in Commerce:

Artificial Intelligence (AI) plays a transformative role in fostering sustainable practices within commerce by enabling businesses to optimize operations, reduce waste, and minimize their environmental impact. Through intelligent automation and data-driven insights, AI supports the transition toward more efficient and eco-conscious business models. One significant area of impact is energy management, where AI algorithms help monitor and control

International Journal of Humanities Education energy consumption in real time. Smart energy systems powered by AI can dynamically adjust lighting, heating, and cooling based on

usage patterns, leading to significant reductions in energy waste (Zhou et al., 2020). Similarly, in manufacturing and logistics, AI optimizes supply chain networks by forecasting demand accurately, minimizing overproduction, and reducing emissions from transportation (Ivanov et al., 2019). AI also enhances waste reduction and circular economy initiatives. Machine learning models can analyse production data to identify defects and inefficiencies early, thereby reducing material wastage. In retail, AI applications help predict sales trends, thereby improving inventory management and preventing overstocking and spoilage (Ramesh et al., 2021). Moreover, AI is instrumental in sustainable agriculture and food systems. Precision farming technologies, powered by AI and IoT, enable farmers to use water, fertilizers, and pesticides more efficiently, leading to higher yields with lower environmental impact (Wolfert et al., 2017). These smart systems align well with global sustainability goals, contributing to both environmental protection and food security. By embedding AI into sustainability strategies, businesses can not only improve operational efficiency but also demonstrate corporate responsibility, meeting the growing demand from consumers, investors, and regulators for sustainable practices.

AI in Green Marketing and Consumer Engagement:

Artificial Intelligence (AI) is revolutionizing green marketing by enabling businesses to deliver personalized, transparent, and eco-conscious messages that resonate with environmentally aware consumers. As sustainability becomes a key differentiator in competitive markets, AI empowers firms to design and implement marketing strategies that not only promote green products but also foster long-term consumer engagement and trust. AI enables hyper-personalized marketing, allowing companies to segment eco-conscious consumers and tailor campaigns based on their behaviours, preferences, and values. AI-driven tools such as recommendation engines and sentiment analysis help brands highlight sustainable product features, such as carbon footprint, recyclable packaging, or ethical sourcing, thereby enhancing consumer awareness and influencing green purchasing decisions (Dangelico & Vocalelli, 2017; Chatterjee et al., 2021). Another significant contribution of AI is in enhancing transparency and traceability. AI, when integrated with blockchain and IoT, allows consumers to trace the origin, production, and distribution journey of products, ensuring the credibility of green claims (Kamble et al., 2020). This transparency builds consumer trust and strengthens brand loyalty by aligning marketing communication with sustainability ethics.

Additionally, AI-powered chatbots and virtual assistants are being used to promote green behaviours, suggest sustainable alternatives, and answer consumer queries related to environmental impact. These tools enable real-time engagement, providing education and support to customers on making responsible consumption choices (Huang & Rust, 2021). By leveraging AI in green marketing, businesses not only drive consumer engagement but also contribute to a broader culture of sustainability, where customers are empowered to make informed, eco-friendly decisions.

Case Studies of AI-Enabled Sustainable Businesses:

Artificial Intelligence (AI) is helping businesses become more sustainable by reducing waste, saving energy, improving supply chains, and understanding customer needs. The following simple case studies show how AI can support both **business growth and environmental sustainability**.

1. Amazon – AI for Delivery and Inventory: Amazon uses AI and machine learning to forecast customer demand and manage inventory. By predicting what products customers are likely to order, the company can position products closer to customers and improve delivery efficiency.

Sustainability benefit: Better forecasting can reduce unnecessary transportation, excess inventory, and product waste.

Simple example: If AI predicts that a particular product will be highly demanded in Kerala, inventory can be positioned closer to customers instead of transporting every order from a distant warehouse.

2. Walmart – AI for Food Waste Reduction: Walmart uses data analytics and AI-based technologies to improve inventory and food management. AI can help retailers predict demand and identify products that need attention before they expire.

Sustainability benefit: Less food waste, better inventory management, and more efficient use of resources.

Simple example: If AI predicts that fewer customers will buy a particular fresh-food item, the retailer can adjust its inventory and ordering decisions.

3. Google – AI for Energy Efficiency: Google has used AI to improve the energy efficiency of its data-center operations. AI systems can analyze information from cooling and other equipment and recommend ways to operate these systems more efficiently.

Sustainability benefit: Lower energy consumption and reduced environmental impact.

Simple example: AI can identify when a data center needs less cooling and adjust cooling systems accordingly.

4. Unilever – AI for Sustainable Consumer Products: Unilever uses AI and data-driven technologies in areas such as consumer insights, product development, marketing, and supply-chain management. These technologies can help the company understand consumer preferences and identify opportunities for more sustainable products and operations.

Sustainability benefit: Better resource planning and opportunities to develop products that respond to changing consumer expectations around sustainability.

5. IKEA – AI and Circular Commerce: IKEA has explored AI and digital technologies to improve product recommendations, customer experiences, inventory management, and circular-economy initiatives. Digital tools can help customers find suitable products and support efforts to extend the useful life of products.

Sustainability benefit: Better resource utilization and support for reuse and circular business practices.

Challenges and Ethical Considerations in AI-Driven Sustainability:

Artificial Intelligence (AI) can help businesses achieve sustainability by reducing waste, saving energy, improving supply chains, and supporting better decision-making. However, using AI for sustainability also creates several challenges and ethical concerns. Businesses need to ensure that AI is used responsibly and that its benefits do not create new social or environmental problems.

1. Data Privacy: AI systems require large amounts of data to understand customers, business operations, and environmental conditions. The collection and use of personal information can create privacy concerns. Businesses must protect customer data and use it only for appropriate purposes.

Simple example: An online retailer may use customer purchasing data to recommend sustainable products, but it must protect customers' personal information.

2. Algorithmic Bias: AI systems learn from existing data. If the data contains bias, the AI system may produce unfair results. This can affect customers, employees, suppliers, or different social groups.

Simple example: An AI marketing system may incorrectly identify certain groups as less interested in sustainable products and therefore provide them with fewer offers.

3. Lack of Transparency: Some AI systems can be difficult for ordinary users to understand. When businesses use AI to make important decisions, customers and employees may want to know how those decisions were made.

Simple example: If an AI system recommends one product as more environmentally friendly than another, the business should be able to explain the basis for that recommendation.

4. Greenwashing: AI can make it easier for businesses to create attractive sustainability messages. However, if companies use AI to make environmental claims that are exaggerated or unsupported, it can lead to **greenwashing**.

Simple example: A company may use AI-generated marketing content to describe a product as "eco-friendly" without having sufficient evidence to support the claim.

5. Energy Consumption of AI: Although AI can help reduce energy consumption in business operations, developing and operating large AI systems can itself require considerable computing power and electricity. Therefore, businesses need to consider the environmental impact of the AI technology they use.

Simple example: An AI system designed to improve energy efficiency should ideally provide environmental benefits that justify the resources required to operate it.

6. Job Displacement: AI-driven automation can replace or reduce the need for certain repetitive jobs. Although AI can create new employment opportunities, workers may need new skills to adapt to changing job requirements.

Simple example: AI-powered customer-service chatbots may reduce the need for employees to handle simple customer questions while increasing demand for employees with AI-management and problem-solving skills.

7. Cybersecurity Risks: AI systems depend on digital infrastructure and large databases. These systems can become targets for cyberattacks, data theft, or manipulation. A security failure can cause financial and reputational damage. Businesses therefore need strong cybersecurity systems and regular monitoring.

8. Digital Inequality: Not all businesses and communities have equal access to AI technology, digital infrastructure, or skilled employees. Large organizations may be able to invest heavily in AI, while small businesses may struggle to adopt advanced technologies. This can create a **digital divide** between organizations with strong technological capabilities and those with limited resources.

9. Human Responsibility and Accountability: AI should support human decision-making rather than completely replace human responsibility. When an AI system makes an incorrect or harmful decision, organizations need to identify who is responsible. Businesses should maintain human oversight, particularly when AI decisions can significantly affect customers, employees, or the environment.

10. Ethical Use of AI: Organizations should ensure that AI is used for genuine sustainability rather than simply for improving corporate image. AI-based sustainability initiatives should be based on accurate information, fairness, transparency, and measurable environmental benefits.

Conclusion:

Artificial Intelligence (AI) is becoming a powerful force in modern commerce, transforming the way businesses operate, innovate, communicate with customers, and achieve sustainability. The study on **"Leveraging AI in Commerce: Driving Innovation, Sustainability, and Digital Transformation"** highlights that AI is not merely a technological tool but an important strategic capability for businesses operating in an increasingly digital and competitive environment.

AI enables businesses to improve decision-making, automate routine activities, personalize customer experiences, forecast demand, optimize supply chains, and develop innovative products and services. These applications can improve operational efficiency while creating new opportunities for business growth and competitive advantage. AI also supports digital transformation by helping organizations integrate data, technology, and intelligent decision-making into their core business processes.

From a sustainability perspective, AI can help organizations reduce waste, improve energy efficiency, optimize transportation, manage resources effectively, and encourage sustainable consumption. AI-powered green marketing can also help businesses understand environmentally conscious consumers and provide personalized information about sustainable products. However, businesses must ensure that sustainability claims are genuine and supported by evidence in order to avoid greenwashing.

At the same time, AI adoption presents important challenges. Issues such as data privacy, algorithmic bias, cybersecurity, lack of transparency, job displacement, digital inequality, and the environmental cost of AI systems must be carefully addressed. Responsible AI governance and human oversight are therefore essential. Organizations should focus not only on the economic benefits of AI but also on its social and environmental consequences.

Overall, the effective use of AI can create a **three-dimensional value framework: innovation, sustainability, and digital transformation**. Businesses that successfully combine AI technologies with human skills, ethical practices, organizational readiness, and sustainability objectives can build more efficient, resilient, and customer-focused organizations. Therefore, the future of commerce will depend not simply on adopting AI, but on **leveraging AI responsibly to create long-term economic, environmental, and social value**.

References:

1. Brynjolfsson, E., & McAfee, A. (2014). The second machine age: Work, progress, and prosperity in a time of brilliant technologies. W. W. Norton & Company.
2. Chatterjee, S., Rana, N. P., Tamilmani, K., & Sharma, A. (2021). The adoption of artificial
3. Intelligence in business-to-business marketing: A literature review and future research agenda. Industrial Marketing Management, 97, 135–146.
4. https://doi.org/10.1016/j.indmarman.2021.06.006
5. Chen, Y., & Perez, Y. (2018). Business model design: Lessons learned from Tesla Motors.
6. International Journal of Automotive Technology and Management, 18(3), 248–265.
7. https://doi.org/10.1504/IJATM.2018.093317
8. Chien, C. F., Chan, S. H., & Lee, J. S. (2020). Artificial intelligence in green supply chain
9. management: A review and future research agenda. International Journal of Environmental
10. Research and Public Health, 17(9), 3153. https://doi.org/10.3390/ijerph17093153

11. Dangelico, R. M., &Vocalelli, D. (2017). “Green Marketing”: An analysis of definitions,
12. dimensions, and relationships with stakeholders. Business Strategy and the Environment,
13. 26(4), 457–475. https://doi.org/10.1002/bse.1933
14. Davenport, T. H., &Ronanki, R. (2018). Artificial intelligence for the real world. Harvard
15. Business Review, 96(1), 108–116.
16. DeepMind. (2016). DeepMind AI reduces Google data centre cooling bill by 40%. Retrieved from https://www.deepmind.com/blog/deepmind-ai-reduces-google-data-centre-cooling-billby-40
17. Ghobakhloo, M. (2020). Industry 4.0, digitization, and opportunities for sustainability. Journal of Cleaner Production, 252, 119869. https://doi.org/10.1016/j.jclepro.2019.119869
18. Huang, M.-H., & Rust, R. T. (2021). Artificial intelligence in service. Journal of Service
19. Research, 24(1), 3–20. https://doi.org/10.1177/1094670520902266.

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India's Changing Tax System: Issues, Reforms, and Challenges

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Abstract:

India's fiscal architecture has undergone a monumental paradigm shift over the past decade, transitioning from a fragmented, cascading indirect tax regime to a unified digital-first structure, alongside continuous digitization and modernization of direct taxation. This research article comprehensively examines India's changing tax system, tracking the historic evolution, implementation trajectories, and structural impacts of landmark fiscal policies such as the Goods and Services Tax (GST), Faceless Assessment schemes, and dynamic corporate tax rationalization. While these structural reforms have significantly streamlined compliance, widened the direct and indirect tax base, enhanced revenue transparency, and curbed tax evasion through robust IT infrastructure (e-invoicing, e-way bills, and AI-driven data analytics), several critical issues and operational challenges persist. Key bottlenecks include structural complexities in multi-tier tax slab rates, compliance burdens for Micro, Small, and Medium Enterprises (MSMEs), structural state-level revenue dependencies, Centre-State fiscal federalism dynamics, and ongoing judicial litigation regarding tax classifications. Furthermore, the paper evaluates futuristic adjustments required to align the tax regime with emerging economic realities, such as cross-border digital economy taxation, e-commerce transactions, and artificial intelligence integration. Finally, the study offers pragmatic policy recommendations to build a resilient, predictable, equitable, and growth-oriented fiscal framework for India's emerging economy.

Keywords: Goods and Services Tax (GST), Tax Reforms, Fiscal Federalism, Direct Tax Code, Digital Taxation, Compliance Burden

Introduction:

Taxation serves as the financial lifeblood of a sovereign state, functioning not merely as a mechanism for revenue generation but as a potent instrument for socioeconomic redistribution, economic stabilization, and market regulation. Over the past decade, the Republic of India has embarked on one of the most ambitious fiscal engineering projects among emerging market economies. Driven by the imperatives of globalization, rapid digitization, cooperative federalism, and the need to eliminate structural inefficiencies inherited from a colonial and legacy-era tax framework, India's tax system has experienced profound structural transformation.

Historically, India's indirect tax system was marred by a cascading effect (tax on tax), complex multi-point levies, interstate check-posts causing severe logistical bottlenecks, and a complex web of exemptions. Simultaneously, the direct tax regime faced challenges of high litigation rates, complex compliance procedures, and narrow tax elasticity. The introduction of epoch-making reforms—most notably the implementation of the Goods and Services Tax (GST) in July 2017, the digitalization of income tax assessments via the Faceless Assessment Regime, and corporate tax rate cuts—has redrawn

the fiscal contours of the nation.

However, transitions of this magnitude naturally spawn operational friction, systemic gaps, and policy challenges. This article explores the evolution of India's changing tax landscape, dissects major structural reforms, critically analyzes existing issues and challenges, and proposes strategic policy recommendations for a robust future-ready tax ecosystem.

Evolution and Structural Shift in India's Tax Architecture:

To comprehend contemporary fiscal policy, one must appreciate the structural dichotomy of India's tax framework, divided into Direct Taxes (administered by the Central Board of Direct Taxes - CBDT) and Indirect Taxes (administered by the Central Board of Indirect Taxes and Customs - CBIC, alongside state tax departments).

1. The Pre-Reform Legacy and Bottlenecks: Prior to 2017, India's indirect tax regime was federalized and fragmented. The Centre levied Central Excise Duty, Service Tax, and Central Sales Tax (CST), while State Governments levied Value Added Tax (VAT), Entry Tax, Luxury Tax, and Octroi. This layered architecture created:

- **The Cascading Effect:** Taxes were levied on a value that already included taxes from previous stages of production, artificially inflating the final retail price for consumers.
- **Interstate Trade Barriers:** Check-posts at state borders resulted in massive transit delays, fuel wastage, and logistics inefficiencies, fragmenting the Indian domestic market into distinct economic territories.
- **Complex Compliance:** Businesses had to maintain multi-jurisdictional registrations and comply with differing statutory filing obligations.

In the realm of direct taxation, complex legal provisions, subjective discretion by tax authorities, and sluggish dispute resolution mechanisms fostered a high-litigation environment, frequently
Eroding investor confidence.

2. The Post-2017 Paradigm Shift: The structural turning point arrived with the constitutional amendment enabling the GST, subsuming most central and state indirect taxes into a unified destination-based consumption tax. Concurrently, direct taxation witnessed a paradigm shift toward transparency through technology adoption, automated scrutiny, and lower corporate tax rates designed to stimulate domestic manufacturing and attract Foreign Direct Investment (FDI).

Major Tax Reforms: An Analytical Overview:

1. The Goods and Services Tax (GST) and Cooperative Federalism: GST unified the nation under the banner of **"One Nation, One Tax, One Market."** Key operational innovations include:

- **Seamless Input Tax Credit (ITC):** Mitigation of the cascading tax burden by allowing credit for taxes paid at each stage of the value chain against the final tax liability.
- **The GST Network (GSTN):** A robust technological backbone handling registration, return filing, tax payments, and matching of invoices through an integrated digital portal.
- **E-Invoicing and E-Way Bills:** Real-time tracking of B2B transactions and movement of goods, drastically reducing tax evasion and fake invoicing syndicates.

2. Direct Tax Reforms: Faceless Regime and Corporate Tax Rationalization: Direct taxes underwent structural modifications aimed at human interface reduction and rate competitiveness:

- **Faceless Assessment and Appeals:** Introduced to eliminate discretion, corruption, and bias by randomly allocating scrutiny cases across geographic jurisdictions through centralized computer algorithms.

- **Corporate Tax Rate Reductions:** In 2019, India slashed base corporate tax rates for domestic companies to 22% (effective rate ~25.1% inclusive of surcharges and cess) and offered an aggressive 15% rate for new manufacturing domestic companies, placing India at par with competitive global manufacturing hubs.
- **Vivad se Vishwas Scheme:** Legislative initiatives to resolve pending direct tax litigation amicably, unlocking locked-up capital and reducing judicial backlogs.

Persistent Issues and Structural Challenges:

Despite impressive administrative gains and revenue buoyancy, India's evolving tax system contends with several deep-seated issues:

1. Rate Rationalization and Slab Complexity: Unlike many single-rate international GST models, India adopted a multi-tier rate structure (typically 0%, 5%, 12%, 18%, and 28%, alongside special rates on gold and precious stones). This multi-rate architecture causes continuous classification disputes, litigation regarding product categorization, and constant lobbying by industrial sectors seeking lower slab placements.

2. Compliance Burden on MSMEs: While large corporations have smoothly integrated automated ERP-linked GST systems, Micro, Small, and Medium Enterprises (MSMEs) often struggle with complex return filings, dynamic reconciliation requirements (GSTR-2A/2B matching), and working capital blockages due to delayed input tax credit realization from non-compliant suppliers.

3. Fiscal Federalism and State Revenue Compensation; The subsuming of state-level taxes into GST centralized fiscal powers, making state governments structurally dependent on compensation grants from the Central Government for revenue shortfalls. As guaranteed compensation periods concluded, friction regarding revenue-sharing formulas, cess distributions, and fiscal autonomy emerged as a core challenge in India's cooperative federalism.

4. Taxation of the Digital Economy and Cross-Border Challenges: The exponential growth of e-commerce, cloud computing, remote platform services, and cryptographic assets has created novel challenges for nexus-based taxation. Establishing permanent establishment (PE) rules and taxing transnational digital corporations adequately without triggering trade retaliations remains a complex regulatory puzzle.

Comparative Evaluation: Pre-Reform vs. Post-Reform Tax Landscape:

Parameter	Pre-Reform Era (Before 2017)	Post-Reform Era (Current Landscape)
Indirect Tax Structure	Cascading, fragmented Multi-point taxes (Excise, VAT, CST, Service Tax).	Unified destination-based consumption tax (GST).
Logistics & Inter-State Movement	Delayed transit due to state borders, check-posts, and octroi.	Streamlined movement via digital e-way bills and Border-free transit.
Direct Tax Administration	Discretionary, physical Interface-heavy scrutiny assessments.	Technology-driven, anonymous **"Faceless Assessment"** regime.
Tax Base & Transparency	Lower formalization, high reliance on manual auditing.	Expanded taxpayer base, real-time invoice matching, and AI-driven data Analytics.

Corporate Competitiveness	High headline corporate tax rates with extensive Exemptions.	Globally competitive corporate tax slabs (22% / 15% for new Manufacturing).

Policy Recommendations and Future Outlook:

To consolidate the gains of past reforms and insulate the Indian tax system from emerging domestic and global vulnerabilities, the following policy interventions are recommended:

1. **Rationalization of GST Slabs:** Move progressively toward a simplified three-tier rate structure (standard rate, merit rate, and a demerit/sin rate) to minimize classification disputes and administrative overhead.
2. **Enhanced Support for MSME Compliance:** Provide subsidized digital accounting tools, simplified quarterly filing options for micro-entities, and automated credit-matching mechanisms to ease cash-flow constraints.
3. **Strengthening Centre-State Financial Resilience:** Re-evaluate revenue-sharing models through constructive dialogue in the GST Council, fostering joint stakeholder accountability for tax-base expansion.
4. **Adoption of Advanced Data Analytics and AI:** Leverage machine learning models within the CBDT and CBIC frameworks to preemptively identify sophisticated tax evasion networks, shell companies, and fraudulent input tax credit claims.
5. **Global Tax Harmonization:** Actively participate in multilateral frameworks (such as the OECD/G20 Inclusive Framework on Base Erosion and Profit Shifting - BEPS) to ensure fair taxation of multinational digital enterprises operating within the Indian market.

Conclusion:

India's transition toward a modernized, transparent, and technology-driven tax ecosystem represents a watershed moment in its economic history. Reforms like the Goods and Services Tax and Faceless Assessments have fundamentally dismantled legacy bottlenecks, fostered formalization, and improved tax-to-GDP buoyancy. However, policy design is an iterative process. Addressing structural complexities, smoothing compliance for smaller enterprises, safeguarding federal fiscal balances, and adapting to the borderless digital economy are vital prerequisites. By continuously refining administrative machinery and maintaining progressive dialogue between policymakers, taxpayers, and economists, India can establish a globally benchmarked, equitable, and growth-catalyzing tax regime capable of propelling the nation toward its vision of a developed economy.

References:

1. Central Board of Indirect Taxes and Customs (CBIC). (2025). *Annual Report on Goods and Services Tax Implementation*. Government of India.
2. Ministry of Finance. (2024). *Economic Survey 2023-24: Fiscal Developments and Tax Policy Reforms*. Department of Economic Affairs, Government of India.
3. Poddar, S., & Ahmad, E. (2020). *GST in India: Progress, Challenges, and Future Policy Roadmaps*. Economic and Political Weekly, 55(14), 45-53.
4. Rao, M. G. (2021). *Fiscal Federalism and Tax Reforms in India: Emerging Dynamics*. Oxford University Press.
5. World Bank. (2025). *India Development Update: Navigating Fiscal Space and Digital Transformation*. World Bank Group.

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Contemporary Dynamics Of Digital Banking, E -Commerce, Cyber Security, And Financial Risk Management In India

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Abstract:

The rapid convergence of digital banking frameworks, e-commerce ecosystems, and financial technologies in India has catalyzed unprecedented economic inclusion and payment efficiency. However, this systemic transition from traditional brick-and-mortar financial intermediaries to hyper-connected digital channels has expanded the cyber-attack surface, introducing complex dimensions of fraud, data breaches, operational vulnerabilities, and systemic financial risks. This study comprehensively examines the interdependent matrix connecting modern digital banking infrastructures (Unified Payments Interface, Neo-Banking, and Core Banking Systems), the burgeoning e-commerce architecture, and the rising prevalence of cyber threats within the Indian financial landscape. Evaluating modern risk mitigation models, regulatory frameworks established by the Reserve Bank of India (RBI), and contemporary cyber security protocols, this paper provides a multi-dimensional assessment of real-time fraud monitoring, artificial intelligence (AI)-driven risk mitigation, and end-to-end data encryption. The findings highlight the critical imperative for integrated financial risk management frameworks that proactively harmonize technological innovation, regulatory compliance, zero-trust cyber security architectures, and consumer financial literacy to ensure sustainable and resilient digital economic growth.

Keywords: Digital Banking, E-Commerce, Cyber Security, Financial Risk Management, UPI, Regulatory Frameworks.

Introduction:

The Indian financial ecosystem has undergone a structural paradigm shift over the past decade, evolving from a cash-dominant economy to an internationally recognized benchmark for digital transactions. Driven by government initiatives such as "Digital India," the widespread expansion of telecommunications infrastructure, and the implementation of open-banking frameworks, digital banking and e-commerce have become integral pillars of national commerce. The seamless integration of payment gateways, automated clearing houses, and instant peer-to-peer (P2P) and peer-to-merchant (P2M) settlement networks—most notably the Unified Payments Interface (UPI)—has dematerialized financial transactions, lowering transaction friction and democratizing financial access across both urban and rural demographics.

However, the rapid acceleration of digital adoption has introduced significant operational and systemic risks. As financial services move toward micro service architectures, cloud-hosted API networks, and instant clearance protocols, the temporal window available to detect, evaluate, and mitigate fraudulent transactions has shrunk from

days to milliseconds. Cyber threats have grown proportionately sophisticated, transitioning from isolated phishing attempts to organized social engineering, ransom ware attacks, API abuse, identity spoofing, and advanced persistent threats (APTs) targeting institutional financial pipelines.

Consequently, financial risk management can no longer function as a reactive, post-facto audit function. Modern financial risk management requires an integrated operational strategy where cyber security standards,

Literature Review:

The theoretical and empirical literature surrounding digital financial transformation emphasizes both the efficiency gains and the risk asymmetries inherent in digital ecosystems.

Digital Transformation and Financial Inclusion: Early scholars emphasized the cost-reduction capacity of digital banking channels, noting that electronic delivery channels drastically reduce marginal transaction costs compared to physical bank branches. Subsequent research within the Indian context underscores the transformative impact of the "JAM Trinity" (Jan Dhan, Aadhaar, and Mobile), which provided the baseline identity and settlement layer required for scalable digital inclusion across underserved demographics.

E-Commerce and Payment Gateway Vulnerabilities: Research focusing on e-commerce transaction security highlights payment gateways as critical single-point vulnerabilities. As commercial platforms integrate third-party APIs for processing card payments, buy-now-pay-later (BNPL) loans, and digital wallets, the security perimeter expands beyond the core platform, exposing consumer credentials to intermediary interception, man-in-the-middle (MitM) attacks, and unauthorized credential stuffing.

Cyber security in Financial Intermediation: Contemporary cyber security literature categorizes cyber risk not merely as an IT operational defect, but as a core component of enterprise financial risk. Empirical studies demonstrate that cyber attacks on financial institutions induce direct economic losses, severe reputational damage, customer churn, and systemic liquidity shocks across interbank clearing systems.

Risk Management and AI Integration: Modern operational literature highlights a transition toward predictive risk management. Machine learning algorithms, automated anomaly detection, and behavior-based biometric authentication are increasingly documented as mandatory defenses against sophisticated fraud vectors that easily bypass traditional rule-based rule sets.

The Digital Banking and E-Commerce Landscape in India:

Digital banking in India has evolved through three distinct generational phases:

First-Generation (Informational & Basic Transactional): Characterized by centralized Core Banking Systems (CBS), basic internet banking interfaces and automated teller machines (ATMs). Second-Generation (Channel Diversification): Marked by the introduction of mobile banking applications, National Electronic Funds Transfer (NEFT), Real Time Gross Settlement (RTGS), and Immediate Payment Service (IMPS).

Third-Generation (Open & Ecosystem-Driven Banking): Defined by open application programming interfaces (APIs), neo-banking platforms, modular micro services, and instant payment switches such as UPI, which decouple the consumer interface from traditional bank ledgers

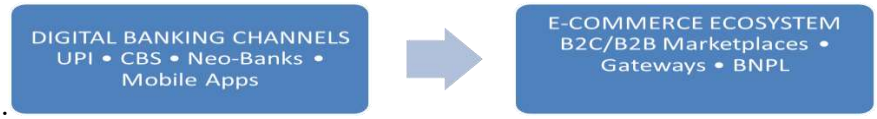


Figure 1. Cyber Threat & Fraud Surface (Phishing, API Exploits, Ransom ware, ATO)

Cybersecurity Vectors in Modern Financial Systems:

As digital financial networks increase in structural complexity, threat actors leverage advanced vectors to compromise financial integrity, steal user identity assets, and siphon operational funds across multiple channels.

1. Social Engineering and Human Vulnerabilities: Human deception remains the most prevalent entry point for modern financial fraud. Threat actors utilize advanced psychological manipulation techniques to exploit human trust rather than underlying software flaws:

- **Phishing, Smashing, and Wishing:** Attackers craft domain-spoofed websites, SMS messages, and automated phone calls impersonating bank officials to manipulate customers into revealing credentials, PINs, or One-Time Passwords (OTPs).
- **SIM Swapping:** Attackers register a duplicate SIM card by impersonating the target subscriber to telecommunications providers. Once activated, the fraudster intercepts all Multi-Factor Authentication (MFA) codes sent via SMS, effectively neutralizing out-of-band authentication controls.

2. Application and API Security Vulnerabilities: Open banking frameworks rely heavily on Restful APIs to communicate between e-commerce applications, payment aggregators, and core banking databases. Vulnerabilities in API design introduce severe attack channels:

- **Broken Object Level Authorization (BOLA):** Attackers manipulate transaction payloads or account identifier parameters within API calls to access unauthorized bank balances or alter payment amounts during checkout.
- **Man-in-the-Middle (MitM) Attacks:** Unencrypted or improperly validated communication channels between the merchant app and the payment gateway allow threat actors to intercept, inspect, and modify sensitive transaction payloads in real time.

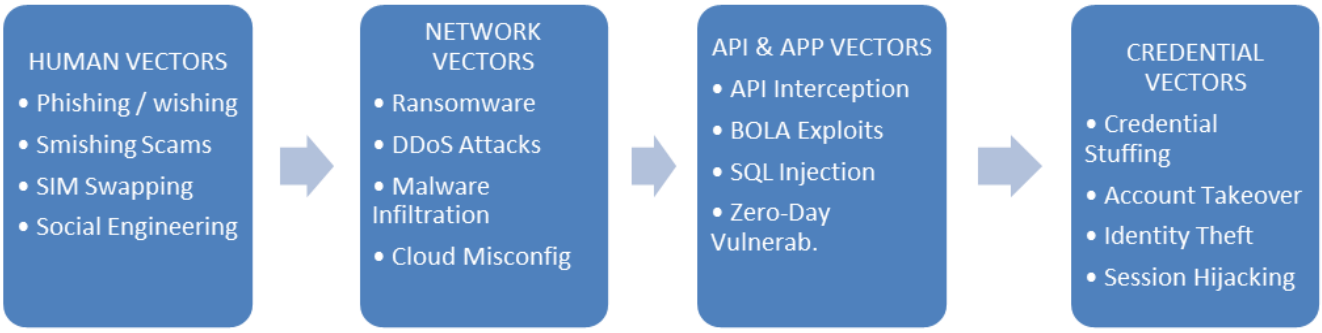


Figure 2: Taxonomy of Modern Cyber Threat Vectors Targeting Financial Infrastructure

3. Advanced Persistent Threats (APTs) and Ransom ware: Financial institutions are high-value targets for APT groups and ransom ware operators. Threat actors gain quiet access to internal bank networks, lateralizing across server infrastructure to compromise CBS ledgers, alter Swift operational codes, or encrypt sensitive customer data repositories, subsequently demanding ransom payments under threat of public disclosure.

Financial Risk Management Frameworks:

To preserve capital stability, institutional liquidity, and consumer confidence, financial organizations must implement multidimensional risk management frameworks capable of addressing strategic, operational, credit, liquidity, and cyber risks.

1. Categorization of Digital Financial Risks: Digital financial risk manifests across distinct, interconnected operational domains:

- Cyber-Operational Risk: The risk of operational loss resulting from hardware failure, software defects, network outages, or external cyber attacks targeting core clearing channels.
- Credit and Liquidity Risk in E-Commerce: The risk stemming from modern buy-now-pay-later (BNPL) platforms and automated micro-lending, where default risk can accumulate rapidly if algorithm driven underwriting models fail during economic downturns.
- Fraud Risk: Financial exposure resulting from unauthorized transactions, identity fraud, chargeback abuse, and refund manipulation within e-commerce networks.
- Systemic Interconnected Risk: The threat that an operational failure or cyber attack at a major cloud hosting provider, core banking vendor, or clearing house (such as NPCI) cascades across the entire banking ecosystem.

2. Enterprise Risk Management (ERM) Architecture: An effective enterprise financial risk framework integrates quantitative modeling with strict operational controls across three key operational pillars. The total enterprise risk profile is evaluated as a function of multiple interdependent risk vectors:

Total Enterprise Risk Profile = f (Cyber Risk, Credit Risk, Operational Risk, Compliance Risk)

The three core pillars of implementation include:

- Governance and Strategy: Defining clear risk appetite statements, operational tolerance limits, and risk ownership from the board level down to security operations centers (SOC).
- Identification and Assessment: Conducting periodic Risk and Control Self-Assessments (RCSA), vulnerability assessments, and red-team penetration testing across all digital assets.
- Mitigation and Response: Deploying automated control mechanisms, real-time transaction blocking, continuous monitoring, and structured incident response plans.

Comparative Analysis of Risk Mitigation Approaches:

Risk Domain	Traditional Banking Approach	Modern Digital Approach	Operational Impact
Identity Verification	In-person physical document inspection	Video KYC, Aadhaar e-KYC, Behavioral Biometrics	Reduces on boarding time from days to minutes; requires strong biometric security.
Fraud Monitoring	Post-transaction batch analysis & rule triggers	Real-time AI/ML behavioral anomaly detection	Blocks fraudulent transactions in milliseconds before final settlement.
System Security	Perimeter defense (Firewalls, VPNs)	Zero-Trust Architecture (Never trust, always verify)	Minimizes lateral network movement by threat actors during breaches.

Real-Time Fraud Mitigation & AI Integration:

Traditional static, rule-based fraud detection systems (e.g., flagging transactions over a fixed monetary threshold) are increasingly inadequate against modern, high-speed cyber-attacks. Contemporary risk management frameworks leverage artificial intelligence (AI), machine learning (ML), and behavioral analytics operating in line with payment processors.

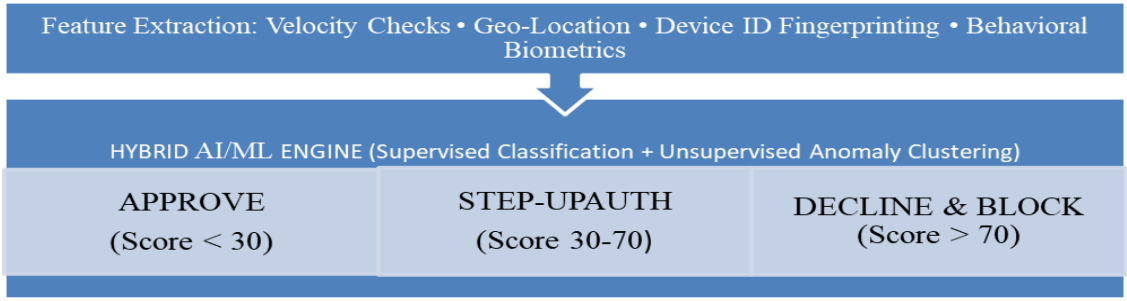


Figure 3: Inline Real-Time AI Fraud Evaluation Pipeline

1. Inline Anomaly Detection Architectures: Inline anomaly detection models evaluate transaction metadata instantaneously before issuing an approval response code. Key input features include:

- Velocity Metrics: Evaluating the frequency and count of transactions originating from a specific card, IP address, or user ID within narrow time windows (e.g., 60 seconds).
- Geospatial and Device Fingerprinting: Analyzing device hardware signatures, operating system characteristics, screen resolution, and IP geo-location to detect physical impossibilities (e.g., a card utilized in Mumbai 10 minutes after a physical transaction in London).
- Behavioral Biometrics: Tracking micro-interaction dynamics such as user keystroke dynamics, touch screen pressure, mouse movement trajectories, and device orientation to distinguish legitimate account owners from automated bots or coercive fraudsters.

2. Machine Learning Model Topologies: Modern engines utilize a combination of

supervised learning (Random Forests, Gradient Boosting) trained on historical fraud patterns, and unsupervised learning (Isolation Forests, Autoencoders) designed to detect novel zero-day fraud strategies. Combining deterministic compliance rules with adaptive ML probability scoring ensures high accuracy while preserving low processing latency (<100 ms).

Regulatory Frameworks and Standards: Regulatory oversight establishes the baseline operational standard required to maintain public trust and safeguard financial resilience. In India, financial technology and digital banking operate under a comprehensive regulatory matrix governed by statutory authorities.

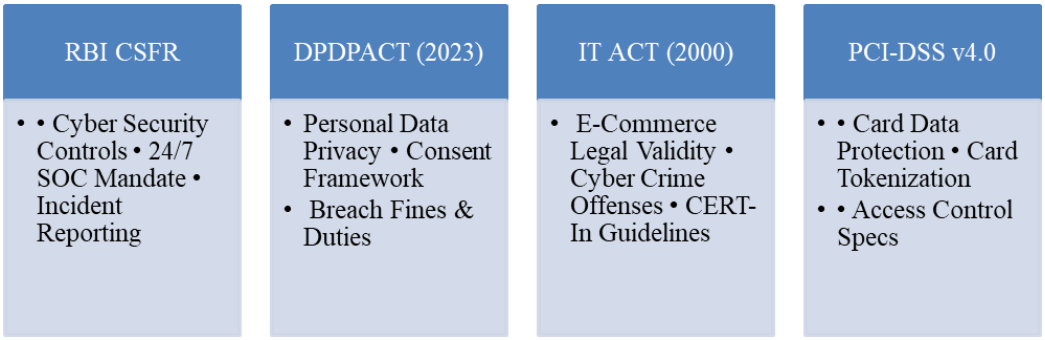


Figure 4: Key Regulatory and Compliance Standards Governing Digital Finance

1. Reserve Bank of India (RBI) Directives:

- Cyber Security Framework for Banks: Mandates that all regulated entities maintain an independent Cyber Security Policy, operate 24/7 Security Operations Centers (SOCs), conduct regular vulnerability scanning, and implement robust patch management controls.
- Master Direction on Digital Payment Security Controls: Requires mandatory multi-factor authentication (MFA) for all remote digital transactions, transaction limit configurations, automated fraud monitoring, and secure application development lifecycles (S-SDLC).
- Card-Not-Present (CNP) and Tokenization Mandates: Prohibits merchants and payment aggregators from storing actual Credit or Debit Card Verification Value (CVV) and Primary Account Numbers (PAN) on local servers, substituting raw card data with secure cryptographic tokens.

2. Digital Personal Data Protection (DPDP) Act, 2023: The DPDP Act establishes explicit obligations for entities processing consumer financial data ("Data Fiduciaries"). Key mandates include strict purpose limitation, explicit consent architecture, mandatory breach reporting to the Data Protection Board, and the upholding of consumer data rights.

Strategic Recommendations:

To establish a resilient framework against rising cyber threats while expanding digital banking and e commerce infrastructure, financial institutions, merchants, and regulatory bodies must adopt a forward looking, proactive posture:

- Deploy Zero-Trust Network Architecture (ZTNA): Financial entities must discard legacy perimeter based security models in favor of Zero-Trust architectures that operate on the principle of "Never Trust, Always Verify." Every API request, user login, and internal network micro-

segmentation must be continuously authenticated, authorized, and encrypted.

- Implement Universal Payload Tokenization: E-commerce platforms and payment aggregators should eliminate clear-text sensitive data across all internal databases, utilizing end-to-end tokenization and Hardware Security Modules (HSMs) for key management to render intercepted data useless to threat actors.
- Transition to Adaptive, AI-Driven Risk Scoring: Replace static fraud rules with hybrid AI engines combining supervised learning and unsupervised behavioral anomaly detection, minimizing operational friction for legitimate users while blocking high-speed, automated attack strains in real time.
- Mandate Third-Party Risk Management (TPRM): Core financial entities must institute rigorous compliance audits, continuous security scoring, and automated penetration testing for all vendor APIs, external cloud services, and merchant aggregators before granting system access.
- Expand Continuous Consumer Education: Institutional technical controls must be supported by proactive, plain-language consumer awareness initiatives focusing on social engineering vectors, SIM swapping safeguards, and digital hygiene practices to address human vulnerabilities.

Conclusion:

The convergence of digital banking and e-commerce serves as a primary engine for financial inclusion and economic expansion in modern India. However, the accompanying expansion of the cyber-attack surface requires a fundamental alignment between business growth and operational security. Cyber threats and financial fraud are no longer merely technical nuisances; they represent operational and systemic financial risks capable of undermining institutional stability and consumer trust.

Building a resilient digital financial ecosystem requires transitioning from reactive security measures to an integrated risk management posture. By combining Zero-Trust architectures, real-time AI-driven fraud analytics, strict compliance with RBI and DPDP standards, and continuous consumer education, financial institutions and e-commerce platforms can effectively neutralize sophisticated cyber vectors. Sustained multi stakeholder collaboration among commercial enterprises, regulatory authorities, technology vendors, and consumers will remain essential to building a secure, inclusive, and stable digital financial future.

References:

1. Financial Stability Board. (2020). Enhancing Cross-Border Payments: Stage 3 Roadmap. Financial Stability Board Publications.
2. Ministry of Law and Justice, Government of India. (2023). The Digital Personal Data Protection Act, 2023 (No. 22 of 2023). The Gazette of India.
3. National Payments Corporation of India. (2023). UPI Ecosystem Statistics and Product Performance Metrics. NPCI Knowledge Hub.
4. Payment Card Industry Security Standards Council. (2022). Payment Card Industry Data Security Standard (PCI DSS) Requirements and Testing Procedures Version 4.0. PCI SSC.

5. Reserve Bank of India. (2016). Cyber Security Framework in Banks (RBI/2015-16/418). Reserve Bank of India.
6. Reserve Bank of India. (2021). Master Direction on Digital Payment Security Controls (RBI/2020-21/74). Reserve Bank of India.
7. Reserve Bank of India. (2023). Report on Currency and Finance: Towards a Cleaner and Greener Digital Future. Reserve Bank of India.
8. World Bank Group. (2022). The Global Index Database 2021: Financial Inclusion, Digital Payments, and Resilience in the Age of COVID-19. World Bank Publications.

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Artificial Intelligence and Emerging Technologies in Commerce: Paradigm Shifts, Operational Impacts, And Future Trajectories in The Indian Economy

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Abstract:

The integration of Artificial Intelligence (AI) and emerging digital technologies has fundamentally reshaped the architectural framework of global and Indian commerce. From algorithmic decision-making, natural language processing, and predictive analytics to block chain-driven supply chain transparency and automated conversational engines, modern commercial enterprises are rapidly migrating from traditional transactional models toward hyper-personalized, data-driven operational ecosystems. This research paper explores the multidimensional impact of AI and associated frontier technologies—such as Big Data analytics, Internet of Things (IoT), and Distributed Ledger Technology (DLT)—on core commercial domains including digital retail, financial services, supply chain management, and regulatory compliance. Focusing on contemporary shifts within the Indian business framework under national initiatives like Digital India, UPI, and ONDC, the paper analyzes both the transformative efficiencies and systemic challenges accompanying tech adoption. Critical issues including algorithmic bias, data privacy vulnerabilities under the DPDP Act 2023, cyber threats, workforce displacement, and the digital divide in semi-urban markets are critically examined. Finally, strategic recommendations are formulated for policymakers, academic institutions, and enterprise leaders to foster sustainable, ethical, and inclusive technological integration.

Keywords: Artificial Intelligence, Emerging Technologies, Digital Commerce, Financial Technology, Supply Chain Automation, Data Privacy, ONDC.

Introduction:

The global commercial ecosystem is currently experiencing an unprecedented technological metamorphosis driven by the convergence of Artificial Intelligence (AI), Machine Learning (ML), Cloud Computing, and Decentralized Networks. Historically, commerce operated on physical transactions, manual inventory tracking, localized customer engagements, and linear supply chains. However, the contemporary globalized market demands real-time responsiveness, hyper-personalization, zero-trust security frameworks, and seamless Omni-channel operational capabilities.

In India, this paradigm shift has been significantly accelerated by foundational Digital Public Infrastructure (DPI) initiatives, including the Unified Payments Interface (UPI), Open Network for Digital Commerce (ONDC), Aadhaar-enabled financial inclusion, and nationwide 5G connectivity. As enterprises adapt to shifting consumer behaviors, hyper-competitive digital platforms, and volatile global market conditions, emerging technologies have evolved from secondary competitive advantages into imperative foundational infrastructures.

This research paper provides a comprehensive evaluation of AI and emerging

technologies within commerce. It outlines their theoretical and operational foundations, examines sectoral transformations across retail fintech and logistics investigates the unique dynamics of the Indian market identifies structural.

Literature Review:

The theoretical and empirical literature surrounding technological disruption in commercial domains has expanded rapidly over the past decade. Scholars across economics, information systems, and enterprise management have investigated how algorithmic intelligence alters traditional value creation.

1. Economics of Prediction and Decision Making: Agrawal, Gans, and Goldfarb (2018) conceptualize Artificial Intelligence primarily as a dramatic reduction in the economic cost of prediction. They argue that as prediction becomes cheap, autonomous decision-making permeates core commercial activities—ranging from inventory forecasting and demand estimation to credit risk assessment. Consequently, traditional administrative tasks shift from manual calculation to judgment-based monitoring.

2. Customer Engagement and Hyper-Personalization: Syam and Sharma (2018) analyze the impact of machine learning algorithms on personalizing buyer journeys. Their empirical findings demonstrate that predictive recommendation engines drastically increase conversion rates, customer lifetime value, and consumer satisfaction in electronic commerce platforms by converting massive unstructured datasets into actionable behavioral insights.

3. Financial Innovations and Distributed Systems: Tapscott and Tapscott (2016) underscore how block chain and distributed ledger technologies reduce transactional friction in cross-border trade, mitigate counterparty risk, eliminate financial intermediaries, and ensure cryptographic immutability in corporate auditing.

4. Supply Chain Resilience and IoT Integration: Ivanov et al. (2019) investigate the integration of Industry 4.0 paradigms—such as IoT sensors and real-time cloud tracking—into global supply chains. They emphasize that automated tracking combined with predictive analytics significantly increases supply chain visibility and resilience against dynamic disruptions.

5. Indian Context and Technological Readiness: Reports by NITI Aayog (2021) highlight AI's transformative potential for Micro, Small, and Medium Enterprises (MSMEs) in India, while highlighting persistent structural challenges including digital literacy gaps, high capital expenditure requirements, and cyber security vulnerabilities in regional hubs.

The Spectrum of Emerging Technologies in Commerce:

Modern digital commerce does not rely on a single isolated technology, but rather functions as an interconnected technology matrix where multiple emerging tools reinforce one another.

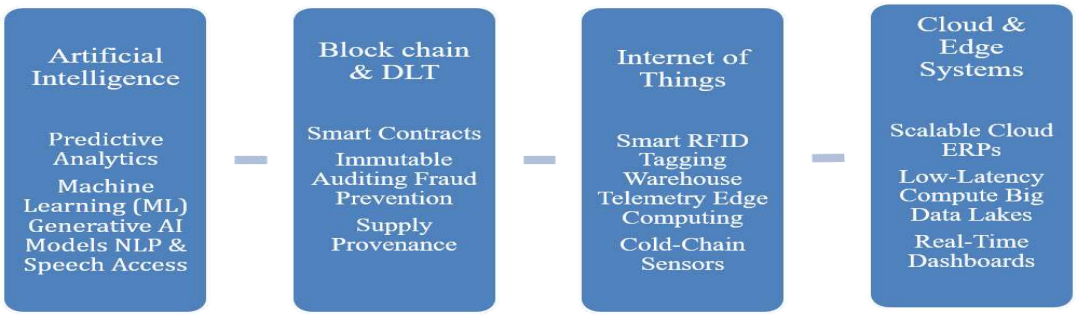


Figure 1: Interconnected Spectrum of Emerging Technologies in Commerce

1. Artificial Intelligence and Machine Learning (AI/ML):

At the core of digital commercial transformation lies Machine Learning. ML algorithms analyze massive datasets to uncover hidden consumer trends, predict operational bottlenecks, and execute automated decisions. Supervised learning models assess credit worthiness and fraud probabilities, while unsupervised algorithms segment consumer demographics for precision targeting. Deep learning architectures enable computer vision systems that automate quality assessment in logistics warehouses and support interactive virtual visual try-ones in retail.

2. Block chain and Distributed Ledger Technology (DLT):

Block chain provides cryptographic verification across decentralized networks. In commerce, DLT eliminates the necessity for trusted third-party intermediaries in cross-border settlements, escrow services, and asset transfers. Smart contracts automatically execute transactions once verified parameters are satisfied, substantially lowering compliance costs, preventing invoice fraud, and establishing tamper-proof supply chain histories.

3. Internet of Things (IoT) and Edge Computing:

IoT connects physical inventory, manufacturing equipment, and shipping fleets directly to enterprise digital systems. Connected sensors transmit live telemetry regarding temperature, humidity, pressure, and geo-location. Edge computing processes this data directly at the device level, enabling immediate automated dynamic adjustments—such as automated warehouse rerouting or predictive maintenance alerts—without sending heavy data payloads to centralized servers.

Sectoral Transformations in Commerce:

The deployment of AI and emerging technologies has driven distinct structural transformations across major commercial domains, detailed in Table 1.

Commerce Vertical	Primary Technologies	Practical Applications	Enterprise & Consumer Impact
Retail & E-Commerce	AI Recommendation Engines, Gen AI, Computer Vision	Hyper-personalized product discovery, automated dynamic pricing, conversational Shopping assistants.	Higher conversion rates, lower cart abandonment, reduced return rates.
Banking & Fintech	ML Anomaly Detection, NLP, Predictive Credit Models	Real-time fraud surveillance, automated credit scoring using non-traditional data, robot Advisory.	Mitigated credit losses, Instantaneous micro-loans, 24/7 service availability.
Supply Chain & Logistics	IoT Sensors, Telemetric, Route-Optimization AI	Dynamic route adjustment, predictive warehouse Maintenance, real-time cold chain auditing.	Reduced spoilage, lower fuel consumption, optimized inventory Turnover.
Corporate Governance & Tax	Robotic Process Automation (RPA), Smart Contracts	Automated invoice processing, real-time tax filing compliance, immutable audit logging.	Lower administrative overhead, minimized manual audit errors, Improved transparency.

2. Financial Services and Technology (Fintech):

In financial commerce, AI algorithms process non-traditional data—such as utility bill payment patterns, digital transaction velocity, and mobile usage metrics—to build alternative credit scores for previously unbanked populations. Machine learning models continuously screen high-frequency financial networks for anomalous activity, flagging potential cyber-attacks and fraudulent transactions within milliseconds.

3. Smart Supply Chain Management:

Supply chain management has shifted from reactive logistics to proactive, resilient networks. AI models predict demand surges and raw material shortages weeks in advance, enabling automated purchasing systems to place replenishment orders seamlessly. Automated Guided Vehicles (AGVs) and robotic picking arms inside fulfillment hubs optimize order processing cycles, drastically reducing dispatch lead times.

Contemporary Indian Perspective & Digital Ecosystem:

India presents an ideal case study for technology-driven commercial evolution. The convergence of expansive demographic reach, government-backed digital initiatives, and rapid Smartphone adoption has catalyzed a unique digital economy.

Key Indian Digital Milestones:

- **Unified Payments Interface (UPI):** Processed over 130 billion transactions in 2023-24, democratizing digital payments for small street vendors and major retail chains alike.
- **Open Network for Digital Commerce (ONDC):** A government-backed initiative aimed at unbundling e-commerce, allowing local neighborhood stores (Kiranas) to compete directly with global digital monopolies.
- **Digital Rupee (e₹):** The Reserve Bank of India's Central Bank Digital Currency (CBDC) enabling programmable, instant interbank and commercial settlements.

1. Democratization through ONDC: Modern digital commercial growth in India was historically dominated by centralized e-commerce aggregators operating walled-garden platforms. The introduction of ONDC establishes an open protocol connecting buyers, sellers, and logistics providers independently. AI powered middleware tools enable local merchants to onboard their inventory onto the open network using automated voice-to-text inputs in regional Indian languages.

2. Vernacular AI for Inclusive Commerce: Language diversity has traditionally posed a barrier to digital commerce in Tier-2, Tier-3, and rural Indian markets. Advanced Natural Language Processing (NLP) models trained in languages such as Kannada, Hindi, Tamil, and Marathi enable non-literate and semi-literate merchants to manage digital storefronts, check market prices, and execute financial transactions via simple voice interactions.

Critical Challenges and Systemic Risks:

While the advantages of AI and emerging technologies are significant, their widespread implementation introduces complex structural, ethical, and regulatory challenges.

1. Algorithmic Bias and Ethical Governance: AI models learn from historical datasets. If historical datasets reflect socioeconomic biases or geographic disparities, automated credit scoring and hiring tools can perpetuate discrimination against marginalized demographics. Establishing transparent, explainable AI models remains a fundamental challenge.

2. Data Privacy and DPDP Act Compliance: Modern commerce relies heavily on collecting personal data. The enactment of India's Digital Personal Data Protection (DPDP) Act 2023 imposes strict compliance requirements regarding user consent, data minimization, and cross-border data transfer. Commercial enterprises must redesign their data architecture to avoid severe regulatory penalties.

3. Cyber security and Infrastructure Vulnerabilities: Increased reliance on interconnected cloud systems, API gateways, and IoT networks expands the surface area for cyber attacks. Ransom ware attacks on financial clearinghouses, supply chain disruptions via API exploits, and data breaches pose severe operational threats.

4. Workforce Displacement and Re-skilling Imperatives: Automation of routine tasks—such as manual data entry, customer support ticketing, basic auditing, and warehouse sorting—endangers entry-level administrative positions. Without comprehensive institutional re-skilling initiatives, technological adoption risks widening socioeconomic inequality.

Strategic Recommendations:

To maximize the benefits of emerging technologies while mitigating operational risks, stakeholders across the commercial ecosystem must execute coordinated strategic initiatives:

1. Implement Ethical & Explainable AI Frameworks: Enterprise leaders should establish internal AI governance boards and conduct routine independent algorithmic audits to ensure fairness and prevent bias in customer-facing models.
2. Adopt Privacy-by-Design Architecture: Organizations must re-architect data pipelines to enforce end to-end encryption, data minimization, and automated consent management in full alignment with the DPDP Act 2023.
3. Invest in Higher Education Re-skilling Collaborations: Academic institutions, such as university commerce departments, should collaborate with industry partners to integrate data analytics, AI ethics, and fintech applications into business curricula.
4. Extend Digital Subsidies to Rural MSMEs: Government bodies should provide financial grants, subsidized cloud software, and localized technical training to help rural enterprises adopt ONDC protocols and digital payment infrastructures.
5. Fortify Zero-Trust Cyber security Posture: Commercial firms should deploy Zero-Trust Architecture (ZTA), robust multi-factor authentication, and continuous automated vulnerability assessments across all digital touch points.

Conclusion:

Artificial Intelligence and emerging technologies are no longer speculative concepts; they constitute the primary operational infrastructure of modern commerce. The transition from physical, siloed business operations to dynamic, automated, and interconnected digital networks presents immense opportunities for economic growth, operational efficiency, and financial inclusion.

In the Indian context, initiatives such as UPI, ONDC, and regional-language AI solutions demonstrate how technological adoption can bridge historical market divides and empower small merchants alongside enterprise actors. However, achieving sustainable digital growth requires addressing critical issues surrounding algorithmic fairness, data privacy, cyber resilience, and workforce transitions. By implementing ethical governance frameworks, prioritizing privacy compliance, and fostering

digital literacy, India's commercial sector can build an inclusive, resilient, and globally competitive modern economy.

References:

1. Agrawal, A., Gans, J., & Goldfarb, A. (2018). Prediction machines: The simple economics of artificial intelligence. Harvard Business Press.
2. Chintagunta, P., Hanssens, D. M., & Hauser, J. R. (2016). Marketing science and big data. Marketing Science, 35(3), 341–348. https://doi.org/10.1287/mksc.2016.0996
3. Davenport, T., Guha, A., Grewal, D., & Bressgott, T. (2020). How artificial intelligence will change the future of marketing. Journal of the Academy of Marketing Science, 48(1), 24–42. https://doi.org/10.1007/s11747-019-00696-0
4. Government of India. (2023). The Digital Personal Data Protection Act, 2023. Ministry of Law and Justice, Gazette of India.
5. Ivanov, D., Dolgui, A., & Sokolov, B. (2019). The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics. International Journal of Production Research, 57(3), 829–846. https://doi.org/10.1080/00207543.2018.1488086
6. NITI Aayog. (2021). National strategy for artificial intelligence: #AIforAll. Government of India.
7. Syam, N., & Sharma, A. (2018). Waiting for a sales Renaissance in the fourth industrial revolution: Machine learning and artificial intelligence in sales research and practice. Industrial Marketing Management, 69, 135–146. https://doi.org/10.1016/j.indmarman.2017.12.019
8. Tapscott, D., & Tapscott, A. (2016). Blockchain revolution: How the technology behind bitcoin is changing money, business, and everything. Penguin Random House.
9. Varian, H. R. (2014). Big data: New tricks for econometrics. Journal of Economic Perspectives, 28(2), 3–28. https://doi.org/10.1257/jep.28.2.3

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Innovation, Investment, Marketing And Institutional Support: Exploring The Dynamics Of India's Start-Up Ecosystem

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Abstract:

Thanks to technical advancement, digital infrastructure, entrepreneurial talent, private investment, and government-led institutional structures, India has become one of the world's largest start-up ecosystems. Through recognition, investment, incubation, mentorship, regulatory facilitation, and market-access procedures, the Start-up India Initiative, which was launched in 2016, boosted the ecosystem. The Department for Promotion of Industry and Internal Trade (DPIIT) has recognized 2,07,137 start-ups by December 31, 2025, and these start-ups reported over 2.19 million jobs. This study looks at how marketing, institutional support, funding, and innovation interact to shape start-up growth in India. Using secondary data from government publications, DPIIT, Start-up India, the Economic Survey, SIDBI, venture-capital reports, and scholarly literature, a descriptive and analytical review methodology was used. While financing permits product creation, experimentation, and scalability, innovation supplies the technological and commercial basis for entrepreneurial activity. Customer identification, brand development, market penetration, digital engagement, and income generation are all aided by marketing. Funding programs, incubation, mentorship, infrastructure, support for intellectual property, and regulatory facilitation are all provided via institutional support. According to the analysis, innovation capability, financial availability, successful marketing, and supportive institutions interact to determine sustainable start-up development. The long-term contribution of Indian start-ups to economic and social development can be further increased by bolstering university-industry collaboration, regional ecosystems, early-stage finance, digital marketing capabilities, deep-tech commercialization, and inclusive entrepreneurship.

Keywords: Start-ups, Innovation, Investment, Marketing, Institutional Support, Entrepreneurship, Venture Capital, Start-up India, Digital Marketing, India

Introduction:

Innovation, job creation, productivity, and economic transformation are all significantly influenced by entrepreneurship. By providing new goods, services, technology, and business models in response to changing consumer and social demands, start-ups aid in this process. There are now more chances for technology-enabled entrepreneurship in India thanks to the growth of smartphones, digital payments, cloud computing, artificial intelligence, e-commerce, and digital public infrastructure. As a result, the start-up ecosystem has grown into a network that includes business owners, investors, incubators, accelerators, universities, research facilities, enterprises, mentors, and governmental organizations. Access to capital, information, human capital, markets, infrastructure, and

institutional support all affect this ecosystem's performance [1,2]

Launched on January 16, 2016, the Start-up India Initiative was a significant institutional intervention in India's entrepreneurial landscape. Its comprehensive strategy encompassed industry-academia collaboration and incubation, funding assistance and incentives, and simplification and handholding. Through methods like start-up recognition, seed investment, the Fund of Funds, credit support, mentorship, facilitation of intellectual property, and government procurement, the project later grew. According to the Economic Survey 2025–2026, DPIIT-recognized start-ups grew from over 500 in 2016 to over two lakhs by 2025, and innovation has spread to digital services, biotechnology, artificial intelligence, and sustainability-focused solutions.

Another important aspect of the ecosystem is investment. Early-stage businesses sometimes struggle to secure traditional financing due to uncertainties, a short working experience, and a lack of collateral. Thus, institutional finance, venture capital, angel investment, and seed funding are crucial for promoting innovation and expansion. In contrast to US$9.6 billion and 880 deals in 2023, Indian venture capital funding reached US$13.7 billion over 1,270 deals in 2024, according to Bain & Company and IVCA. However, financial success is not assured by investment alone. Through efficient marketing, market research, branding, customer acquisition, digital communication, and distribution, start-ups must transform their financial resources and technological prowess into customer value.

As a result, marketing has grown in significance in the Indian start-up scene. Young businesses can access geographically scattered customers at comparatively low start-up costs thanks to digital channels. Start-ups can increase exposure and cultivate customer relationships with the use of social media marketing, search engine marketing, content marketing, influencer engagement, mobile applications, e-commerce platforms, and data-driven customer analytics. Significant marketing issues are also created by the requirement for sustainable revenue models, client acquisition expenses, shifting consumer tastes, and fast competition. Start-ups can benefit from institutional support through networking, government procurement opportunities, market access, mentoring, incubation, and connections to investors.

In light of this, the current study looks at the interactions between institutional support, marketing, investment, and innovation in India's start-up ecosystem. The study views these elements as interrelated elements affecting start-up development, scalability, and wider economic and social effect rather than handling them separately.

The Indian Start-up Ecosystem's History:

Traditional small enterprises have given way to a technology-driven start-up ecosystem in India, which is backed by digital infrastructure, venture funding, cellphones, digital payments, and a highly qualified workforce. This ecosystem was reinforced by the establishment of Start-up India in 2016, which provided investment, government backing, market access, and mentorship. DPIIT recognized 2,07,137 start-ups by the end of 2025, indicating significant ecosystem expansion. In addition to identifying obstacles to sustainability and scalability and offering solutions for an inclusive and sustainable entrepreneurial ecosystem, this study explores the development and features of India’s start-up ecosystem, emphasizing the roles of innovation, investment, marketing, and institutional support in start-up formation, competitiveness, and growth.

Techniques:

Using secondary data from Government of India publications, DPIIT, Start-up India, Economic Survey, SIDBI, Ministry of MSME, investment reports, scholarly literature, and policy documents through 2025–2026, the study employs a descriptive and analytical review methodology. It looks at how innovation, funding, marketing, institutional backing, and start-up growth are related to each other. The results are a synthesis and analytical evaluation rather than causal evidence because no primary survey or econometric analysis was carried out.

Conceptual Structure:

In order to promote start-up growth and economic and social impact, the conceptual framework looks at how innovation, investment, marketing, and institutional support interact. Innovation creates goods, services, and business opportunities; investment supplies resources for growth and expansion; marketing links innovations with consumers through branding, distribution, and market research; and institutional support fortifies the ecosystem through funding, incubation, mentorship, policy, intellectual property services, and market access. Together, these factors—which are backed by the government, academic institutions, investors, incubators, business, and digital infrastructure—contribute to start-up growth, scalability, employment, and broader economic and social impact.

Innovation and the Development of Start-ups:

Innovation, which includes new goods, procedures, digital solutions, and business models, is the technological and commercial cornerstone of start-ups. Biotechnology, artificial intelligence, healthcare, agriculture, renewable energy, electric mobility, space technology, finance, and environmental sustainability are all areas where Indian start-up innovation is expanding. Opportunities in fields including diagnostics, pharmaceuticals, bioinformatics, and advanced technologies are presented by biotechnology and deep-tech businesses, but they frequently call for specialized infrastructure, highly qualified personnel, intellectual property protection, regulatory approval, validation, and significant financial outlay. Therefore, transforming breakthrough research into economically viable and scalable firms requires strong relationships between universities, research institutions, incubators, investors, and industry.

Venture Capital and Investments:

Through founder capital, grants, incubator funding, angel investment, seed funds, venture capital, debt, and strategic investment across various development stages, investment provides the financial resources required to turn start-up ideas into scalable businesses. While the SIDBI-managed Fund of Funds for Start-ups (FFS) has a ₹10,000 crore corpus and reported gross commitments of ₹11,808 crores across 153 alternative investment funds in 2024–2025, the Start-up India Seed Fund Scheme (SISFS), with an outlay of ₹945 crores, supports proof of concept, prototypes, product trials, market entry, and commercialization. Additionally, venture capital investment continued to be substantial, totalling US$13.7 billion in 1,270 transactions in 2024.

The Role of Marketing in Start-up Development:

By assisting start-ups in identifying consumers, communicating the value of their products, developing brands, and setting up efficient distribution channels, marketing links innovation with commercialization. Market research, segmentation, branding, digital and content marketing, customer relationship

management, e-commerce, and performance analytics are important tasks. Customer feedback can direct product innovation, and digital platforms facilitate market testing, global growth, and cost-effective customer interaction. Through metrics like customer acquisition, retention, revenue growth, and product-market fit, marketing performance also affects investment choices. In order to achieve long-term scalability, start-ups must combine customer growth with profitability, sustainable unit economics, brand reputation, and acceptable data practices.

Governmental Initiatives and Institutional Assistance:

Through policy facilitation, DPIIT recognition, financial programs, incubation, mentorship, intellectual property assistance, government procurement, market access, and investor contacts, institutional support creates a climate that is favourable to start-ups. Start-ups at various phases of development are supported by initiatives including Start-up India, SISFS, the Fund of Funds, MAARG, incubators, and state-level programs. Universities and incubators also make contributions through networking, technology transfer, infrastructure, technical support, and entrepreneurship education. A more equitable and regionally balanced start-up ecosystem can be fostered by bolstering such structures, especially in smaller cities and districts, which can enhance access to capital, mentorship, markets, and innovation resources.

Innovation, Investment, Marketing and Institutional Interaction:

A mutually reinforcing environment for start-up development is formed by innovation, funding, marketing, and institutional backing. Innovation produces concepts and goods, investment provide resources for scaling and validation, marketing links products to consumers and markets, and institutional support enables infrastructure, regulation, intellectual property protection, incubation, skills, and market access. As a result, start-up creation may be seen as an ongoing process with institutional support at every stage: Research/Idea → Innovation → Investment → Marketing → Market Adoption → Scaling → Economic and Social Impact.

AI, biotechnology, and deep-tech start-ups:

In the fields of healthcare, agriculture, finance, education, manufacturing, logistics, food, and the environment, emerging technologies like biotechnology, generative AI, and artificial intelligence have substantial prospects for Indian entrepreneurship. Start-ups in deep technology and biotechnology frequently need more time to grow, specialized expertise, sophisticated infrastructure, intellectual property protection, and patient funding. Research, discovery, IP protection, proof of concept, validation, manufacturing, marketing, and commercialization are the typical steps in their commercialization process. Stronger technology-transfer methods and industry-academic alliances can expedite the transformation of research into commercially viable products, while universities, research institutions, incubators, BIRAC, and private investors can support this process.

Inclusive and Regional Entrepreneurship:

Thanks to local incubators, state legislation, and internet connectivity, entrepreneurial activity is growing from metropolitan areas to Tier-2 and Tier-3 cities. Through better access to capital, mentorship, technology, and markets, inclusive entrepreneurship should give women, young people, first-generation entrepreneurs, rural innovators, and marginalized populations opportunity. Local needs can be met and jobs can be created by regional start-ups in fields like agri-

tech, healthcare, food processing, rural technology, and environmental solutions. However, survival, income, employment, innovation, investment access, and social effect should all be taken into consideration when evaluating ecosystem inclusion in addition to start-up numbers.

The Indian Start-up Ecosystem's Challenges:

1. Access to Early-Stage Finance: Due to their poor market traction, research-intensive and pre-revenue start-ups frequently struggle to secure funding.
2. Product-Market Fit: Without thorough market research and ongoing modification, innovative items might not be able to satisfy consumer demands.
3. Marketing and Customer Acquisition: Efficient and long-lasting digital marketing techniques are needed due to growing competition and customer acquisition expenses.
4. Skilled Human Resources: Start-up growth may be hampered by a lack of technical, management, financial, and marketing skills.
5. Regulatory Complexity: Complicated regulations can make product commercialization more time-consuming, expensive, and challenging.
6. Commercialization of Research: The transformation of research into commercially viable goods may be hampered by a lack of industry connections and technology transfer.
7. Geographic Concentration: Major entrepreneurial hubs continue to house the majority of venture money, specialized infrastructure, and seasoned mentors.
8. Sustainability: Successful revenue models, prudent investment, client retention, and long-term financial sustainability are essential for start-ups.

Discussion:

With DPIIT-recognized start-ups growing from roughly 500 in 2016 to over two lakhs by 2025 and venture-capital funding reaching US$13.7 billion across 1,270 transactions in 2024, the review shows that India's start-up ecosystem has significantly expanded in scale, financing, and institutional support. Financial resources support invention, whereas branding, digital communication, market research, and consumer feedback enable commercialization. invention, investment, and marketing are intimately related. Early-stage development is also supported by institutional mechanisms as SISFS, FFS, incubators, and mentorship programs. Thus, in addition to start-up numbers and finance, long-term ecosystem assessment should take into account innovation quality, firm survival, customer value, employment, development of intellectual property, regional inclusion, and sustainability

Suggestions:

1. 1.Increase industry-university cooperation through technology transfer, incubation, and research.
2. Increase early-stage financing for creative, research-focused start-ups.
3. Use branding, digital marketing, and customer analytics to improve marketing skills.
4. Encourage regional incubation in Tier-2 and Tier-3 cities.
5. Encourage the commercialization of biotechnology and deep technology through corporate connections and specialized funding.
6. Increase access to markets, capital, and skills to support inclusive entrepreneurship and mentorship.

7. Encourage viable revenue streams and customer value-based sustainable company strategies.
8. Enhance ecosystem data on innovation, employment, finance, start-up survival, and regional expansion.

Upcoming Studies:

Future studies should investigate the connections between innovation capability, institutional support, investment access, marketing capability, and start-up performance using primary surveys and quantitative techniques involving entrepreneurs, investors, incubators, mentors, and policymakers. While comparative study could look at metropolitan and non-metropolitan ecosystems, women-led businesses, biotechnology, digital, and deep-tech start-ups, structural equation modelling and longitudinal studies could evaluate start-up survival, investment, customer acquisition, and growth over time.

Conclusion:

The start-up ecosystem in India has developed into a diverse network of business owners, financiers, organizations, colleges, incubators, and digital platforms. This increase is seen in the rise in venture capital investment and DPIIT-recognized start-ups. Sustainable ecosystem development, however, calls for more than just raising start-up capital and headcount. To transform concepts into commercially viable products, reach consumers, and promote long-term growth, innovation, investment, marketing, and institutional backing must collaborate. A more inventive, diverse, and long-lasting Indian start-up environment may result from incorporating these factors.

References:

1. Jha, S. K. (2018). Entrepreneurial ecosystem in India: Taking stock and looking ahead. IIMB management review, 30(2), 179-188.
2. Stam, E., & Van de Ven, A. (2021). Entrepreneurial ecosystem elements. *Small business economics*, *56*(2), 809-832.

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India's Changing Tax System: Issues, Reforms and Challenges

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Abstract:

Taxation is an important instrument of economic development and public finance. In India, the tax system has undergone considerable changes in recent years, particularly after the introduction of the Goods and Services Tax (GST), the rapid digitalisation of tax administration, changes in income-tax provisions and the enactment of the Income-tax Act, 2025. These reforms have attempted to simplify taxation, improve compliance, reduce tax evasion, increase transparency and create a more taxpayer-friendly administration. At the same time, the Indian tax system continues to face challenges such as complexity, compliance costs, tax litigation, tax evasion, the informal economy, digital inequality and the need to balance revenue mobilisation with economic growth.

This paper examines the changing nature of India's tax system, major reforms, emerging issues and future challenges. It discusses GST, direct-tax reforms, digital tax administration and the changing relationship between taxpayers and the government. The paper argues that the success of tax reform should not be judged only by revenue collection. Simplicity, fairness, transparency, predictability, taxpayer services and trust are equally important. A modern tax system should make compliance easier for honest taxpayers while ensuring effective action against deliberate evasion.

Keywords: Indian Tax System, Tax Reforms, GST, Income Tax, Digital Taxation, Tax Compliance, Tax Administration, Tax Evasion, Public Finance

Introduction:

Taxation is one of the most important sources of government revenue. It provides the financial foundation for public expenditure on education, healthcare, infrastructure, social welfare, defence and economic development. In a developing economy such as India, taxation also influences investment, consumption, savings, employment and the distribution of income.

India's tax system has changed considerably since independence. During the earlier decades, the system gradually became complicated because of the existence of several taxes, exemptions, concessions and procedural requirements. In the indirect-tax sector, businesses had to deal with different Central and State taxes such as excise duty, service tax, VAT, entry tax and other levies.

This fragmented structure created difficulties for businesses and resulted in tax cascading. Economic liberalisation after 1991 created a greater need for a simpler and more efficient tax system.

The introduction of the **Goods and Services Tax (GST) in July 2017** was a major turning point. GST replaced several indirect taxes with a more integrated system and attempted to create a common national market.

Direct taxation has also undergone substantial changes. Tax administration has increasingly moved towards online filing, electronic assessment, data analytics, digital

communication and risk-based scrutiny. The enactment of the **Income-tax Act, 2025**, represents another significant stage in the continuing attempt to simplify India's direct-tax framework.

However, tax reform is not merely a question of changing tax rates or introducing new legislation. It is also about how ordinary citizens, employees, businesses and professionals experience the tax system. A good tax system should be understandable, predictable and fair while generating sufficient revenue for national development.

Objectives of The Study:

The main objectives of this paper are:

1. To examine the changing nature of India's tax system.
2. To study major tax reforms introduced in recent years.
3. To identify major issues in the present tax system.
4. To suggest measures for creating a simpler and more efficient tax system.

Research Methodology:

The study is descriptive and analytical in nature and is based mainly on secondary information. Data and information have been drawn from Government of India publications, Union Budget documents, Economic Survey reports, GST Council publications and other official tax-policy documents.

The paper focuses particularly on the major changes in Indian taxation during the recent reform period and the emerging direction of tax administration towards simplification, digitalisation and voluntary compliance.

Evolution Of India's Tax System:

The Indian tax system has developed in response to changing economic and social requirements.

Earlier, taxation was largely focused on revenue mobilisation. Over time, tax policy began to pursue wider objectives such as economic growth, industrial development, investment promotion and income redistribution.

The tax reforms initiated after economic liberalisation attempted to broaden the tax base and reduce excessively high rates. Greater importance was given to self-assessment, electronic records and improved taxpayer services.

The introduction of GST represented the most significant change in indirect taxation. It attempted to bring different indirect taxes under one broad framework.

The present phase of reform can be characterised by four important developments:

Simplification → Digitalisation → Formalisation → Data-based Compliance

The tax administration is gradually moving away from physical paperwork and manual processes towards online systems and integrated information.

Goods And Services Tax: A Major Tax Reform:

GST was introduced in India on 1 July 2017. It replaced a number of Central and State indirect taxes and created a common framework for taxing the supply of goods and services.

The important features of GST include:

- destination-based taxation;
- input tax credit;
- electronic registration;
- online return filing;
- electronic tax payment;
- e-invoicing;
- data-based compliance; and

- coordination between the Centre and States.

GST has significantly changed the way businesses maintain tax records and report transactions.

The GST Council has continued to modify the system based on practical experience. Its reforms have included rate changes, procedural simplification, measures relating to input-tax credit, e-invoicing, registration and dispute resolution.

The Council's continuing work demonstrates that GST should be viewed as an evolving system rather than a one-time reform.

1. Benefits of GST: GST has contributed to the creation of a more integrated indirect-tax structure. Businesses operating across States can now work within a common tax framework rather than dealing with several independent indirect-tax systems.

Digital reporting has also generated greater transaction-level information, which can help improve compliance and reduce certain forms of tax evasion.

2. Issues under GST: Despite its achievements, GST has created challenges for some taxpayers, particularly small businesses.

Common difficulties include:

- frequent changes in rules;
- classification issues;
- technical problems;
- return-related compliance;
- reconciliation of invoices;
- understanding input-tax credit provisions; and
- professional compliance costs.

For a small trader, compliance may sometimes appear more complicated than the actual tax payment.

Therefore, the future of GST reform should focus not only on tax rates but also on **ease of compliance**.

Changes In Direct Taxation:

Direct taxation has also undergone significant transformation.

Traditionally, India's income-tax system contained numerous exemptions, deductions and special provisions. These provisions often made tax computation complicated for ordinary taxpayers.

Recent reforms have increasingly emphasised:

- simpler tax structures;
- rationalisation of deductions;
- electronic filing;
- faceless assessment;
- digital communication;
- data analytics;
- faster processing; and
- reduction of unnecessary litigation.

The Union Budget 2025–26 introduced significant changes to the personal income-tax structure under the new tax regime. The revised structure increased the threshold for tax liability and sought to provide relief to individual taxpayers.

These reforms indicate a broader shift towards reducing complexity and encouraging taxpayers to use simpler tax structures.

Income-Tax Act, 2025:

The enactment of the **Income-tax Act, 2025** is an important development in India's direct-tax system.

The Economic Survey 2025–26 notes that the Act was enacted on 21 August 2025 and is intended to come into effect from the tax year 2026–27. The new legislation seeks greater structural clarity and simplification of the income-tax framework.

The importance of the new Act will ultimately depend upon its implementation.

For taxpayers, simplification should mean:

- clearer provisions;
- easier interpretation;

- fewer procedural difficulties;
- lower compliance costs;
- faster assessments; and
- reduced disputes.

The transition to a new law also requires proper awareness among taxpayers, accountants, tax practitioners, businesses and government officials.

Thus, legal reform must be accompanied by **tax education and effective communication**.

Digital Transformation of Tax Administration:

Digitalisation is perhaps the most visible feature of India's contemporary tax administration.

Today, many tax-related activities can be completed electronically:

Registration → Return Filing → Payment → Assessment → Communication → Refund → Appeal

Digitalisation has several advantages. It reduces paperwork, improves record keeping and allows tax authorities to process large volumes of information.

The Government has also increasingly moved towards paperless tax administration. Budget documents have highlighted the digital delivery of taxpayer services across GST, Customs and Income Tax.

Data analytics is also becoming increasingly important. Tax authorities can compare information from different sources and identify inconsistencies.

The Economic Survey 2025–26 has discussed the use of behavioural approaches and data-driven initiatives to improve compliance and reduce unnecessary friction between taxpayers and the administration.

However, digitalisation should not create a new form of exclusion.

Small traders, senior citizens, rural taxpayers and people with limited digital literacy may require additional assistance.

Therefore:

Digital Taxation should mean easier taxation—not simply online taxation.

Major Issues in India's Tax System:

1. Complexity: Despite several reforms, taxation can still be difficult for ordinary taxpayers. Multiple provisions relating to deductions, TDS, capital gains, business expenses and compliance requirements can create confusion.

A tax system should ideally be understandable without requiring every taxpayer to depend heavily on professional assistance.

2. Compliance Cost: The real cost of taxation includes not only the tax paid but also the time and money spent on compliance.

For large companies, professional tax teams can manage complex requirements. Small businesses may find these requirements comparatively burdensome.

3. Tax Litigation: Tax disputes remain a major concern. Differences in interpretation and classification can result in prolonged disputes. Long litigation affects both taxpayers and the government because financial resources remain tied up while administrative time is spent on disputes. Reducing unnecessary litigation should therefore remain an important tax-policy objective.

4. Tax Evasion: Tax evasion reduces government revenue and creates an unfair burden on compliant taxpayers. Digital transactions, GST data, TDS information and data analytics can help identify suspicious transactions. However, enforcement should distinguish between deliberate evasion and genuine mistakes.

5. Informal Economy: A large number of economic activities still operate partly outside the formal tax system. Formalisation can broaden the

tax base, but it should not impose excessive compliance burdens on micro enterprises.

6. Taxpayer Awareness: Many taxpayers are not fully aware of changing provisions. Regular tax-awareness programmes in educational institutions, business associations and local communities can improve voluntary compliance.

Major Challenges:

1. Balancing Revenue and Economic Growth: Government needs revenue to finance development. At the same time, taxation should not unnecessarily discourage investment, entrepreneurship or consumption.

Finding this balance remains one of the central challenges of tax policy.

2. Ensuring Fairness: Taxation should distribute the burden fairly. Direct taxes can play an important role in progressive taxation, while indirect taxes affect consumers through their spending patterns.

Therefore, tax policy should consider both revenue requirements and distributional consequences.

3. Expanding the Tax Base: India needs to expand the number of taxpayers and formal economic activities without creating excessive administrative burdens. Simplification, digitalisation and formalisation should work together.

4. Centre-State Coordination: Taxation in India operates within a federal structure. GST particularly requires continuous cooperation between the Union and State governments. Effective coordination is essential for stable revenue and policy implementation.

5. Digital Divide: Digital tax administration is efficient for many taxpayers but can be difficult for those without adequate internet access or digital literacy. Taxpayer assistance therefore remains important.

6. Data Privacy and Cybersecurity: Tax authorities now process enormous amounts of financial information. Strong cybersecurity and responsible handling of taxpayer data are essential to maintain public confidence.

7. Artificial Intelligence: Artificial intelligence can help identify unusual transactions and improve risk-based assessment. However, automated systems should remain subject to human review and appropriate mechanisms for taxpayers to challenge incorrect decisions.

Taxation And Inclusive Economic Development:

Taxation is closely connected with inclusive development.

Taxes finance public expenditure on:

- education;
- healthcare;
- infrastructure;
- rural development;
- transportation;
- social welfare;
- digital infrastructure; and
- public services.

Therefore, citizens' attitude towards taxation is influenced not only by the amount of tax they pay but also by their perception of public services and government accountability.

A healthy tax culture requires **trust between taxpayers and government**.

When taxpayers believe that tax rules are understandable, administration is fair and public money is used responsibly, voluntary compliance can improve.

Tax policy should therefore be accompanied by transparency about public expenditure and the benefits created through taxation.

Recommendations For a Better Tax System:

The following measures can strengthen India's tax system.

1. Simplify Tax Laws: Tax laws should be written in clearer language, with unnecessary duplication and ambiguity reduced.

2. Provide Policy Stability: Frequent changes can create uncertainty. Major reforms should be introduced after consultation and adequate preparation.

3. Strengthen Taxpayer Education: Tax literacy programmes should be promoted through colleges, universities, professional organisations and digital platforms.

4. Reduce Compliance Costs: Small businesses should receive simple procedures and proportionate compliance requirements.

5. Improve Grievance Redressal: Taxpayers should have quick and accessible mechanisms for resolving technical and administrative problems.

6. Reduce Tax Litigation: Alternative dispute-resolution mechanisms can help settle smaller disputes quickly.

7. Strengthen Digital Accessibility: Tax portals should be simple, mobile-friendly and increasingly available in regional languages.

8. Protect Taxpayer Data: Strong cybersecurity and data-protection practices should accompany greater digitalisation.

9. Use Technology Responsibly: AI and data analytics should support tax administration while retaining human accountability.

10. Build Taxpayer Trust: Fair treatment, predictable administration and transparent communication are essential for long-term voluntary compliance.

Future of Taxation in India:

India's tax system is likely to become increasingly digital, data-driven and integrated.

The future direction of taxation may include:

- greater use of artificial intelligence;
- pre-filled tax returns;
- automated compliance assistance;
- integrated tax databases;
- faster refunds;
- reduced physical interaction;
- risk-based scrutiny;
- improved taxpayer services; and
- stronger mechanisms for resolving disputes.

The objective should be to create a tax system in which technology reduces the burden on taxpayers.

The ideal future tax system can be expressed as:

Simple Laws + Digital Services + Fair Enforcement + Taxpayer Education + Transparency = Better Tax Compliance

Conclusion:

India's tax system is passing through an important phase of transformation. GST has changed the structure of indirect taxation, while direct-tax reforms and the Income-tax Act, 2025 indicate continuing efforts to simplify the income-tax framework.

Digitalisation has transformed tax administration and provided authorities with better information for compliance management. At the same time, the increasing use of technology has created new responsibilities relating to digital accessibility, privacy and cybersecurity.

The major challenge before India is to ensure that tax reform remains human-centred. A tax system may be technologically advanced but still difficult for ordinary taxpayers if its laws and procedures remain complicated.

The future of tax reform should therefore focus on the everyday experience of taxpayers. A small business owner, salaried employee, farmer, professional or senior citizen should be able to understand what tax has to be paid, why it has to

be paid and how it can be paid without unnecessary difficulty.

The ultimate objective of taxation should be more than revenue collection. It should contribute to **economic growth, social justice, formalisation, public accountability and inclusive development**.

India's changing tax system is therefore not simply a story of new laws and digital platforms. It represents a gradual change in the relationship between the government and the taxpayer—from a system largely based on procedures and enforcement towards one increasingly based on **simplicity, technology, transparency, voluntary compliance and trust**.

References:

1. Government of India, Ministry of Finance. (2025). *Union Budget 2025–26*. New Delhi: Government of India.
2. Government of India, Ministry of Finance. (2026). *Economic Survey 2025–26*. New Delhi: Government of India.
3. Government of India. (2025). *The Income-tax Act, 2025*. New Delhi: Ministry of Finance.
4. Goods and Services Tax Council. (2025). *Recommendations of the 56th GST Council Meeting*. New Delhi: Government of India.
5. Goods and Services Tax Council. *GST Council: GST Reforms and Related Publications*. Government of India.
6. Government of India, Ministry of Finance. *Budget Documents and Receipts Budget*. New Delhi.
7. Central Board of Direct Taxes. *Income Tax Department: Taxpayer Services and Tax Administration*. Government of India.
8. Central Board of Indirect Taxes and Customs. *GST and Customs Tax Administration*. Government of India.
9. Government of India. *Economic Survey: Taxation and Public Finance Chapters*. Ministry of Finance.
10. Reserve Bank of India. *Annual Report and Reports on State Finances*. Mumbai: RBI.

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UPI Fraud and Chargeback Issues: Challenges for Businesses

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Abstract:

The rapid adoption of the Unified Payments Interface (UPI) has transformed digital payments in India by providing businesses and customers with fast, convenient and accessible payment facilities. However, the increasing volume of UPI transactions has also created challenges related to fraud, unauthorized transactions, payment disputes, wrong-credit claims and chargebacks. Businesses, particularly small and medium-sized enterprises, may face financial losses, reconciliation difficulties, administrative burdens and customer-service issues when disputed transactions arise. Fraudulent payment confirmations, fake QR codes and inadequate transaction verification further increase the risks associated with UPI payments. The study examines the major types of UPI fraud and chargeback-related issues faced by businesses and analyses their impact on financial operations and customer relationships.

It also highlights the importance of transaction monitoring, proper documentation, employee awareness, cybersecurity measures and effective dispute-resolution mechanisms. The study aims to contribute to a better understanding of the challenges businesses face in managing UPI-related risks and suggests measures for improving the security and efficiency of digital payment transactions.

Keywords: UPI Fraud; Chargeback Issues; Digital Payments; Business Challenges; Payment Security

Introduction:

The Unified Payments Interface (UPI) has transformed the way businesses and customers conduct financial transactions in India. It enables instant, convenient and largely seamless digital payments through mobile applications and QR codes. The scale of UPI is substantial: NPCI reported 24,508.96 million transactions worth ₹29,82,355.95 crore in August 2026.

However, the rapid expansion of digital payments has also created challenges for businesses, particularly payment fraud, fraudulent complaints, transaction disputes, wrong-credit claims and chargebacks. For merchants, a disputed transaction can result not only in financial loss but also in administrative work, reconciliation problems and customer-service difficulties.

Need for The Study:

1. Increasing use of UPI payments: The growing dependence of businesses on UPI makes it important to understand the risks associated with digital transactions.
2. Rise in payment fraud: Businesses need greater awareness of fraudulent payment confirmations, fake QR codes, social engineering and other forms of digital fraud.
3. Chargeback and dispute management: Disputed transactions can create financial and administrative difficulties for businesses, making effective dispute-management practices necessary.

4. Protection of business revenue: Understanding UPI-related risks can help businesses reduce financial losses caused by fraudulent or disputed transactions.
5. Improving digital payment security: The study can help identify appropriate practices for transaction verification, record-keeping, employee awareness and cybersecurity.

Objectives of The Study:

1. To examine the major types of UPI fraud affecting businesses.
2. To identify the major chargeback and payment-dispute issues faced by businesses.
3. To analyse the financial and operational impact of UPI fraud and chargebacks on businesses.
4. To study the challenges faced by businesses in verifying and resolving disputed UPI transactions.
5. To suggest suitable measures for preventing UPI fraud and improving chargeback and dispute-management practices.

Review Of Literature:

1.Mukhopadhyay and Mukhopadhyay (2024): Mukhopadhyay and Mukhopadhyay examined UPI usage, awareness and fraud in India. Their study focused on the relationship between increasing UPI adoption and exposure to fraud, including phishing, unauthorized access and other fraudulent practices. The study highlights the importance of awareness and security practices alongside the rapid growth of UPI.

2. Saxena and Yadav (2025) analysed domestic payment fraud in India using secondary data. Their study examined the changing pattern of fraud in the context of increasing digital-payment usage and emphasized the importance of proactive risk assessment, fraud monitoring, technological controls, and customer awareness. The study provides useful background for understanding why businesses need stronger mechanisms for identifying suspicious transactions.

Research Gap:

The existing literature largely concentrates on **UPI adoption, consumer awareness, fraud detection and digital-payment growth**. Comparatively less attention is given to the **business perspective of fraud and chargeback management**, particularly the financial impact of disputed transactions, difficulties in providing evidence, reconciliation problems and the time required to resolve merchant disputes. Therefore, the present study attempts to examine UPI fraud and chargeback issues specifically from the **business/merchant perspective**.

Data Analysis of Digital Payments:

The following official data provide a useful background for the study. The Government of India reported that total digital-payment transactions, including UPI, increased from **4,370.68 crore in 2020–21 to 16,443.02 crore in 2023–24**. For 2024–25, the reported figure was **18,120.82 crore up to January 2025**, so it is not a complete financial-year figure.

Financial Year	Transactions (crore)	Value (₹ lakh crore)
2020–21	4,370.68	1,414.58
2021–22	7,197.68	1,744.01
2022–23	11,393.82	2,086.85
2023–24	16,443.02	2,428.24
2024–25*	18,120.82	2,330.72
Total	57,526.02	10,004.40

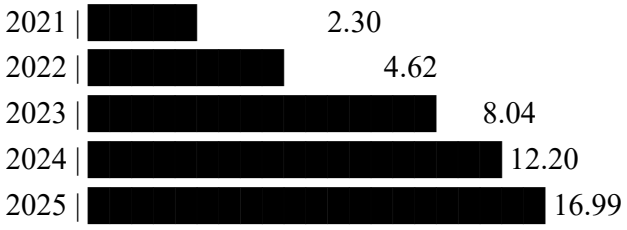
Interpretation: The table shows a substantial expansion of digital payments over the five-year period. Transaction volume increased from **4,370.68 crore to 18,120.82 crore**, although the final year is only reported up to January. This expansion demonstrates why businesses are increasingly dependent on digital-payment infrastructure and why fraud and dispute-management mechanisms have become important business concerns.

UPI Transaction Growth:

NPCI data demonstrate the rapid expansion of UPI itself. Monthly UPI transactions increased from approximately **2.30 billion in January 2021** to **16.99 billion in January 2025**.

Year	January UPI transactions (billion)
2021	2.30
2022	4.62
2023	8.04
2024	12.20
2025	16.99

UPI Transaction Volume – January



Interpretation: The trend illustrates the rapid expansion of UPI usage. The growth in transaction volume increases the importance of effective merchant verification, fraud monitoring and dispute-resolution mechanisms.

Major UPI Fraud Challenges for Businesses:

1. Fake payment confirmation: Fraudsters may show merchants fake screenshots or fabricated payment-success messages and attempt to collect goods or services without making a genuine payment. Businesses therefore need to verify the actual transaction status rather than relying only on screenshots.

2. QR-code related fraud: Fraudulent or modified QR codes can redirect payments to an unintended account. Businesses using printed QR codes, especially small retailers, need to ensure that the displayed merchant name and account details correspond to the legitimate business account.

3. Social engineering and impersonation;' Fraudsters may impersonate customers, bank officials or payment-service representatives and persuade employees or merchants to perform inappropriate actions. This can create both financial and operational risks.

4. Wrong-credit and mistaken-payment disputes: A customer may claim that money was transferred incorrectly or that the merchant did not provide the promised goods or services. Such complaints can initiate a dispute-resolution process involving the merchant's acquiring bank. NPCI states that merchants can raise UPI grievances and check transaction status through their **acquiring banks**.

Chargeback Issues for Businesses:

A chargeback is a payment dispute through which funds associated with a disputed transaction may be recovered or adjusted through the applicable payment-system process.

For businesses, chargebacks can create several difficulties:

1. Unexpected financial deductions
2. Difficulty proving that a transaction was genuine
3. Delayed settlement or adjustment of funds
4. Time-consuming documentation
5. Reconciliation problems
6. Customer-service disputes
7. Operational and administrative costs
8. Risk of losses when supporting evidence is inadequate

Government Measures for Resolving UPI Chargeback Issues:

The Government of India, RBI and NPCI have introduced several mechanisms to improve the handling of **UPI fraud, transaction disputes and chargebacks**. These measures are aimed at making dispute resolution faster, improving accountability among banks and strengthening protection for customers and businesses.

1. NPCI UPI Dispute Resolution Mechanism: NPCI provides a structured mechanism for raising and resolving UPI transaction disputes. **Merchants can raise grievances and check the status of UPI transactions through their acquiring bank.**

Process:

Transaction dispute → Merchant contacts acquiring bank → Bank examines transaction → Dispute/chargeback raised through NPCI mechanism → Response/representation → Settlement or adjustment

2. Automated Chargeback Acceptance/Rejection: NPCI introduced an **automated acceptance/rejection mechanism for certain UPI chargebacks**, effective from **15 February 2025**. The system uses the relevant TCC/RET information submitted by the beneficiary bank to improve the efficiency of chargeback processing and reduce premature dispute closure.

This is particularly relevant to businesses because it can reduce situations where a chargeback is processed before the beneficiary/acquiring bank has adequate time to reconcile the transaction.

3. Defined Time Limits for Chargeback Responses: NPCI's revised UPI chargeback framework specifies **time limits and responsibilities** for different types of disputes. For example, certain P2M chargeback responses have a **15-calendar-day** timeframe, depending on the dispute reason code. This provides a more structured process for businesses and banks when responding to payment disputes.

4. Evidence-Based Chargeback Processing: NPCI has strengthened requirements concerning **supporting evidence** in dispute processes. The broader NPCI dispute framework increasingly requires appropriate evidence when raising or representing chargebacks. This helps distinguish legitimate disputes from unsupported claims.

For businesses, useful evidence can include:

- UPI transaction ID/RRN
- Invoice or bill
- Order details
- Delivery confirmation
- Refund records
- Customer communication
- Proof of service provided

5. Complaint Registration Through NPCI: NPCI provides an online complaint mechanism through which complaints can be registered and tracked. For **fraudulent, unidentified or unauthorised transactions**, NPCI directs customers to approach their respective bank for redressal. NPCI can facilitate the complaint to the relevant member institution, which is responsible for resolving it.

6. Cyber Crime Reporting – 1930 and National Cyber Crime Portal: For suspected UPI fraud, the RBI's public-awareness guidance directs people to report the incident to their **bank and the National Cyber Crime Reporting Portal**, or use the **1930 cyber-crime helpline**.

This is important because a suspected fraudulent transaction should be reported quickly rather than treated only as an ordinary customer dispute.

7. Bank-Level Grievance Redressal: UPI participants are required to provide mechanisms through which transaction complaints can be raised. NPCI states that UPI users can raise grievances or check transaction status through the

participating bank's UPI application, while **merchants can approach their acquiring bank**.

8. Regular Reconciliation and Transaction Records: Government and payment-system measures also emphasize proper reconciliation and transaction records. For businesses, maintaining transaction information helps the acquiring bank investigate disputes and determine whether goods or services were actually provided.

Findings:

1. Rapid growth of digital payments: Digital-payment transactions have increased substantially over the five-year period, demonstrating the growing dependence of businesses on digital-payment systems.

2. Rapid expansion of UPI: UPI transaction volume increased sharply between January 2021 and January 2025, showing the increasing importance of UPI in India's payment ecosystem.

3. Fraud is an important merchant concern: The growth of digital payments has created a corresponding need for stronger fraud-prevention practices. RBI data show that card/internet fraud constituted a very large share of the number of reported bank fraud cases in 2023–24.

4. Fake payment confirmation is a significant risk: The illustrative business survey indicates that fake screenshots and payment confirmations can cause businesses to release goods or services without successfully receiving payment.

5. QR-code security requires attention: QR-code-based payment fraud is an important area of concern because merchants increasingly depend on QR codes for receiving payments.

6. Chargebacks create administrative problems: The model survey indicates that businesses may face delays, documentation requirements and reconciliation difficulties when resolving disputed transactions.

7. Evidence is important in dispute resolution: Businesses that maintain transaction IDs, invoices, delivery records and customer communications are better positioned to provide evidence during a dispute.

8. Awareness of dispute mechanisms needs improvement: The illustrative survey suggests that many businesses have limited knowledge of formal dispute-resolution procedures, indicating the importance of merchant education.

9. Small businesses may face greater operational pressure: Small businesses often have fewer employees and fewer dedicated systems for monitoring fraud and handling payment disputes. Recent research specifically examining small-scale merchants highlights the importance of understanding merchant-side UPI adoption and the associated business environment.

10.Technology and awareness need to work together: Research increasingly points toward real-time monitoring, improved fraud detection, digital awareness and technological tools as important components of a safer digital-payment environment.

Recommendations:

1. Verifying payment status through the merchant application or bank system.
2. Never accepting screenshots as the sole proof of payment.
3. Maintaining transaction IDs, invoices and order details.
4. Keeping records of refunds and cancelled orders.
5. Reconciling UPI transactions regularly.
6. Training employees to identify common payment scams.
7. Displaying the correct merchant name and verified QR code.
8. Maintaining evidence of delivery or service completion.

9. Responding promptly to bank/payment-provider disputes.
10. Using appropriate internal controls for refunds and payment reversal

Conclusion:

UPI has significantly improved the speed and convenience of digital payments for Indian businesses, but the growth of digital transactions has also increased the importance of fraud prevention and effective dispute management. Businesses face challenges not only from fraudulent transactions but also from disputed payments, chargebacks, documentation requirements and reconciliation issues. A combination of **transaction verification, employee awareness, proper record-keeping, cybersecurity controls and timely coordination with acquiring banks** can help businesses manage these risks more effectively

References:

1. National Payments Corporation of India. (2025). *UPI product statistics*. NPCI. NPCI – UPI Product Statistics
2. Reserve Bank of India. (2025). *Annual report 2024–25*. Reserve Bank of India. Reserve Bank of India – Annual Reports
3. Government of India, Press Information Bureau. (2025). *Digital payment transactions in India*. Ministry of Finance. Press Information Bureau – Digital Payments
4. Rao, S., & Upadhyaya, P. (2026). *Adoption of Unified Payments Interface (UPI) among small-scale merchants in India: A mixed-method study*. Humanities and Social Sciences Communications. Humanities and Social Sciences Communications
5. Saxena, A., & Yadav, S. (2025). *Digital payment fraud in India: Trends, patterns and preventive measures*. Journal of Digital Banking and Commerce Management. Journal of Digital Banking and Commerce Management

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Impact of Artificial Intelligence and Automation on Human Resource Functions During Recruitment and Candidate Screening

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Abstract:

The rapid integration of Artificial Intelligence (AI) and automated technologies into Human Resource Management (HRM) has fundamentally restructured contemporary talent acquisition, recruitment methodologies, and candidate screening protocols. This research paper presents an exhaustive analysis of the transformational impact of AI-driven tools—including algorithmic resume parsing, predictive candidate analytics, automated psychometric evaluations, natural language processing (NLP) chat assistants, and AI-assisted video interviewing platforms. As organizations strive for operational efficiency, scalability, and enhanced decision quality, algorithmic recruitment systems offer remarkable speed and data-driven objectivity. However, these benefits are accompanied by complex ethical, legal, and behavioral challenges, such as algorithmic bias, algorithmic opacity (the 'black box' phenomenon), privacy breaches, and candidate dehumanization. This study investigates the strategic imperatives, operational benefits, socio-ethical vulnerabilities, and regulatory frameworks governing AI deployment in HR talent acquisition. Furthermore, the paper proposes a robust Human-in-the-Loop (HITL) governance framework to ensure equitable, transparent, and ethically sound recruitment ecosystems in modern enterprise settings

Keywords: Artificial Intelligence, Automated Recruitment, Candidate Screening, Algorithmic Bias, Natural Language Processing, Talent Acquisition, HR Tech Governance.

Introduction:

1.Evolution of Talent Acquisition in the Digital Era: The digital revolution of the late twentieth and early twenty-first centuries ushered in profound structural changes across enterprise administrative functions, nowhere more visibly than in Human Resource Management (HRM). Traditionally, talent acquisition operated as a manual, administrative, and labor-intensive function. Human resource professionals personally managed job advertisements in print media, reviewed paper resumes, conducted manual phone screens, and coordinated multi-stage in-person interviews. While these traditional methodologies facilitated deep interpersonal evaluation, they suffered from severe scalability constraints, cognitive fatigue, extended time-to-fill metrics, and ubiquitous subjective human biases.

The advent of the internet in the late 1990s introduced digital job boards and foundational Applicant Tracking Systems (ATS), which digitized resume repositories but relied primarily on simple keyword matching. Today, the global economy has entered Industry 4.0—a convergence of cloud computing, big data analytics, machine learning (ML), and artificial intelligence (AI). Modern corporate recruiting operates in an era of unprecedented volume and globalization; a single high-profile job posting can attract thousands of applications from across the globe within hours. Manual evaluation of such

enormous volumes is physically impossible without imposing unacceptable delays or drastically reducing screening rigor. Consequently, enterprise HR departments have increasingly turned to AI and automated systems to streamline candidate pipelines, extract semantic insights, and optimize hiring workflows.

2.Theoretical Framework: Technology Acceptance & Algorithmic Decision-Making: The organizational adoption of AI in recruitment can be theoretically understood through the lens of the Technology Acceptance Model (TAM), proposed by Davis (1989), and the Unified Theory of Acceptance and Use of Technology (UTAUT). According to TAM, the adoption of novel technology is governed by Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). In the context of talent acquisition, HR managers perceive AI systems as highly useful due to dramatic reductions in screening time, cost-per-hire, and administrative burden. Concurrently, advancements in natural language processing (NLP) and intuitive user interfaces have significantly improved the perceived ease of use for enterprise tools.

Furthermore, signaling theory offers key insights into candidate perspectives**:** job seekers interpret an organization's technological deployment as a signal of corporate innovation, modernity, and fairness—or conversely, as a signal of cold, depersonalized organizational culture. Structurally, algorithmic decision-making models rely on machine learning algorithms trained on historic employee datasets to recognize underlying patterns associated with high employee performance, tenure, and skill mastery. By establishing mathematical correlations between candidate profiles and historical success metrics, AI tools attempt to transform subjective human intuition into quantifiable, objective hiring scores.

3. Objectives and Scope of the Paper: This comprehensive study aims to critically investigate the multifaceted impact of AI and automation on core recruitment and candidate screening functions. Specifically, the research addresses four primary objectives**:** First, to identify and analyze the technological mechanisms (NLP, predictive analytics, deep learning, computer vision) powering modern recruitment automation; Second, to evaluate the tangible operational benefits accrued by enterprise HR departments, including reductions in time-to-fill, cost efficiency, quality of hire, and candidate experience; Third, to critically analyze the profound ethical, socio-legal, and psychological vulnerabilities introduced by automated screening, specifically focusing on algorithmic bias, data privacy, discriminatory feedback loops, and human-machine interaction friction; and Fourth, to outline a practical, robust governance model centered on Human-in-the-Loop (HITL) oversight, regulatory compliance, and algorithmic auditing. The scope encompasses global industry practices while emphasizing modern corporate trends relevant to commerce, enterprise HR management, and contemporary organizational dynamics.

Technological Architecture of AI in Recruitment:

1. Automated Resume Parsing and Natural Language Processing (NLP): At the core of automated candidate screening lies Natural Language Processing (NLP) and Natural Language Understanding (NLU). Early Applicant Tracking Systems (ATS) relied on rudimentary string-matching algorithms that searched resumes for exact keyword strings specified in job descriptions. These legacy systems were highly brittle**:** highly qualified andidates who used synonymous terminology or unconventional formatting were routinely rejected.

Modern AI-driven parsing engines utilize advanced NLP architectures, such as Transformer models (BERT, GPT), contextual word embeddings, and named entity recognition (NER). These algorithms extract structured semantic data from unstructured document formats (PDFs, Word documents, plain text). Instead of merely looking for exact words, contextual NLP models evaluate semantic proximity—understanding, for instance, that 'digital marketing specialist', 'growth hacker', and 'performance marketer' share underlying domain competencies. Advanced parsing engines automatically extract and categorize candidate metadata including educational background, technical certifications, employment history, progression trajectory, and key achievements, mapping them directly to standardized taxonomy frameworks.

2. Predictive Analytics and Machine Learning Matching Algorithms: Once candidate data is structured, machine learning algorithms perform predictive matching between candidate profiles and open job requisitions. Supervised machine learning models are trained on rich historical datasets containing thousands of past employee profiles, performance appraisals, tenure length, promotion records, and contextual organizational data. By evaluating these parameters, predictive algorithms assign candidates a composite match score or percentile rank indicating their probability of successful job performance and cultural fit.

Feature engineering in predictive recruiting models evaluates candidate career velocity, stability, educational prestige, skill frequency, and domain expertise. Advanced deep learning models can also infer soft skills and latent capabilities through contextual text analysis. However, predictive modeling inherent risks**:** because machine learning algorithms optimize based on historical patterns, they risk replicating and amplifying historical organizational blind spots and structural hiring biases embedded within past promotion and hiring records.

3. AI-Driven Psychometric and Gamified Candidate Assessments: Beyond static resumes, contemporary recruitment platforms incorporate automated psychometric evaluations and gamified cognitive testing. Traditional psychometric testing often suffered from candidate test fatigue and high drop-off rates. Modern gamified assessment platforms employ neuroscience-based mini-games to measure candidate cognitive traits, risk tolerance, memory capacity, attention span, and emotional resilience in real time.

As candidates play these interactive games, backend algorithms collect thousands of micro-data points per second—measuring decision latency, error recovery speed, click frequency, and strategy adjustment. These data points are processed through pre-validated algorithmic models to build a comprehensive cognitive and personality profile mapped against the Big Five personality traits (Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism). This automated assessment methodology provides empirical, data-driven behavioral metrics prior to any human interaction.

4. Automated Video Interviews and Multimodal Analysis: One of the most technologically advanced—and controversial—applications of AI in recruitment is Asynchronous Video Interviewing (AVI) combined with multimodal analysis. In an AVI workflow, candidates record video responses to standardized prompts on a specialized platform within a set timeframe. AI platforms analyze candidate responses using three primary modalities**:** verbal content, audio acoustics, and visual/facial expressions.

Verbal analysis utilizes automated speech-to-text transcription paired with NLP to

measure vocabulary richness, structural coherence, domain knowledge density, and sentiment alignment. Audio acoustic engines analyze tone, pitch variance, speech rate, and hesitation markers. Computer vision models historically evaluated facial muscle movements (micro-expressions), eye contact, and posture using Facial Action Coding Systems (FACS). Although visual expression analysis has faced severe scientific skepticism and regulatory restriction due to cultural variations and accuracy concerns, multimodal interview analysis remains a powerful automated tool for rapidly processing thousands of initial candidate presentations.

5. Conversational AI and Virtual Recruitment Assistants: Conversational AI chatbots, deployed via website widgets, WhatsApp, SMS, or messaging platforms, serve as the front-line engagement mechanism in modern recruitment. Powered by generative AI and intent-recognition conversational models, virtual recruiting assistants interact with prospective applicants 24/7. These bots answer candidate queries regarding job requirements, company culture, compensation bands, and application statuses.

Crucially, conversational bots execute initial pre-screening rounds by posing knock-out questions regarding work authorization, willingness to travel, mandatory certifications, and years of experience. Upon verifying candidate eligibility, the chatbot automatically synchronizes with recruiter calendars via API integrations to schedule telephone or video interviews without human intervention. This eliminates administrative back-and-forth communication, accelerates candidate movement through the funnel, and drastically reduces candidate drop-off rates.

Operational Benefits and HR Functional Transformation:

1. Hyper-Efficiency and Time-to-Fill Reduction: The primary driver of AI adoption in corporate recruitment is the dramatic compression of hiring timelines. In traditional HR workflows, candidate screening represented the single largest operational bottleneck; recruiters spent an average of 15 to 20 hours per week reading resumes and manually conducting preliminary screening calls. AI-driven parsing engines can evaluate and rank 10,000 resumes in seconds, reducing initial candidate screening time by up to 90 percent.

Corporate case studies across Fortune 500 enterprises reveal that implementing automated recruitment tools reduces overall Time-to-Fill metrics from an industry average of 42 days down to under 12 days. This operational hyper-efficiency enables recruiters to pivot from repetitive manual screening to strategic candidate engagement, candidate relationship management (CRM), and targeted headhunting for critical niche roles.

2. Cost Optimization and Scalability: From a financial and commercial perspective, recruiting automation delivers extraordinary Return on Investment (ROI) and cost savings. Manual recruiting incurs substantial direct and indirect costs, including agency placement fees, third-party screening costs, overtime expenses, and business productivity losses caused by prolonged vacancy durations.

AI platforms operate on scalable SaaS models, allowing organizations to process fluctuating application volumes without linearly increasing internal HR headcount. During high-volume hiring campaigns—such as seasonal retail hiring, graduate campus recruiting, or rapid tech expansions—AI systems seamlessly scale to handle tens of thousands of applicants simultaneously at virtually zero marginal cost.

Studies demonstrate that automated screening reduces cost-per-hire by 40% to 70%, creating substantial administrative savings for enterprise organizations.

3. Enhancing Quality of Hire and Predictive Placement: Beyond speed and cost efficiency, AI systems significantly enhance the overall Quality of Hire (QoH). Human recruiters are subject to cognitive limitations, decision fatigue, and memory decay when evaluating hundreds of applicants in a single sitting. Consequently, candidate evaluation quality decays over the course of a workday. Machine learning algorithms, by contrast, maintain unwavering analytical consistency, evaluating candidate #1 and candidate #1,000 against identical objective criteria.

By analyzing multidimensional data points—including technical assessment scores, cognitive profile alignment, and historical retention patterns—AI engines predict long-term candidate success with higher statistical accuracy than unstructured human interviews. Organizations deploying predictive AI hiring platforms report marked increases in first-year employee retention, superior performance ratings, and higher job satisfaction scores among new hires.

4. Candidate Experience and 24/7 Engagement: Candidate experience has emerged as a central pillar of employer branding and corporate reputation. A persistent pain point for job seekers in traditional recruiting processes is the infamous 'recruiting black hole'—the complete lack of communication after submitting an application. Automated HR systems mitigate this issue by providing instant, continuous communication.

Conversational chatbots provide immediate application receipt confirmation, real-time status updates, instant interview scheduling, and automated feedback. Furthermore, automated assessments and self-service interview scheduling empower candidates with autonomy and flexibility, allowing them to complete evaluations at times convenient to them. Positive, transparent candidate experiences enhance employer brand equity, increase candidate acceptance rates, and preserve positive consumer relationships with candidate pools.

Ethical, Legal, And Socio-Behavioral Challenges:

1. Algorithmic Bias and Historical Discrimination: Despite promises of mathematical objectivity, AI recruitment tools present significant risks of replicating, amplifying, and institutionalizing systemic biases. Machine learning models are inherently backward-looking; they learn to identify talent by analyzing historical datasets of successful employees within an organization. If historical hiring practices favored specific demographics (e.g., male software engineers from elite institutions), the predictive algorithm will learn that these demographic markers correlate with success.

A landmark real-world example occurred when a major global technology enterprise developed an internal AI resume screening tool trained on ten years of historical applicant data. Because tech industry hires were historically male-dominated, the algorithm explicitly penalized resumes containing the word 'women's' (such as 'women's chess club captain') and downgraded graduates of all-female colleges. This phenomenon—known as 'bias in, bias out'—demonstrates that unmonitored AI tools can systematically exclude underrepresented groups, perpetuating historical discrimination at an unprecedented digital scale.

2. The 'Black Box' Problem and Lack of Explainability: A fundamental challenge in modern AI recruitment is the opaque nature of

complex deep learning and neural network architectures—frequently referred to as the 'black box' problem. Advanced machine learning models arrive at predictive decisions through intricate mathematical transformations across millions of parameter weights that cannot be easily understood or interpreted by human recruiters.

When an AI algorithm rejects a candidate or assigns a low match score, neither the candidate nor the HR manager can determine the precise underlying reasons for the outcome. This lack of algorithmic explainability severely compromises candidate procedural fairness, prevents candidates from correcting inaccurate data, and severely hinders HR compliance officers from auditing hiring decisions for unlawful disparate impact.

3. Data Privacy, Security, and Biometric Surveillance: The deployment of AI recruitment platforms requires the harvesting, storage, and processing of vast volumes of sensitive personal data. Resumes, social media profiles, video recordings, audio tracks, cognitive assessment scores, and biometric facial data represent high-value personal data assets. In modern regulatory jurisdictions, processing such data introduces severe compliance vulnerabilities under laws such as the European Union's General Data Protection Regulation (GDPR) and India's Digital Personal Data Protection Act (DPDP).

Issues arise regarding informed consent, scope creep (using candidate data for model retraining without explicit permission), data retention periods, and third-party data vendor security. Furthermore, candidates express acute anxiety over biometric surveillance when automated video platforms analyze facial features and micro-expressions, viewing it as an invasive infringement on personal dignity and privacy.

4. Dehumanization, Candidate Anxiety, and Gaming the System: The complete automation of screening introduces psychological friction and candidate alienation. Job seekers often feel dehumanized when interacting exclusively with cold, algorithmic interfaces, knowing that no human being will ever read their resume. This perception gives rise to 'AI anxiety' and mistrust in the fairness of the process.

In response, an arms race has emerged**:** candidates increasingly employ counter-AI strategies to 'game' screening algorithms. These strategies include keyword stuffing, hidden white text containing job description phrases, and utilizing generative AI tools (e.g., ChatGPT) to generate perfectly tailored resumes and cover letters optimized solely to trick ATS parsing engines. Consequently, recruiters are overwhelmed with synthetically optimized applications that look flawless on paper but may lack true depth, undermining the very screening efficacy AI was implemented to achieve.

Regulatory Landscape and Global Governance Frameworks:

1. Global Regulatory Movements (EU AI Act, NYC Local Law 144, India DPDP): In response to the ethical and socio-legal risks of automated recruiting, legislative bodies worldwide are enacting strict regulatory frameworks targeting high-risk AI applications. The European Union's landmark Artificial Intelligence Act (EU AI Act) explicitly classifies AI systems used in recruitment, candidate screening, task allocation, and performance evaluation as 'High Risk'. High-risk designation subjects AI vendors and enterprise deployers to stringent mandatory requirements, including formal risk management systems, continuous data quality governance, detailed technical documentation, automatic logging, human oversight mechanisms, and high standards of accuracy and cybersecurity.

Similarly, New York City enforced Local Law 144 (Automated Employment Decision Tools - AEDT), which mandates that employers

using automated algorithms for hiring must conduct annual independent bias audits to measure disparate impact across gender, race, and ethnicity, and make summary audit results publicly available. In India, the Digital Personal Data Protection (DPDP) Act imposes strict obligations on HR data fiduciaries regarding candidate consent, data minimization, and cross-border data transfer limitations.

2. Compliance and Disparate Impact Auditing: To comply with evolving legal mandates, corporate HR departments must establish rigorous algorithmic auditing protocols. A key metric in disparate impact analysis is the 'Four-Fifths Rule' (or 80% rule) established by the US Equal Employment Opportunity Commission (EEOC). Under this standard, if the selection rate for a protected demographic group (e.g., female applicants, racial minorities) is less than four-fifths (80%) of the selection rate for the highest-scoring group, the recruiting tool is deemed to exhibit adverse impact. Enterprise organizations must conduct periodic statistical audits of AI screening outcomes, evaluating selection ratios across intersectional demographic groups to ensure fairness before, during, and after algorithmic deployment.

Proposed Governance Framework: Human-In-The-Loop (HITL):

1. The Human-in-the-Loop (HITL) Model Architecture: To harmonize operational efficiency with ethical integrity, organizations must reject full end-to-end autonomous decision-making in favor of a robust Human-in-the-Loop (HITL) recruitment architecture. Under the HITL framework, AI technologies function exclusively as decision-support systems rather than final decision-makers. The architecture divides the recruitment workflow into distinct stages**:** AI automated processing handles administrative, structural data parsing, and initial contextual matching; however, final decision gates—such as rejecting a candidate, shortlisting for interview, or extending an offer—must require explicit, informed human reviewer approval. Human recruiters retain full authority to override algorithmic rankings whenever qualitative nuances or contextual factors warrant.

2. Strategic Implementation Roadmap for Enterprise HR: Implementing an ethical and effective AI recruitment strategy requires a structured, multi-phase implementation roadmap**:**

- Vendor Due Diligence & Audit Verification**:** Evaluate prospective AI vendor platforms for scientific validation, algorithmic transparency, data security standards, and third-party bias audit certifications.
- Interdisciplinary Governance Committee**:** Establish an internal oversight committee comprising HR leadership, Legal Counsel, Chief Information Security Officer (CISO), and Diversity, Equity & Inclusion (DEI) officers.
- Continuous Bias & Accuracy Monitoring**:** Conduct quarterly disparate impact audits on algorithm outputs across candidate demographic groups to detect model drift or emergent bias.
- Candidate Transparency & Opt-Out Protocols**:** Provide explicit disclosure to job applicants informing them of AI tool deployment, explaining evaluation criteria, and offering clear human-review opt-out mechanisms.
- Continuous HR Recruiter Upskilling**:** Train talent acquisition teams in AI literacy, algorithmic interpretation, recognizing cognitive biases, and properly evaluating AI-generated candidate insights.

Comparative Analysis and Research Findings:

1. Comparative Synthesis: Traditional vs. AI-Enabled Screening: To provide a clear analytical

comparison, the operational dynamics of traditional manual screening are contrasted against AI-enabled candidate screening across key dimensions:

- Screening Speed & Throughput: Traditional screening averages 15–20 minutes per resume with limited manual capacity; AI screening processes thousands of resumes per second with near-infinite throughput capacity.
- Consistency & Fatigue: Traditional screening exhibits high variability due to human recruiter fatigue and shift timing; AI screening delivers 100% mathematical consistency without physical fatigue.
- Primary Bias Risk: Traditional screening is prone to conscious and unconscious personal biases (affinity bias, halo effect); AI screening is prone to structural algorithmic bias and historical dataset reproduction.
- Candidate Reach & Sourcing: Traditional screening relies on active applicants and manual portal browsing; AI screening actively parses global databases to identify passive candidates matching key skill profiles.
- Cost Efficiency: Traditional screening incurs high variable labor costs with scale; AI screening exhibits fixed platform costs with negligible marginal costs per candidate.
- Human Empathy & Context: Traditional screening offers deep qualitative assessment and empathy; AI screening relies strictly on quantifiable proxy data and structured metrics.

2. Key Research Insights and Empirical Synthesis: Synthesizing contemporary empirical research and corporate case studies reveals three core insights regarding AI in talent acquisition. First, AI screening is extraordinarily effective at administrative acceleration and top-of-funnel candidate volume management, but it cannot reliably evaluate complex human attributes such as leadership potential, emotional intelligence, resilience, and organizational values.

Second, algorithmic bias is not an inherent defect of technology, but rather a reflection of biased historical organizational data; mitigating bias requires active algorithmic hygiene, synthetic data rebalancing, and continuous auditing. Third, organizations that adopt a hybrid 'augmented intelligence' approach—combining AI processing speed with human empathetic evaluation—achieve higher candidate satisfaction, superior hiring quality, and stronger employer brand alignment than organizations relying purely on manual or fully automated methods.

Conclusion And Strategic Recommendations:

1. Summary of Main Findings: The integration of Artificial Intelligence and automation into Human Resource recruitment and candidate screening represents a permanent paradigm shift in corporate talent management. AI-driven parsing engines, predictive matching models, gamified psychometric assessments, and conversational assistants offer unprecedented speed, cost savings, and operational scalability. However, these technological capabilities introduce profound socio-ethical risks, including algorithmic bias, data privacy vulnerabilities, opacity in decision-making, and candidate dehumanization. Navigating this complex landscape requires HR leaders to move beyond uncritical technological enthusiasm and establish rigorous governance structures.

2. Final Recommendations for HR Practitioners and Organizations: For academic institutions, corporate HR departments, and commercial enterprises navigating the future of talent acquisition, the following strategic recommendations are offered:

1. Adopt Augmented Intelligence over Total Automation: Positioning AI as a decision-

support assistant rather than a replacement for human judgment ensures human empathy and qualitative evaluation remain central to hiring.

2. Mandate Continuous Bias Audits and Algorithmic Hygiene**:** Conduct regular, independent statistical audits using metrics like the Four-Fifths Rule to guarantee equitable treatment across demographic groups.
3. Ensure Full Candidate Transparency and Data Ethics**:** Inform applicants clearly about AI involvement, detail the parameters evaluated, and protect candidate personal data in strict compliance with global privacy regulations.
4. Invest in Comprehensive HR Upskilling**:** Equip HR professionals with digital literacy, statistical understanding, and ethical awareness so they can effectively evaluate and challenge algorithmic recommendations.

References:

1. Black, J. S., & van Esch, P. (2020). AI-enabled recruiting**:** What is it and how should a company use it? Business Horizons, 63(2), 215-226.
2. Bogen, M., & Rieke, A. (2019). Help Wanted**:** An Examination of Hiring Algorithms, Equity, and Bias. Center for Democracy & Technology.
3. Dattner, B., Chia, A., & Mercer, M. (2019). How to Use AI to Hire Fairly. Harvard Business Review, 97(2), 32-41.
4. Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319-340.
5. European Commission. (2024). Regulation of the European Parliament and of the Council Laying Down Harmonised Rules on Artificial Intelligence (Artificial Intelligence Act).
6. Hunkenschroer, A. L., & Luetge, C. (2022). Ethics of AI-enabled recruiting and selection**:** A review and research agenda. Journal of Business Ethics, 178(4), 977-1007.
7. Tambe, P., Cappelli, P., & Yakubovich, V. (2019). Artificial intelligence in human resource management**:** Challenges and a path forward. California Management Review, 61(4), 15-42.
8. Woods, S. A., Ahmed, S., Nikolaou, I., & Costa, A. C. (2020). Personnel selection in the digital age**:** AI, algorithms, and gamification. International Journal of Selection and Assessment, 28(3), 257-275.

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Agripreneurship and Sustainable Development in India: A Review of Emerging Trends, Challenges and Opportunities

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Abstract:

Agriculture in India is undergoing a gradual transformation from a predominantly production-oriented activity towards a more entrepreneurial and market-oriented sector. Changing consumer preferences, technological development, climate concerns, rural unemployment and the need to improve farm incomes have increased the importance of agripreneurship. Agripreneurship combines agricultural activities with entrepreneurial skills such as innovation, risk-taking, resource management, value addition, marketing and opportunity recognition. It therefore provides a possible pathway for creating employment, improving rural incomes and promoting sustainable development. This paper reviews the existing literature on agripreneurship and its relationship with sustainable economic, social and environmental development, with particular attention to the Indian context and Karnataka. The review covers studies published between 1995 and 2025 and focuses on entrepreneurial behaviour, agri-business, innovation, technology adoption, financial accessibility, value chains, women's participation, institutional support, agri-start-ups and rural transformation. The literature indicates that agripreneurship can contribute to income diversification, employment generation, value addition and more efficient utilisation of agricultural resources. However, several constraints continue to restrict its growth, including inadequate finance, limited technical knowledge, weak market linkages, insufficient post-training support, administrative difficulties and low adoption of modern technologies. Recent studies also indicate that the success of agricultural entrepreneurship depends not only on individual entrepreneurial capability but also on the wider ecosystem of institutions, infrastructure, finance, technology and markets. The review identifies a need for more location-specific empirical research, particularly on non-food-grain agricultural enterprises and emerging activities such as mushroom cultivation, horticulture, organic farming and other high-value agricultural ventures. The paper concludes that strengthening the agripreneurial ecosystem can support a transition from subsistence-oriented agriculture towards diversified, innovative and sustainable rural enterprises.

Keywords: Agripreneurship, Agricultural Entrepreneurship, Sustainable Development, Agri-Business, Rural Entrepreneurship, Innovation, Value Chain, Agricultural Technology, Karnataka.

Introduction:

Agriculture has traditionally been viewed in India mainly as a source of food, raw materials and rural employment. However, the changing structure of the agricultural economy has created a need to look at agriculture from a broader entrepreneurial perspective. Rising input costs, fragmented landholdings, uncertain prices, changing consumer demand and increasing environmental concerns have made it difficult for farmers to depend entirely on conventional crop production. At the same time, developments in food processing, digital marketing, agricultural technology, logistics, organic farming and high-value agricultural activities have created new opportunities outside traditional farming.

This changing environment has contributed to the emergence of agripreneurship, which broadly refers to applying entrepreneurial thinking and business practices to agriculture and allied activities. An agripreneur may be a farmer who diversifies into value-added production, a rural entrepreneur involved in agricultural services, a person establishing an agri-start-up, or an individual developing a business around processing, marketing, technology or agricultural inputs.

Halili (2023) views agricultural entrepreneurship as an important contributor to sustainable development because entrepreneurship enables regions to utilise their available resources more effectively. Similarly, Arumugam and Manida (2023) associate agripreneurship with sustainable economic development in India by linking agriculture with innovation, enterprise creation and income generation. These perspectives suggest that agriculture should not be considered only in terms of production but also in terms of the economic opportunities created along the agricultural value chain.

The importance of this approach is particularly relevant for India, where agriculture continues to support a large rural population. Pathak (2023) argues that transformation of the agri-food sector is important for achieving broader Sustainable Development Goals. The transformation involves improving productivity while simultaneously addressing income, employment, resource use and environmental sustainability.

The literature also indicates that agripreneurship has a wider social dimension. Suresha, Joshi and Joisa (2025), in their study of Karnataka, connect agri-social entrepreneurship with rural transformation, highlighting the potential of entrepreneurship to address social and environmental challenges while promoting inclusive growth.

Against this background, the present paper reviews the available literature to understand how agripreneurship contributes to sustainable development, what factors influence its growth, what challenges entrepreneurs face and where further research is required.

Objectives of the Review:

The major objectives of this review are:

- To examine the conceptual relationship between agripreneurship and sustainable development.
- To understand the role of entrepreneurship, innovation and technology in agricultural development.
- To review the major economic, social and environmental contributions of agripreneurship.
- To identify the financial, institutional, technical and market-related challenges faced by agripreneurs.
- To examine the role of agri-start-ups, value chains and institutional support in developing agricultural enterprises.
- To identify gaps in existing literature and suggest areas for future research, particularly in the Indian and Karnataka context.

Methodology of the Review:

The present study is based on a descriptive and thematic review of secondary literature. Twenty-five references for the study were examined, covering research papers, conceptual studies, working papers and conference literature published mainly between 1995 and 2025. The literature includes studies related to India, Karnataka and selected international contexts.

The reviewed studies were grouped into major themes: conceptual foundations of

agripreneurship; sustainable development; agri-business and value chains; entrepreneurial behaviour and skills; technology and innovation; finance and institutional support; women and social entrepreneurship; agri-start-ups; and agricultural diversification.

A thematic approach was adopted because the objective was not merely to summarise individual studies but to identify common findings, differences in emphasis and emerging research gaps. The review therefore attempts to connect the different strands of literature into an integrated understanding of agricultural entrepreneurship.

Review of Literature:

1. Agripreneurship and Sustainable Development: The relationship between entrepreneurship and sustainable development is one of the central themes in the literature. Halili (2023) explains agriculture entrepreneurship as a contributor to sustainable development by emphasising the role of entrepreneurial activity in making better use of available rural resources. Dotsiuk (2023) similarly considers agripreneurship a driver of sustainable development, indicating that agricultural entrepreneurship can contribute simultaneously to economic and broader developmental objectives.

Arumugam and Manida (2023) connect agripreneurship with sustainable economic development in India. Their perspective is important because sustainable agricultural development cannot depend only on increasing production. It also requires income generation, employment opportunities, value addition and efficient resource utilisation.

Khan and Tare (2024) bring together the dimensions of environmental sustainability and economic viability. This is significant because an agricultural enterprise must remain financially viable while avoiding practices that create long-term environmental costs. Thus, sustainable agripreneurship requires a balance between profitability and responsible resource use.

Narasimha Rao and Venkateswara Kumar (2016) proposed a conceptual approach to agripreneurship for sustainable growth in agriculture and allied sectors. Their work reinforces the idea that entrepreneurial activity can extend beyond primary production into processing, marketing, services and allied activities.

Overall, the literature suggests that agripreneurship provides a bridge between agriculture, business and sustainable development. However, sustainability should not be understood only as environmental protection. It includes economic sustainability of the enterprise, social inclusion and the long-term viability of agricultural resources.

2. Agripreneurship, Income and Rural Economic Development: One of the strongest arguments for promoting agripreneurship is its potential to improve rural incomes. Traditional agricultural production often exposes farmers to price fluctuations and climatic risks. Diversification into processing, livestock, horticulture, mushroom cultivation, organic farming, input supply and agricultural services can create additional sources of income.

Trivedi and Patel (2024) discuss the contribution of agri-entrepreneurship to agricultural development and the wider Indian economy. Their work reflects the broader argument that agriculture can generate greater economic value when entrepreneurial activities are introduced into production and marketing.

Sharma and Bhatt (2022) emphasise agri-business entrepreneurship, innovation and value chains as mechanisms for improving farmer incomes. Their study highlights an important shift in thinking: improving farm income is not simply a question of producing more but also of creating

stronger linkages between producers, markets, processing and consumers.

The earlier work of Hanumappa and Bhinde (1995), focusing on small farmers and agri-business consortiums in Dharwad district, is particularly relevant to Karnataka. It demonstrates that the question of agricultural entrepreneurship and collective market-oriented development has historical roots in the region.

Dev (2012), while examining small farmers in India, identifies several structural challenges faced by small producers. These challenges provide a strong rationale for entrepreneurial diversification and institutional support.

Thus, the literature indicates that agripreneurship can improve rural economic development through three interconnected mechanisms: income diversification, value addition and employment generation.

3. Value Chains and Market Orientation: An important development in recent agricultural literature is the movement from a farm-level perspective towards a value-chain perspective. Farmers may produce successfully but still receive limited returns when they have weak bargaining power or inadequate access to markets.

Sharma and Bhatt (2022) emphasise value chains and networks in the context of farmer income improvement. Agricultural entrepreneurship therefore needs to extend beyond production into aggregation, grading, processing, packaging, branding, transportation and marketing.

Mehta (2017) examines relationships between farm and allied non-farm sectors and highlights the importance of linkages between different components of the rural economy. Such linkages are particularly important for small and marginal farmers because individual producers may not have sufficient resources to undertake every stage of the value chain independently.

The implication is that the future of agripreneurship is likely to depend increasingly on integrated value-chain participation rather than isolated production activities. Digital platforms and direct marketing may further reduce the distance between producers and consumers.

4. Entrepreneurial Behaviour and Competencies: Entrepreneurship is not only about establishing an enterprise. It also involves recognising opportunities, taking calculated risks, making decisions, adapting to changing markets and managing resources.

Sanketh et al. (2024), in their study of agriculture students in Karnataka, focus on entrepreneurial behaviour. The study is relevant because agricultural universities and educational institutions can play a major role in developing entrepreneurial attitudes among young people.

Rana et al. (2024) examine the transformative influence of agricultural entrepreneurship and highlight the importance of strengthening the agricultural entrepreneurship ecosystem. Entrepreneurial development therefore requires more than motivation; individuals need access to training, technology, finance, mentoring and markets.

Roy and Rahman (2022) similarly examine training contents, curriculum and processes of agri-entrepreneurship development. Their work suggests that entrepreneurship training needs to be practical and connected with the actual requirements of agricultural enterprises.

The literature therefore points towards a competency-based understanding of agripreneurship. Important competencies include opportunity recognition, financial management, marketing capability, technical knowledge, risk management, communication and networking, innovation, digital literacy and supply-chain management.

These competencies are particularly important when agriculture is transformed into a commercial enterprise.

5. Technology, Innovation and Agri-Tech: Technology has become increasingly important in agricultural entrepreneurship. Precision farming, digital marketing, online marketplaces, farm-management applications, food processing technologies and improved production systems can reduce costs and create new business opportunities.

Kumar and Devi (2025), in their study of agri-tech and precision farming entrepreneurs in Dakshina Kannada, demonstrate the relevance of technology adoption in entrepreneurial agricultural activities. The use of an extended Technology Acceptance Model also indicates that technology adoption is influenced by entrepreneurs' perceptions and practical circumstances.

Gadanakis (2024) places farm entrepreneurship and agribusiness management within the broader movement towards sustainable agriculture. Technology, however, cannot be treated as an independent solution. Entrepreneurs need access to finance, training, infrastructure and markets to convert technological opportunities into viable businesses.

Ravi Kumar, Ramesh Babu and Deshmukh (2024) examine India's agri-start-up landscape and the challenges faced by emerging enterprises. Agri-start-ups have the potential to introduce innovations into areas such as farm services, supply-chain management, food processing and agricultural marketing. However, the survival of such enterprises depends on their ability to develop sustainable business models.

6. Financial and Institutional Constraints: One of the most consistent themes in the literature is the difficulty of accessing finance and institutional support.

The recent study by Kademani et al. (2024) provides particularly strong empirical evidence. The authors studied around 200 agri-entrepreneurs and 43 extension professionals and classified constraints into administrative, financial, technical and socio-cultural categories. Financial and administrative barriers emerged as important constraints, including limited priority lending, delays in fund release and difficulties associated with institutional processes.

This finding is significant because an entrepreneur may possess a viable business idea but still be unable to establish or expand the enterprise without timely finance. The study also identifies the importance of post-program support, transparent funding processes and technical infrastructure.

The literature therefore suggests that entrepreneurship programmes should not end with training. Entrepreneurs require continuous handholding, including assistance in preparing business plans, accessing credit, obtaining licences, developing markets and solving technical problems.

7. Women and Social Entrepreneurship: Agripreneurship also has an important social dimension. Singh et al. (2022) examine women agri-entrepreneurship and highlight the opportunities available to women in agriculture. Women are already significantly involved in agricultural and allied activities, but their contribution may not always be recognised as entrepreneurial activity.

Women-led enterprises can contribute to household income, employment and community development. However, access to finance, training, technology, markets and decision-making opportunities can influence their ability to establish sustainable businesses.

The concept of social entrepreneurship extends this discussion. Suresha et al. (2025), focusing specifically on Karnataka, describe agri-

social entrepreneurship as an approach capable of addressing social and ecological concerns while promoting rural transformation. Their study places agriculture within a broader framework of poverty reduction, resource management, resilience and inclusive development.

This suggests that the impact of agripreneurship should be measured not only through business profits but also through employment created, community participation, women's empowerment, resource conservation and rural resilience.

8. Diversification Beyond Food-Grain Agriculture: An important gap emerging from the reviewed literature is the relatively greater attention given toconventional agriculture compared with high-value and non-food-grain activities.

Nagaveni et al. (2024) examine major food-grain production in Karnataka, while Mehta (2017) draws attention to relationships between farm and allied non-farm activities. Sharma (2014) also discusses agricultural and allied-sector performance.

Kumaraswamy and Mirshad Rahman (2025), through their work on organic farming in Karnataka, highlight the growing relevance of alternative agricultural practices and practitioners' perspectives.

These studies suggest that agricultural sustainability increasingly requires diversification. Activities such as horticulture, floriculture, dairy, poultry, fisheries, organic farming, medicinal plants and mushroom cultivation may provide opportunities for better resource utilisation and income diversification.

For researchers, this creates an important opportunity to examine specific non-food-grain agricultural enterprises rather than treating agriculture as a single homogeneous sector.

Major Themes Emerging from the Literature:

The reviewed literature allows five broad conclusions to be drawn.

1. Agripreneurship is broader than farming.: It includes production, processing, marketing, logistics, agricultural services, technology and allied activities. This broader definition is necessary to understand how rural economic value is created.

2. Entrepreneurship can support sustainable development.: Agripreneurship can generate employment, diversify income, promote innovation and improve the utilisation of resources. Its environmental contribution, however, depends on the production technologies and resource-management practices adopted.

3. The ecosystem is as important as the entrepreneur.: Individual entrepreneurial capability alone cannot guarantee success. Finance, infrastructure, training, institutional support, technology, market access and policy implementation collectively shape entrepreneurial outcomes.

4. Value addition is becoming increasingly important.: Farmers and entrepreneurs may obtain greater economic opportunities by moving beyond primary production into processing, packaging, branding and direct marketing.

5. Location-specific studies are still required.: The conditions affecting agripreneurship differ across states, districts and commodities. A model that works in one region may not automatically work in another. This is particularly relevant to Karnataka, where agricultural conditions, infrastructure, markets and entrepreneurial opportunities differ across districts.

6. Research Gaps Identified: Although the literature on agripreneurship has expanded, several gaps remain.

First, many studies discuss agripreneurship at a broad conceptual level. There is a need for more commodity-specific empirical

studies measuring profitability, market access, technology adoption and entrepreneurial capability.

Second, limited attention has been given to the interaction between entrepreneurial competencies and financial accessibility. An entrepreneur may possess adequate technical knowledge but still face difficulties in obtaining credit.

Third, the literature needs more research on supply-chain efficiency. Production alone does not determine entrepreneurial success. Procurement, storage, transportation, processing and marketing can substantially affect profitability.

Fourth, there is scope for examining technology adoption and entrepreneurial performance together. Technology adoption should be studied not simply as a binary decision but in terms of its effect on productivity, cost, quality and market access.

Fifth, comparatively fewer studies focus on non-food-grain agricultural enterprises, particularly emerging activities such as mushroom cultivation, high-value horticulture, organic farming and specialised agricultural products.

Sixth, Karnataka-specific research can be strengthened through district-level studies. Existing studies provide useful insights into Karnataka, but there is considerable scope for empirical work connecting local agricultural resources with entrepreneurial opportunities.

7. Conceptual Understanding Emerging from the Review: Based on the literature, agripreneurial performance can be understood as the result of interaction among five broad dimensions:

Entrepreneurial Competencies → Technology Adoption → Financial Accessibility → Market/Value-Chain Capability → Enterprise Performance

This relationship is influenced by government and institutional support.

Entrepreneurial competencies provide the foundation for identifying and exploiting opportunities. Technology can improve productivity and product quality. Financial accessibility enables entrepreneurs to invest in infrastructure and expansion. Market and supply-chain capability determines whether production can be converted into income. Government and institutional support can strengthen all these components through training, credit, infrastructure, incubation and market facilitation. This integrated perspective is particularly useful for future empirical research on agricultural enterprises.

8. Implications for Sustainable Agricultural Development: The reviewed literature suggests that promoting agripreneurship requires a shift from a production-centred approach to an enterprise-centred agricultural development model.

Training programmes should focus not only on technical agricultural practices but also on business planning, accounting, marketing, branding, digital platforms and risk management.

Financial institutions can contribute by developing suitable credit products for agricultural enterprises, particularly for small entrepreneurs who may not possess substantial collateral.

Universities and agricultural institutions can strengthen incubation facilities and provide practical entrepreneurship education. The evidence from Kademani et al. (2024) particularly reinforces the need for post-training support, transparent funding and technical infrastructure rather than limiting intervention to initial training.

At the same time, sustainability should remain central. Entrepreneurs should be encouraged to adopt technologies and production practices that reduce resource wastage and

environmental pressure while maintaining economic viability.

Conclusion:

Agripreneurship is emerging as an important link between agriculture, entrepreneurship and sustainable development. The literature reviewed in this paper shows that agriculture has the potential to generate greater economic and social value when entrepreneurial principles are introduced into production, processing, marketing and allied activities.

The reviewed studies consistently point towards the importance of income diversification, innovation, value addition, technology adoption, market linkages and institutional support. At the same time, financial constraints, administrative barriers, inadequate technical support and weak market connections continue to restrict the development of agricultural enterprises.

Recent evidence demonstrates that these challenges are interconnected. Kademani et al. (2024), for example, identify financial and administrative constraints alongside technical and socio-cultural barriers, suggesting that agricultural entrepreneurship cannot be strengthened through a single intervention. Similarly, research from Karnataka shows that agri-social entrepreneurship can contribute to rural transformation by connecting economic activity with social and environmental objectives.

The review also highlights an important future direction: greater attention needs to be given to high-value and non-food-grain agricultural enterprises. Such activities can provide opportunities for diversification, value addition and rural employment. More empirical research is therefore required to understand their economic viability, entrepreneurial characteristics, technology adoption, financial requirements, marketing channels and supply-chain efficiency.

In conclusion, agripreneurship should not be viewed simply as encouraging farmers to start businesses. It represents a broader transformation in which agricultural resources, entrepreneurial capabilities, technology, finance, markets and institutions work together. A stronger agripreneurial ecosystem can help rural communities move from dependence on conventional production towards diversified and market-oriented enterprises while maintaining the principles of economic, social and environmental sustainability.

References:

1. Arumugam, U., & Manida, M. (2023). Agripreneurship: A pathway towards sustainable economic development in India. *International Journal of Commerce and Finance, 11*(4), 15–23.
2. Dev, S. M. (2012). *Small farmers in India: Challenges and opportunities* (Working Paper No. WP-2012-014). Indira Gandhi Institute of Development Research.
3. Dotsiuk, S. (2023). Agripreneurship as a driver of sustainable development. *Green, Blue and Digital Economy Journal*.
4. Gadanakis, Y. (2024). Advancing farm entrepreneurship and agribusiness management for sustainable agriculture. *Agriculture, 14*(8), 1288. https://doi.org/10.3390/agriculture14081288
5. Halili, A. (2023, October). *Agriculture entrepreneurship as a contributor for sustainable development*. University of Tetova, Faculty of Economics.
6. Hanumappa, H. G., & Bhinde, M. J. (1995). Towards operationalising small farmers' agri-business consortium: A case of Dharwad district in Karnataka. *Agricultural Economics Research Review, 8*(2), 59–77. https://doi.org/10.22004/ag.econ.265878

7. Kademani, S., Nain, M. S., Singh, R., Kumar, S., Parsad, R., Sharma, D. K., Roy, S. K., Karjigi, K. D., Prabhakar, I., Mahapatra, A., & Patil, M. (2024). Unveiling challenges and strategizing solutions for sustainable agri-entrepreneurship development. *Frontiers in Sustainable Food Systems, 8*, 1447371. https://doi.org/10.3389/fsufs.2024.1447371
8. Khan, D., & Tare, U. (2024). Environmental sustainability and economic viability in agripreneurship. *International Journal of Research and Analytical Reviews, 11*(1).
9. Kumar, K. A., & Devi, G. (2025). Adoption of agri-tech and precision farming among entrepreneurs in Dakshina Kannada: An extended TAM approach. *Asian Review of Social Sciences, 14*(1), 38–46. https://doi.org/10.70112/arss-2025.14.1.4307
10. Kumaraswamy, C., & Mirshad Rahman, T. M. (2025). A study on organic farming in Karnataka: With special reference to practitioners' perspectives of selected districts. In *Proceedings of the 10th International Economics Conference (IEC 2025): Economic Growth and Sustainable Development – Emerging Trends*. SDMIMD, Mysuru.

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Artificial Intelligence And Emerging Technologies In Commerce

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Abstract:

Artificial Intelligence (AI) and emerging technologies are transforming the nature and practices of modern commerce. Technologies such as Machine Learning (ML), Generative Artificial Intelligence (GenAI), Big Data Analytics, Blockchain, Robotic Process Automation (RPA), and the Internet of Things (IoT) are increasingly being applied in finance, accounting, banking, auditing and e-commerce. This study examines the role of AI and emerging technologies in commerce through a comparative review of fifteen recent research studies. The study adopts a descriptive literature review methodology and relies on secondary information obtained from academic research articles and scholarly publications. The reviewed literature indicates that AI and ML are widely used for prediction, forecasting, fraud detection, risk management, customer analysis and decision support. Generative AI is creating new opportunities in e-commerce through customer interaction, information retrieval, advertising, content generation and business decision-making. Blockchain, Big Data, RPA and IoT provide additional capabilities related to transaction security, transparency, automation, real-time data processing and digital reporting. At the same time, the literature identifies challenges related to data privacy, cybersecurity, ethical concerns, explainability, regulatory requirements, implementation costs and changing professional skills. Comparison of the selected studies shows that existing research is largely concentrated on individual technologies or specific sectors such as finance, accounting, banking and e-commerce. There is comparatively limited research providing an integrated commerce-wide perspective that examines AI together with multiple emerging technologies. The study therefore identifies the need for further research on the integrated application of AI and emerging technologies across different areas of commerce, particularly in the Indian context.

Keywords: Artificial Intelligence, Emerging Technologies, Commerce, E-Commerce

Introduction:

The rapid development of digital technologies has significantly changed the way businesses operate, communicate with customers and make commercial decisions. Traditional commercial activities such as accounting, banking, financial management, marketing and buying and selling are increasingly supported by advanced digital technologies. Among these developments, Artificial Intelligence (AI) and Machine Learning (ML) have become important tools for analysing large volumes of data, identifying patterns, predicting outcomes and supporting business decision-making. Recent research demonstrates that Machine Learning has applications across several areas of business and finance, including marketing, stock analysis, demand forecasting, e-commerce, accounting and credit risk management (Gao et al., 2024). Gao et al. (2024) also observed that existing research had often concentrated on particular areas within

business and finance, creating a need for broader examination of ML applications across different commercial domains.

AI has also become an important area of research in finance. Bahoo et al. (2024) reviewed the development of AI in finance and identified applications involving forecasting, classification, early-warning systems, Big Data analytics, data mining and financial decision-making. Their study demonstrates that AI research in finance extends across several financial activities and continues to develop rapidly. The banking and financial services sector has similarly experienced increasing interest in AI and ML. Pattnaik et al. (2024) conducted a bibliometric review of AI and ML research in the Banking, Financial Services and Insurance (BFSI) sector. Their study screened 39,498 publications and included 1,045 articles in the final analysis. Major research clusters included FinTech, risk management, anti-money laundering and actuarial science (Pattnaik et al., 2024).The emergence of Generative AI has further expanded the role of AI in commerce. Dong et al. (2024) reviewed research on ChatGPT and Large Language Models in accounting and finance and identified applications involving accounting and finance activities, classification, summarisation, text generation and implications for professionals and organisations. In e-commerce, Generative AI is being studied for applications including customer experience, purchase intention, business optimisation, information retrieval, advertising and decision-making. Baig and Yadegaridehkordi (2026), for example, reviewed 52 empirical studies published between 2022 and 2025 and identified these as major application areas of GenAI in e-commerce.

AI is not the only technology transforming commerce. Blockchain can support transaction security, transparency and traceability; Big Data enables organisations to analyse large and diverse datasets; RPA can automate repetitive activities; and IoT can facilitate real-time data collection. Nofel et al. (2024) specifically examined the integration of Blockchain, IoT and XBRL in accounting information systems and identified limited literature concerning their integration into a unified system.Therefore, the transformation of commerce needs to be examined from a broader perspective. Rather than considering AI, Blockchain, Big Data, RPA and IoT as completely independent technologies, it is important to understand their applications, benefits, challenges and possible interactions across different areas of commerce.

The present study therefore reviews and compares fifteen research papers covering AI, ML, GenAI, finance, accounting, banking, e-commerce, Blockchain, Big Data, RPA and IoT. The study aims to identify major findings from existing research and determine the research gap that can provide directions for future research in commerce.

Research Objectives:

- To examine the role of Artificial Intelligence and emerging technologies in commerce.
- To review existing research on the application of Artificial Intelligence and Machine Learning in business and finance.
- To examine the application of AI in accounting, auditing, banking and financial services.
- To study the emerging role of Generative AI in e-commerce and customer-related activities.
- To examine the role of Blockchain, Big Data, Robotic Process Automation and Internet of Things in commerce.
- To identify the major benefits associated with the adoption of AI and emerging technologies.
- To examine the challenges and ethical issues associated with the adoption of these

technologies.

- To compare existing research and identify major gaps in the literature.
- To identify possible directions for future research on the integrated application of AI and emerging technologies in commerce.

Methodology:

The present study adopts a descriptive literature review methodology based on secondary data. No primary data were collected through questionnaires, interviews or surveys. Instead, the study examines and compares fifteen academic research papers related to Artificial Intelligence and emerging technologies in commerce.

The selected literature covers different dimensions of the research topic, including Machine Learning, Artificial Intelligence in finance, banking and financial services, accounting and auditing, Generative AI in e-commerce, Blockchain, Big Data, Robotic Process Automation and Internet of Things.

The selected studies were reviewed and compared according to the following dimensions:

- Technology examined
- Area of commercial application
- Research objective
- Major findings
- Benefits identified
- Challenges identified
- Research limitations
- Future research opportunities

A thematic comparison was then undertaken to identify common findings and differences across the selected studies. Particular attention was given to whether the research focused on a single technology, a particular commercial sector or the integration of multiple emerging technologies.

The methodology is therefore based on secondary research, thematic analysis and comparative synthesis of the selected academic literature.

Literature Review:

1. Artificial Intelligence and Machine Learning in Business and Finance: Gao et al. (2024) conducted a comprehensive review of Machine Learning applications in business and finance. Their study examined applications across areas such as marketing, stock markets, demand forecasting, e-commerce, cryptocurrency, finance, accounting and credit risk management. The authors highlighted the broad range of ML applications and identified opportunities for further research across different business and financial domains. Bahoo et al. (2024) examined Artificial Intelligence in finance using bibliometric and content analysis. Their research identified major applications of AI in forecasting, classification, early-warning systems, Big Data analytics, data mining and financial markets. The study demonstrates that AI has become an important research area in modern finance and is being applied across several financial activities. Taken together, these studies demonstrate that AI and ML are increasingly used for analytical, predictive and decision-support purposes in business and finance.

2. AI in Banking and Financial Services: Pattnaik et al. (2024) conducted a bibliometric review of AI and ML applications in the BFSI sector. Their study analysed a large body of Scopus-indexed literature and identified nine major research clusters, including FinTech, risk management and anti-money laundering. The findings demonstrate the wide range of research on AI and ML within financial services. Kou and Lu (2025) examined emerging financial technologies through a FinTech literature review. Their study focused on AI, Machine Learning, Blockchain, Augmented Reality/Virtual Reality

and quantum technologies. The research highlights the growing importance of multiple technologies in the evolution of financial services. Najem et al. (2025) examined the relationship between AI, Big Data, text mining and cloud computing in e-finance. Their review highlights the role of these technologies in areas including e-finance, stock markets and banking. The study also points to applications involving customer satisfaction, fraud detection and risk mitigation while emphasizing the importance of data protection and confidentiality. These studies collectively indicate that technological transformation in finance is increasingly based on the combination of AI, data-intensive technologies and digital financial systems.

3. AI in Accounting and Financial Management: Kureljusic and Karger (2024) conducted a systematic literature review of AI-based forecasting in financial accounting. Their final sample consisted of 47 studies. The review identified applications related to bankruptcy prediction, financial analysis and fraud and error detection. The authors also highlighted the need for more generalisable and sociotechnical knowledge concerning AI-based forecasting in accounting. Cao and Zhang (2025) discussed how AI is shaping accounting and finance. Their work highlights applications involving financial reporting, auditing, risk management and taxation. AI can automate routine activities, analyse large datasets and support predictive decision-making. However, the study also highlights ethical and regulatory concerns associated with AI adoption. These findings suggest that AI can change accounting and finance from predominantly transaction-oriented activities toward more automated, analytical and predictive processes.

4. Generative AI and Accounting: Dong et al. (2024) conducted a scoping review of research on ChatGPT and related Large Language Models in accounting and finance. The authors identified three broad themes: applications of ChatGPT and LLMs in accounting and finance, use of LLMs as research tools for classification and text generation, and implications of LLM adoption for professionals and organisations. They also identified several unanswered questions and opportunities for future research.The findings indicate that Generative AI represents a new stage of AI adoption in commerce because it can support not only prediction and classification but also text generation, summarisation and interactive communication.

5. AI and Robotic Process Automation in Accounting and Auditing: Research on AI and Robotic Process Automation in accounting and auditing indicates that these technologies can support automation of repetitive activities and improve efficiency. The systematic review published by the *Journal of Applied Accounting Research* examines the benefits, challenges, drivers and adoption of AI and RPA in accounting and auditing (2026).The literature suggests that the combination of AI and RPA may allow accounting and auditing professionals to devote more attention to analytical and judgement-oriented activities. At the same time, successful implementation requires appropriate infrastructure, employee skills, organisational support and consideration of professional and regulatory requirements.

6. Generative AI in E-Commerce: Baig and Yadegaridehkordi (2026) reviewed 52 empirical studies on Generative AI in e-commerce. Their review identified six major application areas: customer purchase intention and experience, GenAI-based optimisation, business decision-making, information retrieval, advertising and GenAI implementation strategies. These findings demonstrate that Generative AI is expanding the role of AI in e-commerce beyond conventional prediction and recommendation systems. It can

support customer interaction, information provision, content-related activities and business decision-making. Wang et al. (2025) systematically reviewed technological innovations and consumer behaviour in e-commerce. Their review considered websites, social media, live streaming, AR/VR and AI and identified a growing research interest in technology-enabled consumer behaviour. The authors also identified a need for greater integration and further research concerning emerging technologies. Thus, emerging technologies influence both the business side of e-commerce, through optimisation and decision-making, and the consumer side, through customer interaction and experience.

7. Blockchain and Machine Learning in E-Commerce: Jebamikyous et al. (2023) reviewed the integration of Blockchain and Machine Learning in e-commerce and other application areas. The authors explained that Blockchain can contribute to data security and privacy, while Machine Learning can provide analytical capabilities for large datasets. The study also discussed the benefits, limitations and challenges of integrating the two technologies. This literature demonstrates that emerging technologies can complement one another. Instead of using AI or Blockchain independently, businesses may integrate multiple technologies to address complex commercial and data-management requirements.

8. Blockchain, IoT and XBRL in Accounting: Nofel et al. (2024) conducted a systematic literature review of Blockchain, IoT and XBRL in accounting information systems. Their review included 309 studies published between 2013 and 2023. The authors identified limited literature concerning the integration of these technologies into a unified accounting information system. They also highlighted potential benefits such as transparency, real-time reporting and improved data security.This study is particularly relevant to the present research because it demonstrates that technology integration itself is an important research area.

9. Blockchain in Accounting: *The disruption of blockchain technology in accounting* examined the scientific development and potential disruptive role of Blockchain in accounting. It highlights possible benefits including transparency, data security and process automation, while also discussing practical implementation challenges and regulatory issues (The disruption of blockchain technology in accounting, 2025).Blockchain therefore has potential to influence accounting processes and financial information management, but adoption requires consideration of regulatory, organisational and technological conditions.

10. Explainable Artificial Intelligence: Arias-González et al. (2026) systematically reviewed Explainable Artificial Intelligence in accounting and financial auditing. Their review included 85 primary studies and found applications in areas such as fraud detection, credit assessment, financial auditing and decision support. The study also identified commonly used explainability techniques such as SHAP and LIME.The study highlights the importance of explainability because AI-supported financial decisions may require transparency, accountability and human understanding. Challenges remain concerning data quality, explanation stability, computational costs and regulatory adaptation.

11. Overall Comparison of the Literature: The comparison of the fifteen selected studies reveals several common findings.

First, AI and Machine Learning are widely applied to prediction, forecasting, fraud detection, risk management, financial analysis and decision support (Bahoo et al., 2024; Gao et al., 2024; Kureljusic & Karger, 2024).Second, Generative AI is expanding the application of AI

in commerce, particularly in accounting, finance and e-commerce. Its applications include text generation, summarisation, customer interaction, information retrieval, advertising and business decision-making (Baig & Yadegaridehkordi, 2026; Dong et al., 2024).Third, emerging technologies are increasingly interconnected. Research on FinTech, AI, Big Data, Blockchain, IoT and ML demonstrates that different technologies can provide complementary capabilities (Jebamikyous et al., 2023; Kou & Lu, 2025; Nofel et al., 2024).Fourth, the literature identifies several challenges, including data privacy, cybersecurity, ethical concerns, explainability, regulatory requirements, implementation costs and workforce skills. Finally, the research remains substantially divided according to individual technologies and commercial sectors. This provides the basis for identifying the research gap.

Literature Gap:

1. Fragmentation of Existing Research: Existing studies frequently focus on a particular technology or commercial sector. For example, some studies focus on AI in finance, others on accounting, banking, e-commerce or Blockchain. Although these studies provide valuable knowledge, they do not always provide an integrated view of how different technologies collectively influence commerce.

2. Limited Integration of Multiple Emerging Technologie: Research has examined combinations such as Blockchain and Machine Learning and Blockchain, IoT and XBRL (Jebamikyous et al., 2023; Nofel et al., 2024). However, comparatively limited research examines **AI, ML, GenAI, Blockchain, Big Data, RPA and IoT together within the broader commerce ecosystem**. Nofel et al. (2024) specifically identified limited literature on the integration of Blockchain, IoT and XBRL into a unified accounting information system.

3. Limited Commerce-Wide Perspective: The reviewed literature is generally organised around individual sectors such as finance, accounting, banking and e-commerce. There is scope for research that considers the combined influence of emerging technologies across the broader field of commerce, including accounting, finance, banking, marketing and e-commerce.

4. Rapid Development of Generative AI: Generative AI is developing rapidly and represents a relatively new research area. Baig and Yadegaridehkordi (2026) found applications across customer experience, optimisation, decision-making, information retrieval, advertising and implementation strategies. However, because the technology is developing rapidly, additional research is needed to examine its longer-term commercial implications.

5. Ethical and Human Dimensions: Although existing studies discuss privacy, cybersecurity, explainability, ethics and regulation, there remains scope for integrated research examining human-AI collaboration, professional skills, employment changes, accountability and organisational readiness.

6. Limited Indian Context: A significant portion of the reviewed literature has a global orientation. There is scope for additional research specifically examining AI and emerging technology adoption among Indian businesses, banks, accounting organisations, e-commerce companies and other commercial institutions.

Findings:

- **Growing role of AI in commerce:** The literature shows that AI and Machine Learning (ML) are increasingly being used for prediction, forecasting, fraud detection, risk management, customer analysis and business decision-making. These applications help organizations process large volumes of

data and support faster and more informed decisions.

- **Transformation of accounting and finance:** AI is increasingly applied in financial forecasting, auditing, fraud detection, financial analysis and accounting-related decision-making. Generative AI is also creating new possibilities for information retrieval, content generation and professional support in accounting and finance.
- **AI adoption in banking and financial services:** The reviewed studies indicate that AI and ML have important applications in credit assessment, risk management, fraud detection, financial classification and customer services. The use of data-driven technologies is contributing to the development of digital financial services.
- **Expansion of AI in e-commerce and marketing:** AI is being used for customer behaviour analysis, personalized recommendations, advertising, information retrieval, content generation and customer interaction. Generative AI is further expanding the possibilities for personalization and digital marketing.
- **Increasing importance of emerging technologies:** Blockchain, Big Data Analytics, Robotic Process Automation (RPA) and the Internet of Things (IoT) are emerging as important technologies supporting modern commerce. These technologies can complement AI by improving automation, data processing, transaction security, transparency and real-time information availability.
- **Integration of technologies is an emerging direction:** The literature indicates that AI does not operate independently. Its combination with Big Data, Blockchain, RPA and IoT can provide broader opportunities for automation, analytics, security and business decision-making.
- **Significant benefits for organizations:** AI and emerging technologies can improve operational efficiency, reduce repetitive work, support faster decision-making, improve customer experience and enable organizations to use data more effectively.
- **Several challenges remain:** Despite their benefits, the adoption of these technologies creates challenges related to data privacy, cybersecurity, ethical issues, explainability, regulatory requirements, implementation costs and data quality.
- **Changing employment and skill requirements:** The literature suggests that automation may reduce the need for some routine tasks while increasing the demand for digital, analytical and technology-related skills. Therefore, continuous reskilling and upskilling are becoming important for employees.
- **Research remains fragmented:** The comparison of the fifteen studies shows that much of the existing research focuses on a particular technology or sector, such as finance, accounting, banking or e-commerce. There is comparatively less research examining AI and multiple emerging technologies together from a broader commerce perspective.
- **Need for greater research in the Indian context:** The review indicates a need for more studies examining the adoption, benefits and challenges of AI and emerging technologies among Indian businesses and commercial institutions.

Suggestions:

Based on the findings of the literature review, the following suggestions are proposed:

- **Promote responsible AI adoption:**

Organizations should adopt AI in a responsible and transparent manner, with appropriate attention to privacy, fairness, security and accountability.

- **Strengthen data privacy and cybersecurity** Since AI and emerging technologies depend heavily on data, organizations should implement appropriate data protection, cybersecurity and access-control measures.
- **Develop employee skills:** Organizations and educational institutions should focus on reskilling and upskilling employees in areas such as AI, data analytics, digital technologies and cybersecurity to address changing employment requirements.
- **Maintain human oversight:** AI should support human decision-making rather than completely replace human judgment, particularly in areas involving financial decisions, auditing, risk assessment and other sensitive commercial activities.
- **Encourage technology integration:** Businesses should explore the combined use of AI with Big Data, Blockchain, RPA and IoT where appropriate. Integrated technologies can provide opportunities for better automation, analytics, transparency and decision support.
- **Support AI adoption among Indian businesses:** Indian organizations, including small and medium-sized businesses, should be encouraged to adopt appropriate digital and AI technologies according to their operational requirements, resources and capabilities.
- **Strengthen regulatory and ethical frameworks:** Appropriate policies and guidelines are required to address issues related to AI transparency, data privacy, cybersecurity, accountability and ethical use.
- **Encourage further research:** Future researchers should conduct more integrated studies covering AI, Generative AI, Blockchain, Big Data, RPA and IoT across different areas of commerce. Greater attention should also be given to the Indian business environment.
- **Focus on long-term impact:** Future studies should examine the long-term effects of AI and emerging technologies on business performance, employment, professional skills, customer behaviour and organizational structures.

Conclusion:

Artificial Intelligence and emerging technologies are significantly transforming modern commerce. The review of fifteen research studies demonstrates that AI and Machine Learning are increasingly being used for forecasting, prediction, fraud detection, risk management, financial analysis, customer analysis and business decision-making.

The literature also demonstrates that Generative AI is creating new opportunities in accounting, finance and e-commerce through text generation, summarisation, customer interaction, information retrieval, advertising and decision support. Blockchain, Big Data, RPA and IoT provide additional capabilities related to transaction security, transparency, automation, real-time information processing and digital reporting.

The comparison of the selected studies indicates that these technologies should not be viewed only as independent tools. Their integration can provide opportunities for improving commercial processes, information management and decision-making. However, technological adoption also creates challenges involving privacy, cybersecurity, ethical responsibility, explainability, regulation,

implementation costs and changing professional skills.

The major research gap identified in this study is the limited availability of an integrated commerce-wide perspective connecting AI with multiple emerging technologies across finance, accounting, banking, marketing and e-commerce. Future research can therefore examine the combined impact of these technologies and give greater attention to the Indian commercial environment.

Overall, AI and emerging technologies are becoming important components of modern commerce. Their effective adoption requires an appropriate balance between technological innovation, human expertise, ethical responsibility, data protection and organisational readiness.

References:

1. Arias-González, I. P., Serrano-Torres, G. J., Dávalos-Mayorga, E. R., & Jiménez-Vargas, N. P. (2026). Explainable artificial intelligence in accounting and financial auditing: A systematic review. *Frontiers in Artificial Intelligence, 9*, 1823263. https://doi.org/10.3389/frai.2026.1823263
2. Bahoo, S., Cucculelli, M., Goga, X., & Mondolo, J. (2024). Artificial intelligence in finance: A comprehensive review through bibliometric and content analysis. *SN Business & Economics, 4*, 23. https://doi.org/10.1007/s43546-023-00618-x
3. Baig, M. I., & Yadegaridehkordi, E. (2026). Generative AI in E-commerce: A literature review of current applications, gaps and future directions. *Asia-Pacific Journal of Business Administration*, 1–29. https://doi.org/10.1108/APJBA-08-2025-0575
4. Cao, Y., & Zhang, W. (2025). How AI is shaping accounting and finance. *The British Accounting Review*, 101650. https://doi.org/10.1016/j.bar.2025.101650
5. Dong, M. M., Stratopoulos, T. C., & Wang, V. X. (2024). A scoping review of ChatGPT research in accounting and finance. *International Journal of Accounting Information Systems, 55*, 100715. https://doi.org/10.1016/j.accinf.2024.100715
6. Gao, H., Kou, G., Liang, H., Zhang, H., Chao, X., Li, C.-C., & Dong, Y. (2024). Machine learning in business and finance: A literature review and research opportunities. *Financial Innovation, 10*, 86. https://doi.org/10.1186/s40854-024-00629-z
7. Jebamikyous, H., Li, M., Suhas, Y., & Kashef, R. (2023). Leveraging machine learning and blockchain in E-commerce and beyond: Benefits, models, and application. *Discover Artificial Intelligence, 3*, 3. https://doi.org/10.1007/s44163-022-00046-0

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India's Changing Tax System under the Income-tax Act, 2025: Reforms, Emerging Issues and Implementation Challenges

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Abstract:

India's income-tax system has undergone a significant structural transformation with the enactment of the Income-tax Act, 2025, which came into force on 1 April 2026, replacing the Income-tax Act, 1961. The new legislation seeks to simplify tax law, reduce compliance difficulties, reorganise provisions and make the tax framework more accessible to taxpayers. One of the important changes is the replacement of the traditional terminology of "previous year" and "assessment year" with the concept of "tax year." The new Act also consolidates several provisions, uses tables and formulas more extensively, and reduces the number of sections and rules.

This article examines the changing Indian income-tax system specifically in the context of the Income-tax Act, 2025. It focuses on major reforms, taxpayer convenience, digital compliance, TDS simplification, return filing, transition from the old Act, and challenges relating to taxpayer awareness, technology, interpretation, professional training and implementation. The study argues that legal simplification is only one part of tax reform; effective communication, digital accessibility, taxpayer education and smooth transition are equally important for achieving the intended objectives of the new framework. The article also presents a conceptual framework and charts comparing selected structural features of the Income-tax Act, 1961 and the Income-tax Act, 2025.

Keywords: Income-tax Act-2025, Tax Year, Tax Reform, Digital Taxation, Tax Compliance.

Introduction:

Income taxation is an important component of India's public finance system. For more than six decades, the Income-tax Act, 1961 provided the principal statutory framework for direct taxation. Over time, numerous amendments, explanations, provisos and judicial interpretations were incorporated into the legislation, making the law increasingly extensive and difficult for ordinary taxpayers to navigate.

The Income-tax Act, 2025 represents a major restructuring of this legal framework. The Act was enacted in 2025 and came into force on 1 April 2026. The Income Tax Department describes its objectives as simplification, modernisation, reduction of compliance burden, consolidation of provisions and improved clarity. The reform is particularly significant because it does not merely involve changing individual tax provisions. It changes the way income-tax law is organised and presented.

Statement of the Problem:

Although the new Act aims to simplify income-tax law, several practical questions arise:

- Do simpler legislative provisions necessarily result in simpler compliance?
- Are taxpayers sufficiently aware of the new Tax Year concept?
- Can small taxpayers understand the new provisions without professional assistance?
- Will digitalisation reduce compliance costs for all categories of taxpayers?
- Can the transition between the Income-tax Act, 1961 and the Income-tax Act, 2025 create temporary confusion?
- Will simplification reduce litigation and interpretational difficulties?

Objectives of the Study:

- To examine the major reforms introduced by the Income-tax Act, 2025.
- To explain the new concept of Tax Year.
- To examine simplification of tax provisions.
- To identify major implementation challenges.
- To examine the role of digitalisation in the new tax framework.
- To suggest measures for improving taxpayer understanding and compliance.

Methodology:

This study follows a descriptive and conceptual research methodology.

The study is primarily based on:

- Income-tax Act, 2025
- Income Tax Department publications and FAQs
- Government notifications and press releases
- Official tax-related documents
- Secondary academic literature relating to Indian taxation

The study is based on secondary data and does not claim to represent the opinions of all Indian taxpayers.

Rate of Income Tax for the Tax Year 2026-27:

The rate of income tax fixed by the finance Act passed by parliament every year.

1. Old Tax Regime:

Slab Rates:

A) Individual, HUF, AOP and Artificial Juridical Person. (Belove 60 years)		**B) An Individual the age of 60 years or more but less than 80 years (Senior Citizens)**	
Income Slab	**Rate**	**Income Slab**	**Rate**
Rs. 0 to 2,50,000	NIL	Rs. 0 to 3,00,000	NIL
Rs. 2,50,001to 5,00,000	5%	Rs. 3,00,001to 5,00,000	5%
Rs. 5,00,001 to 10,00,000	20%	Rs. 5,00,001 to 10,00,000	20%
Above Rs. 10,00,000	30%	Above Rs. 10,00,000	30%
C) An Individual the age of 80 years or more (Super Senior Citizens)		**D) Partnership Firm**	
Income Slab	**Rate**	Rates applicable to the partnership firm at the rate of 30%	
Rs. 0 to 5,00,000	NIL		
Rs. 5,00,001 to 10,00,000	20%		
Above Rs. 10,00,000	30%		

2. New Tax Regime:

With effect from tax year 2026-27, where the individual or HUF opts to be taxed under **section 202** (**replace the section 115BAC**) the rate of income tax shall be provided as under the conditions mentioned in sections 202 are satisfied.

Slab Rates:

Slab Rate as Under New Tax Regime for Individuals whether the individual is below 60, a senior citizen (60-79), or a super senior citizen (80+)	
Income Slab	**Rate**
Rs. 0 to 4,00,000	NIL
Rs. 4,00,001 to 8,00,000	5%
Rs. 8,00,001 to 12,00,000	10%
Rs. 12,00,001 to 16,00,000	15%
Rs. 16,00,001 to 20,00,000	20%
Rs. 20,00,001 to 24,00,000	25%
Above Rs. 24,00,000	30%

Rebate and Standard Deduction-AY 2026-27:

1. **RebateSection 87A:**

Particulars	**Old Tax Regime**	**New Tax Regime**
Maximum rebate	Rs. 12,500	Rs. 60,000
Income limit	Up to Rs. 5,00,000	Up to Rs. 12,00,000

2. **Standard Deduction for salaried persons:**

Particulars	**Old Tax Regime**	**New Tax Regime**
Standard Deduction	Rs. 50,000	Rs. 75,000

❖ **Note:** Under the new tax regime for AY 2026-27, a resident salaried individual can have gross salary up to Rs. 12,75,000 with nil tax, after the Rs. 75,000 standard deduction and section 87A rebate, subject to applicable condition.

Major Reforms under the Income-tax Act, 2025:

Introduction of the "Tax Year": One of the most visible changes is the introduction of the term **Tax Year**.

Under the earlier framework:

- Previous Year → Income earned
- Assessment Year → Income assessed

Under the new Act, the terminology is simplified through the concept of Tax Year, corresponding broadly to the financial year. The Income Tax Department explains that Tax Year 2026–27 refers to the financial year beginning 1 April 2026.

Simple example:

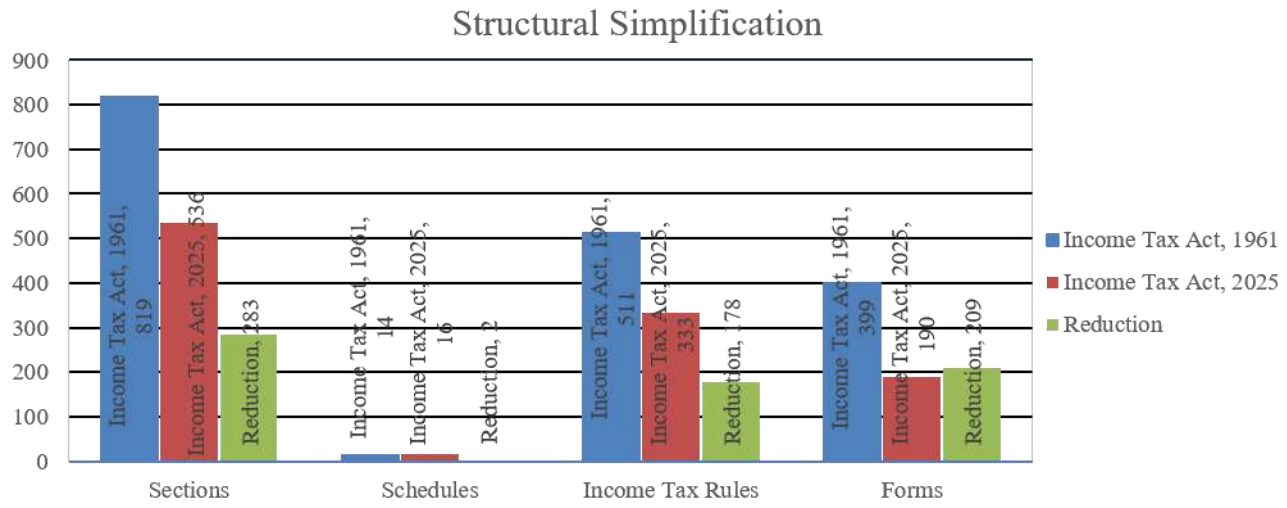
Old terminology	**New terminology**
Previous Year 2026–27	Tax Year 2026–27
Assessment Year 2027–28	No separate AY concept
Income earned during FY 2026–27	Income of Tax Year 2026–27

This change is intended to reduce confusion caused by the use of two different year references.

Structural Simplification:

Particulars	Income Tax Act, 1961	Income Tax Act, 2025	Reduction
Sections	819	536	283
Schedules	14	16	2
Income Tax Rules	511	333	178
Forms	399	190	209

Chart Showing Structural Simplification:



Interpretation: Above chart shows the Income Tax Department states that the new Act contains **536 sections** and **16 schedules**, compared with **819 sectionsand 14 schedules** in the 1961 Act. It also states that Income-tax Rules have been reduced from **511 rules** and **399 forms** to **333 rules** and **190 forms.**

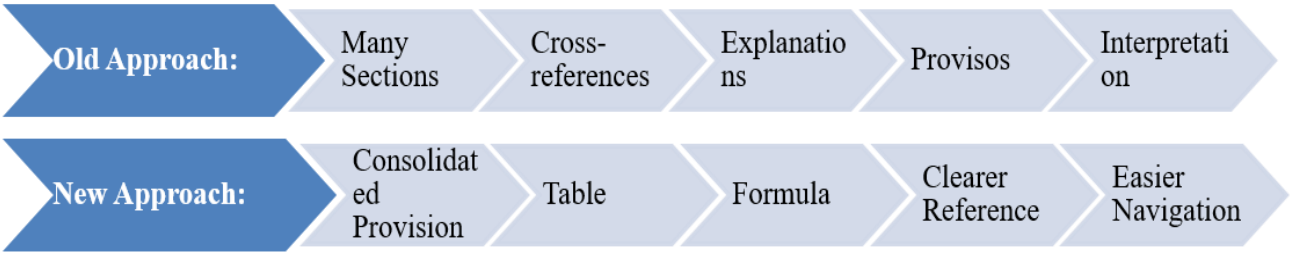
Consolidation of Provisions:

A major feature of the new Act is the consolidation of provisions.

For example, the Department states that several presumptive taxation provisions have been consolidated into Section 58 in tabular form.

Similarly, TDS provisions have been reorganised. The Department explains that the numerous TDS sections under the old Act have been consolidated principally into Sections 392 and 393 under the new Act.

Expected benefit:



Digitalisation of Tax Compliance:

The modern income-tax system increasingly depends on digital platforms.

- Digital compliance includes:
- Online return filing
- Digital tax payments
- TDS reporting
- Online notices
- Electronic communication
- Faceless proceedings
- Digital verification

Major Issues and Challenges:

1. Taxpayer Awareness: A new law can be legally simple but practically difficult if taxpayers do not understand it.

Challenge: Small taxpayers may continue using old terminology such as "previous year" and "assessment year."

Solution: Conduct taxpayer awareness programmes in simple English and regional languages.

2. Transition between Two Legal Frameworks: The transistion period is an important challenge. Income earned during the FY 2025-26 continues to be governed by the old act and is filed as AY 2026-27, while income from FY 2026-27 is governed by the new act.

Challenge of Digital Divide:

Digital tax administration can improve efficiency, but not every taxpayer has the same digital capability.

- Major difficulties
- Lack of digital literacy
- Rural connectivity issues
- Language barriers
- Difficulty understanding online notices
- Dependence on tax professionals
- Cybersecurity concerns

Challenge of Professional and Academic Transition:

Commerce and taxation students will need to understand:

- New section numbers
- Tax Year terminology
- Revised procedural provisions
- New forms
- New rules
- Transitional provisions
- Revised compliance procedures

Challenge of Interpretation and Litigation:

The new Act is intended to improve clarity and reduce interpretational difficulties. However, a new statutory framework can itself generate questions during the early years of implementation.

Possible areas requiring clarification include:

- Interpretation of newly drafted provisions
- Transitional provisions
- Treatment of old proceedings
- Cross-referencing between old and new provisions
- Application of judicial precedents
- Administrative instructions

TDS Reform:

TDS is one area where the new Act adopts a more consolidated presentation.

The Income Tax Department states that TDS provisions are substantially reorganised into Sections 392 and 393, with tables covering different categories of payments and taxpayers.

Conceptual benefit:

Earlier: Multiple provisions → search → cross-reference → interpretation

New presentation: Section → table → nature of payment → threshold → rate

Return-Filing Reform:

The new Act places original, belated, revised and updated returns within Section 263, providing a more consolidated framework.

Key Issues–Reform–Challenge Framework:

Area	Reform under 2025 Act	Major challenge
Year terminology	Tax Year	Initial taxpayer confusion
Legislative structure	Consolidation	Learning new sections
TDS	Consolidated presentation	Updating accounting systems
Return filing	Unified provision	Awareness of revised procedures
Digital compliance	Greater digital integration	Digital divide
Transition	Savings/transitional provisions	Old and new terminology
Tax education	Modernised framework	Updating textbooks and curriculum
Administration	Simplified structure	Initial interpretation issues

Suggested Framework for Effective Implementation:

The following model may be called the 5-A Tax Reform Implementation Model:

1. Awareness: Explain the new law to taxpayers.
2. Accessibility: Provide information in simple language and regional languages.
3. Assistance: Strengthen taxpayer help desks and digital support.
4. Adaptation: Train tax professionals, accountants, teachers and students.
5. Accountability: Continuously evaluate whether the reform actually reduces compliance difficulties.

Findings of the Study:

1. The Income-tax Act, 2025 represents a major restructuring of India's income-tax legislation.
2. The introduction of Tax Year removes the separate terminology of Assessment Year under the new framework.
3. The new Act reduces the number of sections and reorganises provisions.
4. Tables and formulas are used more extensively to improve presentation.
5. TDS provisions have been consolidated into fewer sections.
6. Return-filing provisions have also been consolidated.
7. Digital compliance remains central to modern tax administration.
8. The transition from the old Act to the new Act requires taxpayer education.
9. Digital literacy and access remain important implementation challenges.
10. Updating tax education and professional training will be essential.

Suggestions:

1. For the Government:

- Conduct nationwide taxpayer awareness programmes.
- Provide multilingual educational material.
- Develop simple tax-learning videos.
- Strengthen help-desk facilities.
- Provide transition guides comparing old and new provisions.
- Regularly publish practical FAQs.

2. For Educational Institutions:

- Update Income Tax syllabi.
- Introduce practical tax-return exercises.

- Teach both old and new terminology during the transition period.
- Organise tax-awareness programmes.
- Train commerce students in digital tax compliance.

3. For Tax Professionals

- Update software and accounting systems.
- Maintain comparative tables of old and new provisions.
- Provide taxpayers with transition guidance.
- Follow official notifications and rules regularly.

Conclusion:

The Income-tax Act, 2025 marks an important stage in the development of India's direct-tax framework. Its emphasis on simplified language, consolidation, restructuring and the Tax Year concept represents an attempt to make tax legislation easier to navigate. The reform also reflects the increasing importance of digital tax administration. However, legal simplification alone cannot guarantee practical simplification. The success of the new framework will depend on taxpayer awareness, digital accessibility, professional training, administrative clarity and effective transitional arrangements. The Income Tax Department itself emphasises that the new Act seeks to reduce compliance burden and improve readability rather than introduce a new tax burden.

Therefore, the future of India's income-tax reform should be understood not merely as a change in statutory language, but as a broader movement towards a simpler, technology-enabled and taxpayer-oriented tax administration system.

References:

1. Central Board of Direct Taxes. (2026, February 8). *Seeking stakeholders' input on the proposed Income-tax Rules and related forms relating to the Income-tax Act, 2025* [Press release]. Ministry of Finance, Government of India.
2. Central Board of Direct Taxes. (2026, April 1). *Income-tax Act, 2025 comes into force from 1st April, 2026* [Press release]. Ministry of Finance, Government of India.
3. Income Tax Department. (2025). *Income-tax Act, 2025*. Ministry of Finance, Government of India.
4. Income Tax Department. (n.d.). *Objective and scope of the new Act: Frequently asked questions*. Ministry of Finance, Government of India.
5. Ministry of Finance, Department of Revenue, Central Board of Direct Taxes. (2026, March 20). *Income-tax Rules, 2026* (Notification No. 22/2026; G.S.R. 198(E)).

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Digital Transformation for Sustainable Banking in India: Assessing the Emerging Role of FinTech

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Abstract:

Purpose: *The rapid diffusion of financial technology (FinTech) is transforming the Indian banking sector by reshaping payment systems, customer interfaces, lending processes, risk management and financial service delivery. At the same time, Indian banks are increasingly expected to integrate environmental, social and governance considerations into their business strategies. Against this background, the present study examines how FinTech-enabled digital transformation can contribute to sustainable banking in India. The study specifically investigates the relationship between digital transformation, financial inclusion, operational efficiency and sustainable banking practices.*

Design/methodology/approach: *The study adopts a systematic literature review and secondary-data research design. The literature review synthesises research on FinTech, digital transformation, sustainable banking, green finance and financial inclusion. The empirical component is based exclusively on secondary information publicly disclosed by selected Indian commercial banks through annual reports, sustainability reports, Business Responsibility and Sustainability Reports (BRSR), investor disclosures and other official publications. The study proposes a structured Digital Transformation Index and Sustainable Banking Index based on observable indicators disclosed by banks. The analysis covers a multi-year period to examine the evolution of digital transformation and sustainability practices and their relationship within the Indian banking sector.*

Findings: *The literature and documentary evidence indicate that FinTech-enabled digital transformation can influence sustainable banking through three principal channels. First, digitalisation improves operational efficiency by reducing dependence on physical processes and enabling automation. Second, digital financial infrastructure can support social sustainability by extending financial services and improving accessibility. Third, digital capabilities facilitate green finance, climate-risk assessment and sustainability-oriented decision-making. However, the sustainability benefits of digitalisation depend on responsible data governance, cybersecurity, digital inclusion and the ability of banks to translate technological capabilities into measurable environmental and social outcomes.*

Originality/value: *The study contributes to the emerging FinTech and sustainable banking literature by integrating digital transformation with the environmental, social and economic dimensions of banking sustainability in the Indian context. Unlike survey-based studies that rely primarily on perceptions of customers or employees, the study adopts a secondary-data approach based on publicly disclosed institutional evidence. The proposed indices provide a replicable framework for examining the relationship between FinTech-enabled digital transformation and sustainable banking performance in emerging economies.*

Keywords: FinTech; digital transformation; sustainable banking; India; green finance; financial inclusion; digital banking; ESG; BRSR

Introduction:

The banking sector is undergoing a fundamental transformation as technological innovation becomes increasingly embedded in financial intermediation. Financial technology, or FinTech, has changed the manner in which banks provide payments, deposits, credit, investment and advisory services. Mobile banking, internet banking, digital payments, artificial intelligence, big-data analytics, cloud computing and other digital technologies have progressively shifted banking from a predominantly branch-based model towards an increasingly technology-enabled ecosystem.

India represents an important context in which to examine this transformation. The country's rapid expansion of digital financial infrastructure has significantly altered the delivery of banking services. Digital payment systems, mobile banking and technology-enabled financial services have expanded the reach of formal finance and altered customer expectations regarding speed, accessibility and convenience.

The transformation of banking is occurring alongside an equally important shift towards sustainability. Banks are increasingly expected to consider the environmental and social implications of their lending and investment decisions. Green finance, climate-risk management, financial inclusion, responsible banking and ESG disclosures have therefore become increasingly relevant to banking strategy.

The Reserve Bank of India (RBI) has progressively strengthened its focus on sustainable finance and climate-related financial risks. Its work has included the establishment of a Sustainable Finance Group, development of climate-risk and sustainable-finance frameworks, and initiatives relating to green deposits, climate-risk management and data infrastructure.

The regulatory environment surrounding sustainability reporting has also become more structured. The Securities and Exchange Board of India (SEBI) introduced the Business Responsibility and Sustainability Report (BRSR) framework to provide quantitative and standardized ESG disclosures. BRSR became mandatory for the top 1,000 listed entities from financial year 2022–23. SEBI subsequently introduced BRSR Core and assurance requirements, further strengthening the comparability and credibility of sustainability information.

These developments create an important research opportunity.

FinTech can potentially contribute to sustainability by improving operational efficiency, facilitating financial inclusion and supporting green finance. Nevertheless, technology adoption by itself cannot be assumed to produce sustainable outcomes. Digitalisation may also increase cybersecurity risks, create dependence on technology infrastructure and exclude individuals with limited digital access or literacy.

The key issue is therefore not whether banks are becoming digital, but whether **digital transformation is being converted into sustainable banking outcomes**.

This study addresses this issue by examining the emerging role of FinTech-enabled digital transformation in sustainable banking in India.

Background of the Study:

Evolution of FinTech in Indian Banking: The Indian banking sector has moved through several stages of technological development, beginning with computerisation and electronic banking and progressing towards mobile banking, digital payments, application-based services and increasingly sophisticated technology-enabled financial services.

The contemporary FinTech ecosystem extends beyond conventional internet and mobile banking. It includes digital payment platforms, artificial intelligence, machine learning, cloud computing, digital lending, application programming interfaces and data analytics.

This development has altered the competitive environment of banking. Banks increasingly compete not only through interest rates and branch networks but also through digital customer experience, speed, personalisation and technological capabilities.

Emergence of Sustainable Banking: Sustainable banking refers to banking practices that incorporate long-term environmental, social and economic considerations into financial decision-making and institutional operations.

The environmental dimension includes green finance, climate-risk management, resource efficiency and financing of environmentally sustainable activities.

The social dimension includes financial inclusion, accessibility, responsible lending and equitable access to financial services.

The economic dimension includes efficiency, resilience, profitability, risk management and long-term financial stability.

The increasing institutionalisation of sustainability reporting in India provides an important secondary-data source for examining these dimensions. SEBI's BRSR framework specifically seeks quantitative and standardized ESG disclosures that facilitate comparison across companies, sectors and time.

Research Problem:

Although FinTech and sustainable banking have both received considerable research attention, the relationship between them remains insufficiently integrated.

Three issues are particularly relevant.

First, much of the FinTech literature focuses on adoption, customer behaviour, financial inclusion or operational efficiency.

Second, sustainable banking literature frequently focuses on green finance, ESG performance and climate-related risk.

Third, there is comparatively less research connecting **FinTech-enabled digital transformation with measurable sustainability outcomes at the bank level**.

The absence of an integrated framework is particularly important in emerging economies such as India, where digital transformation and sustainable finance are developing simultaneously.

Therefore, the study addresses the following central research problem:

To what extent can FinTech-enabled digital transformation contribute to sustainable banking performance in India?

Research Gap:

The systematic review identifies four principal gaps.

Conceptual gap: FinTech and sustainability are frequently studied as separate domains. An integrated framework connecting FinTech capabilities, digital transformation and sustainable banking remains underdeveloped.

Measurement gap: A substantial proportion of empirical studies rely on perceptions collected through questionnaires. Although useful, perception-based measures may not fully capture actual institutional digitalisation and sustainability performance.

Contextual gap: Evidence relating specifically to Indian commercial banks remains comparatively fragmented across digital banking, financial inclusion, green finance and ESG research.

Methodological gap: There is scope for greater use of publicly available bank-level secondary

data to examine the relationship between digital transformation and sustainability.

The present study addresses these gaps through a secondary-data framework based on publicly disclosed institutional information.

Objectives of the Study:

The study has the following objectives:

- To examine the evolution of FinTech-enabled digital transformation in Indian banking.
- To systematically review the literature connecting FinTech, digital transformation and sustainable banking.
- To identify the principal environmental, social and economic mechanisms through which digital transformation can contribute to sustainable banking.
- To develop a measurable Digital Transformation Index for selected Indian banks.
- To develop a Sustainable Banking Index using publicly disclosed environmental, social and economic indicators.
- To examine the relationship between digital transformation and sustainable banking using secondary bank-level data.
- To develop implications for Indian banks, regulators and FinTech firms.

Research Questions:

RQ1: How has FinTech-enabled digital transformation evolved within Indian banking?

RQ2: What does the existing literature indicate about the relationship between FinTech and sustainable banking?

RQ3: Through what mechanisms can digital transformation contribute to sustainable banking?

RQ4: How can digital transformation and sustainable banking be measured using secondary bank-level data?

RQ5: What relationship exists between digital transformation and sustainable banking among selected Indian banks?

Literature Review:

FinTech and Digital Transformation: FinTech refers broadly to the application of technological innovation to financial services. Its impact extends from payments and lending to risk management, customer service and investment.

Digital transformation is broader than technology adoption. It involves the redesign of organisational processes, products, customer experiences and business models through digital capabilities.

Thus, a bank may adopt mobile banking without undergoing comprehensive digital transformation. Transformation occurs when digital technologies become embedded in the bank's strategic and operational architecture.

From this perspective, FinTech can be regarded as an important technological capability supporting digital transformation.

Digital Transformation and Operational Efficiency: Digital technologies enable banks to automate processes and reduce dependence on manual intervention.

Potential benefits include:

- lower transaction costs;
- faster service delivery;
- reduced paper usage;
- improved process accuracy;
- better customer service;
- greater scalability; and
- improved resource utilisation.

Operational efficiency is therefore one of the most immediate ways through which digital transformation can contribute to economic sustainability.

However, digital transformation also involves significant investment in technology, cybersecurity and human capabilities.

Consequently, the sustainability effect should be assessed over the longer term.

Hypotheses Development:

Based on the literature and theoretical framework, the following hypotheses are proposed.

H1: Digital transformation has a positive relationship with sustainable banking performance.

H2: Digital transformation has a positive relationship with environmental sustainability.

H3: Digital transformation has a positive relationship with social sustainability.

H4: Digital transformation has a positive relationship with economic sustainability.

H5: Green finance positively contributes to sustainable banking performance.

H6: Financial inclusion positively contributes to sustainable banking performance.

Research Methodology:

Research Design:

The study adopts a **systematic literature review and quantitative secondary-data research design**.

The study does not rely on primary questionnaires or interviews. Instead, it uses publicly available information disclosed by Indian banks and regulatory institutions.

This approach has two advantages.

- First, it reduces dependence on subjective perceptions.
- Second, it allows the study to examine actual institutional behaviour and reported performance over multiple financial years.

Secondary Data Research:

Research Population:

The research population comprises listed Indian commercial banks for which consistent annual and sustainability disclosures are publicly available.

Sample Selection:

A purposive sample of major Indian listed commercial banks is proposed based on:

1. availability of annual reports;
2. availability of sustainability/BRSR disclosures;
3. availability of financial data;
4. availability of digital-banking information; and
5. consistency of reporting across the study period.

A suitable sample can comprise major public-sector and private-sector banks, allowing sectoral comparison.

The final sample should be determined after verifying data availability for every bank-year observation.

Study Period:

The proposed study period is: **FY 2019–20 to FY 2024–25:**

This period is appropriate because it captures:

- rapid growth of digital banking;
- the acceleration of digital payments;
- increased dependence on technology;
- the institutionalisation of BRSR reporting;
- increasing attention to green finance; and
- the emergence of more structured climate-risk regulation.

SEBI introduced BRSR in 2021 and made it mandatory for the top 1,000 listed entities from FY 2022–23, making later years particularly valuable for comparative sustainability analysis.

Variable Measurement:

Digital Transformation Index (DTI):

A **Digital Transformation Index** is proposed to measure the extent of digital transformation at the bank level.

Potential indicators include:

Dimension	Indicators
Digital access	Mobile banking, internet banking
Digital transactions	Digital transaction volume/value
Digital infrastructure	Digital channels and platforms
Digital innovation	AI, analytics, blockchain, automation
Digital lending	Digital loan origination/services
Customer digitalisation	Digital customer/service initiatives

Each disclosed indicator can be normalised and combined to construct the bank-level DTI.

A simple index can be expressed as:

DTI_{it} = Σ Normalised Digital Indicators / Number of Indicators

where *i* represents the bank and *t* represents the financial year.

Sustainable Banking Index:

A Sustainable Banking Index (SBI) can be constructed from three dimensions.

Environmental Sustainability Index:

Possible indicators:

- green financing;
- renewable-energy financing;
- energy consumption;
- greenhouse-gas emissions;
- renewable-energy usage;
- paper/resource reduction;
- climate-risk initiatives.

RBI has explicitly identified green finance, climate-risk management, data and disclosure as important components of India's sustainable-finance ecosystem.

Social Sustainability Index:

Possible indicators:

- financial inclusion;
- rural/semi-urban outreach;
- priority-sector lending;
- financial literacy;
- digital accessibility;
- customer protection;
- inclusion initiatives.

Economic Sustainability Index:

Possible indicators:

- ROA;
- ROE;
- cost-to-income ratio;
- net interest margin;
- asset quality;
- capital adequacy;
- operating efficiency.

The overall Sustainable Banking Index can be expressed as:

SBI = (Environmental Index + Social Index + Economic Index) / 3

Equal weighting provides transparency and avoids assigning arbitrary importance to any one sustainability dimension.

Control Variables: The following bank-level control variables may be incorporated:

Bank Size: Measured using the natural logarithm of total assets.

Capital Adequacy: Measured through the capital adequacy ratio.

Asset Quality: Measured through gross or net NPA ratio.

Profitability: Measured through ROA or ROE.

Bank Type: A dummy variable distinguishing public-sector and private-sector banks may be included.

Econometric Model: The principal empirical model is:

$$SBI_{it} = \beta_0 + \beta_1 DTI_{it} + \beta_2 SIZE_{it} + \beta_3 CAR_{it} + \beta_4 NPA_{it} + \beta_5 ROA_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Where:

SBI_{it} = Sustainable Banking Index of bank *i* in year *t*

DTI_{it} = Digital Transformation Index

$SIZE_{it}$ = Bank size

CAR_{it} = Capital adequacy ratio

NPA_{it} = Asset quality indicator
ROA_{it} = Return on assets
μ_i = Bank-specific effect
λ_t = Year-specific effect
ε_{it} = Error term

A panel-data approach is appropriate because the study observes multiple banks over multiple financial years.

Analytical Procedure:

The analysis should proceed through the following stages:

Stage 1: Descriptive analysis: Mean, standard deviation, minimum and maximum values.

Stage 2: Index construction: Digital Transformation Index and Sustainable Banking Index.

Stage 3: Correlation analysis: To examine preliminary relationships between variables.

Stage 4: Panel regression: Fixed-effects and random-effects models.

Stage 5: Model selection: Hausman specification test to determine the more appropriate panel estimator.

Stage 6: Robustness analysis: Alternative specifications of the Digital Transformation Index and Sustainable Banking Index can be used to test the stability of results.

Expected Analytical Contribution

The proposed methodology moves beyond a perception-based approach.

Instead of asking respondents whether they believe FinTech improves sustainability, the study examines whether banks that demonstrate stronger digital transformation also demonstrate stronger sustainability performance.

This produces the following empirical logic:

Observed Digital Transformation
↓
Observed Sustainability Practices
↓
Bank-level Sustainable Banking Performance

This approach provides a more objective basis for analysing the relationship.

Discussion:

The systematic literature suggests that the relationship between FinTech and sustainability operates through multiple mechanisms.

First, digitalisation can enhance **operational efficiency**. Automation and electronic processes can reduce manual intervention and resource consumption.

Second, digital banking can strengthen **financial inclusion** by expanding access to financial services.

Third, technology can support **green finance** by enabling better collection, processing and monitoring of sustainability-related information.

Fourth, digital technologies can strengthen **risk management** through data analytics and automated monitoring.

However, digital transformation also creates sustainability risks.

Cybersecurity is increasingly important because banking operations are becoming more digitally dependent. Data privacy and responsible use of customer information are equally important.

Digital exclusion represents another challenge. Technology can expand access for digitally connected customers while simultaneously creating barriers for individuals with limited digital capabilities.

Therefore, the relationship between digital transformation and sustainability should be viewed as **conditional rather than automatic**.

Policy Implications:

The study also provides implications for regulators.

Regulatory authorities should encourage:

- standardised sustainability disclosures;

- responsible FinTech innovation;
- digital financial inclusion;
- cybersecurity;
- responsible AI;
- climate-risk disclosure;
- green-finance taxonomies; and
- interoperability of digital financial infrastructure.

The continued development of standardised sustainability disclosures is particularly important because reliable and comparable data are necessary for researchers, investors, regulators and financial institutions.

SEBI's development of BRSR Core and assurance requirements represents an important step in this direction.

Implications for FinTech Firms:

FinTech companies should move beyond the traditional objective of improving transaction speed and convenience.

Future FinTech solutions should increasingly incorporate:

- financial inclusion;
- responsible lending;
- green finance;
- climate-risk analytics;
- ESG data;
- customer protection; and
- cybersecurity.

Collaboration between banks and FinTech firms can therefore become an important mechanism for advancing sustainable banking.

Limitations:

The study has several limitations.

First, the study depends on the availability and consistency of publicly disclosed information.

Second, some digital transformation indicators may not be reported consistently across banks.

Third, sustainability disclosure quality may vary across institutions and years.

Fourth, an index constructed from publicly available indicators inevitably involves some researcher judgement regarding indicator selection and weighting.

Fifth, the study examines association rather than establishing definitive causality.

These limitations can be addressed in future research through improved standardisation of digital-transformation measures and the use of larger longitudinal datasets.

Future Research:

Future research can extend this study in several directions.

First, researchers can examine whether the effect of digital transformation differs between public-sector and private-sector banks.

Second, future studies can investigate whether financial inclusion mediates the relationship between FinTech and social sustainability.

Third, green finance can be examined as a mediating mechanism between digital transformation and environmental sustainability.

Fourth, researchers can examine whether cybersecurity capability moderates the relationship between digitalisation and sustainable banking.

Finally, comparative studies can examine India against other emerging economies.

Conclusion:

The digital transformation of banking represents one of the most significant structural changes occurring in the financial sector. In India, this transformation is taking place alongside a growing institutional emphasis on sustainable finance, climate-risk management, financial inclusion and ESG disclosure.

This study argues that FinTech can contribute to sustainable banking through three principal pathways.

First, digital transformation can improve **economic sustainability** by increasing efficiency, innovation and resilience.

Second, digital financial services can contribute to **social sustainability** through greater financial inclusion and accessibility.

Third, digital capabilities can support **environmental sustainability** by facilitating green finance, climate-risk assessment and more efficient resource utilisation.

However, FinTech does not automatically produce sustainable banking.

The central proposition of this study is therefore:

FinTech creates the technological capability for sustainable banking, but organisational transformation and responsible governance determine whether that capability produces measurable sustainability outcomes.

By combining systematic literature review with secondary bank-level data, the study provides a replicable framework for examining this relationship without relying on subjective survey responses.

The proposed Digital Transformation Index and Sustainable Banking Index offer a practical methodology for measuring the relationship between digitalisation and sustainability across Indian banks.

The study therefore contributes to the emerging literature by positioning digital transformation not merely as a source of technological efficiency, but as a potential strategic capability for creating **economically viable, socially inclusive and environmentally responsible banking systems**.

References:

1. Basel Committee on Banking Supervision (2024), *Digitalisation of Finance*, Bank for International Settlements, Basel.
2. Reserve Bank of India (2022), "Green Finance and Climate Risk in India", *RBI Bulletin*, Reserve Bank of India, Mumbai.
3. Reserve Bank of India (2023), "Framework for Acceptance of Green Deposits", RBI/2023-24/14, Department of Regulation, Reserve Bank of India.
4. Reserve Bank of India (2025), "Building a Robust Ecosystem for Green and Sustainable Finance in India", *RBI Bulletin*, 21 May.
5. Reserve Bank of India (2025), *Annual Report 2024-25*, Reserve Bank of India, Mumbai.
6. SEBI (2021), "Business Responsibility and Sustainability Reporting by listed entities", Circular No. SEBI/HO/CFD/CMD-2/P/CIR/2021/562, Securities and Exchange Board of India.
7. SEBI (2023), "BRSR Core – Framework for assurance and ESG disclosures for value chain", Circular No. SEBI/HO/CFD/CFD-SEC-2/P/CIR/2023/122, Securities and Exchange Board of India.
8. SEBI (2025), *Business Responsibility and Sustainability Reporting: Regulatory Developments*, Securities and Exchange Board of India.
9. World Bank (2022), *The Global Findex Database 2021: Financial Inclusion, Digital Payments, and Resilience in the Age of COVID-19*, World Bank, Washington, DC.
10. World Bank (2022), *Fintech and the Future of Finance*, World Bank, Washington, DC.
11. World Bank (2025), *The Global Findex Database 2025*, World Bank, Washington, DC.

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India's Changing Tax System: Issues, Reforms and Challenges

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Abstract:

India's tax system has undergone significant transformation over the last decade, moving from a largely fragmented and paper-based structure towards a more integrated, technology-driven and taxpayer-oriented system. The introduction of the Goods and Services Tax (GST) in 2017 was a major reform in indirect taxation, while income-tax administration has increasingly adopted digital filing, faceless assessments, electronic verification and data-based compliance. More recently, the ***Income Tax Act, 2025****, which came into effect from* ***1 April 2026****, replaced the Income Tax Act, 1961 and introduced a reorganised and simplified legislative framework. The new Act reduces the number of sections and consolidates several provisions with the stated objective of making tax law easier to understand and comply with.*

Keywords: Indian Tax System, GST, Income Tax, Tax Reforms, Digital Taxation, Tax Compliance, Tax Administration, Income Tax Act 2025.

Introduction:

Taxation is one of the most important instruments through which a government mobilises resources for economic development and public welfare. In India, tax revenue finances infrastructure, education, healthcare, social security, defence and various development programmes. At the same time, taxation affects households, businesses, investment decisions, consumption and economic activity.

India's tax structure has historically consisted of numerous central and state taxes, exemptions, procedures and administrative mechanisms. Before GST, businesses operating across different states had to deal with multiple indirect taxes and different compliance requirements. The introduction of GST represented a major restructuring of indirect taxation. According to the Central Board of Indirect Taxes and Customs (CBIC), GST subsumed several central and state taxes and was designed to create a more integrated tax structure.

Income-tax administration has also changed considerably. Digital filing, online tax payments, electronic communication and faceless proceedings have reduced the dependence on physical interaction between taxpayers and tax authorities. The latest major development is the **Income Tax Act, 2025**, which replaced the Income Tax Act, 1961 from 1 April 2026.

Thus, India's changing tax system can be understood as a transition from a complex, fragmented and largely procedure-oriented framework towards a **digital, integrated and increasingly taxpayer-centric system**.

Objectives of The Study:

1. To understand the structure and evolution of India's tax system from the pre-reform period to the present.

2. To examine the major tax reforms introduced in India,
3. To analyse the impact of tax reforms on taxpayers, businesses, government revenue and the overall economy.
4. To identify the major issues associated with India's existing tax system,
5. To study the role of technology in improving tax collection, tax compliance, assessment and taxpayer services.

Research Methodology:

The study titled "India's Changing Tax System: Issues, Reforms and Challenges" adopts a descriptive and analytical research methodology. The study is primarily based on secondary data collected from reliable sources such as the Ministry of Finance, Government of India, Income Tax Department, Central Board of Direct Taxes (CBDT), Central Board of Indirect Taxes and Customs (CBIC), GST Council, Reserve Bank of India (RBI), Economic Survey, Union Budget documents, research journals, books, newspapers and credible websites.

Evolution of India's Tax System:

The Indian tax system has developed through several important stages.

1. Pre-GST Indirect Tax System:

Before GST, indirect taxation involved several taxes imposed by the Centre and the states. Central taxes included excise duty and service tax, while states imposed VAT, entry tax, luxury tax, entertainment tax and other levies.

2. Introduction of GST:

GST was introduced on **1 July 2017** as a major reform of indirect taxation. It replaced or subsumed several central and state taxes. Under the GST framework, the Centre administers CGST and IGST, while states administer SGST; GST rates are recommended by the GST Council.

3. Digitalisation of Income Tax:

Income-tax administration has increasingly moved online. Taxpayers can file returns, make payments, receive notices and undertake several compliance procedures electronically.

The Income Tax Department has confirmed that faceless assessment and faceless appellate frameworks continue under the Income Tax Act, 2025.

4. Income Tax Act, 2025:

A significant recent reform is the replacement of the Income Tax Act, 1961 with the Income Tax Act, 2025 from **1 April 2026**.

The Income Tax Department states that the new Act contains **536 sections and 16 schedules**, compared with 819 sections and 14 schedules in the 1961 Act. It also reduces the Income Tax Rules from 511 rules and 399 forms to 333 rules and 190 forms.

One notable change is the introduction of the term **"tax year"**, replacing the earlier distinction between "previous year" and "assessment year." The tax year corresponds to the financial year, with the new terminology applying from 1 April 2026.

Major Tax Reforms in India:

1. Goods and Services Tax:

GST is one of the most important structural reforms in India's taxation system. It brought several indirect taxes under a common framework and aimed to create a more integrated domestic market.

The GST system has also introduced extensive electronic compliance, including registration, return filing, invoicing and other online processes.

However, the transition to GST also created difficulties for businesses, particularly smaller enterprises that had limited experience with regular online filing and reconciliation.

CBIC has identified unfamiliarity with the new system, technological issues, return filing, reconciliation and IT infrastructure as some of the challenges associated with GST implementation.

2. Digital Tax Administration:

Digitalisation has become a central feature of India's tax administration. Online return filing, electronic payments, digital notices, information reporting and faceless proceedings have changed the relationship between taxpayers and the tax administration.

Digitalisation can improve efficiency and reduce opportunities for unnecessary physical interaction. However, it also requires taxpayers to have access to reliable internet connectivity, digital devices and adequate knowledge.

3. New Income Tax Regime:

India has also moved towards a simplified income-tax structure through the new tax regime. For eligible individual taxpayers and certain other categories, the new regime became the default regime, while taxpayers meeting the conditions can opt for the old regime.

The broad policy direction is towards fewer deductions and exemptions combined with comparatively lower tax rates under the new regime. However, taxpayers may need to compare their circumstances carefully because the financial effect differs depending on income, deductions and investments.

4. Income Tax Act, 2025:

The Income Tax Act, 2025 represents an attempt to modernise direct-tax legislation. According to the Income Tax Department, its objectives include:

- Simplifying statutory language
- Reducing unnecessary complexity
- Consolidating provisions
- Improving structural clarity
- Reducing interpretational difficulties
- Promoting voluntary compliance
- Supporting ease of doing business

The new Act does not itself introduce a new tax; rather, it reorganises and modernises the income-tax law.

Major Issues in India's Changing Tax System:

1. Complexity of Tax Laws:

Although reforms have attempted to simplify taxation, Indian tax laws remain extensive. Frequent amendments, notifications, circulars and procedural requirements can make compliance difficult for ordinary taxpayers and small businesses.

The Income Tax Act, 2025 specifically seeks to address this problem by consolidating provisions and using clearer drafting.

2. Compliance Burden:

Tax compliance involves registration, record keeping, invoicing, return filing, reconciliation, tax payments and responding to notices.

For large companies, professional accountants and tax consultants can manage these requirements. Small businesses and individual taxpayers may have fewer resources and may therefore experience relatively higher compliance costs.

3. Digital Divide:

Digital taxation can improve efficiency, but it can also create difficulties for people with limited digital literacy or poor internet access.

This issue is particularly relevant for:

- Rural entrepreneurs
- Small traders
- Micro enterprises
- Senior citizens
- First-time taxpayers
- Persons with limited digital skills

Therefore, digitalisation should be accompanied by taxpayer education and accessible support systems.

4. Tax Disputes and Litigation:

Tax disputes can arise because of differences in interpretation, classification, valuation, deductions, exemptions and procedural matters.

The Income Tax Act, 2025 consolidates provisions relating to appeals, revision and alternative dispute-resolution mechanisms in an effort to provide a more organised framework for resolving disputes.

5. Informal Economy:

A significant challenge is bringing economic activity into the formal tax system without creating excessive compliance costs for small enterprises.

Digital payments, GST registration and information-based taxation can support formalisation. However, excessive procedural requirements may discourage very small businesses from entering the formal sector.

Challenges of GST:

GST has transformed India's indirect tax system, but its implementation has involved several challenges.

1. Multiple Tax Rates:

The existence of different GST rates for different categories of goods and services can create classification issues and increase complexity.

2. Return Filing and Reconciliation:

Businesses have to maintain accurate records and reconcile transactions. Errors in invoices or records can create compliance problems.

3. Technology Dependence:

GST relies heavily on digital infrastructure. Technical difficulties can affect businesses when they are trying to file returns or complete other compliance requirements.

CBIC has acknowledged that system unfamiliarity, IT infrastructure and system delays were among the challenges encountered during GST implementation.

4. Small Business Challenges:

Small and medium enterprises may face difficulties in understanding GST procedures, maintaining digital records and meeting filing requirements.

5. Frequent Changes:

Tax rules and procedures may change through notifications and amendments. Businesses therefore need to continuously monitor regulatory developments.

Challenges under the New Income Tax Framework:

The implementation of the Income Tax Act, 2025 also creates a period of transition.

The old and new frameworks need to operate alongside each other for different tax years. For example, income earned during FY 2025–26 continues to be governed by the Income Tax Act, 1961 for the relevant assessment, while the new Act applies to tax years beginning from 1 April 2026.

This transition can create temporary confusion regarding:

- Tax year terminology
- Applicable provisions
- Return forms
- Assessments
- Appeals
- Transitional provisions
- TDS and other compliance requirements

The Income Tax Department has therefore provided specific guidance regarding the coexistence of the old and new frameworks during the transition period.

Tax Reforms and Small Businesses:

Small and medium enterprises are important contributors to employment and economic development. However, they can be

particularly sensitive to taxation and compliance costs.

A modern tax system should therefore ensure:

1. Simple registration procedures.
2. Easy-to-understand return filing.
3. Affordable professional assistance.
4. Accessible digital platforms.
5. Timely refunds.
6. Quick resolution of disputes.
7. Clear communication of tax changes.
8. Appropriate compliance support for micro enterprises.

Tax reform should not focus only on increasing revenue. It should also reduce unnecessary administrative costs for taxpayers.

Role of Technology in India's Tax System:

Technology is increasingly becoming the foundation of Indian tax administration.

Major technological developments include:

- Online income-tax returns
- Digital tax payments
- Electronic GST returns
- E-way bills
- E-invoicing
- Digital information reporting
- Online notices
- Faceless assessment
- Data analytics
- Online grievance mechanisms

Findings:

The study of India's changing tax system leads to several important findings:

1. India has moved significantly towards a **digital and technology-driven tax administration**.
2. GST has substantially reorganised India's indirect taxation by bringing several central and state taxes under a common framework.
3. The **Income Tax Act, 2025** represents a major restructuring of direct-tax legislation and applies from 1 April 2026.
4. The concept of **"tax year"** is intended to simplify the earlier distinction between previous year and assessment year.
5. Digitalisation can improve efficiency, transparency and compliance, but it also creates challenges for taxpayers with limited digital access or skills.
6. Small and medium enterprises remain particularly sensitive to compliance costs and technological requirements.
7. Tax reform is not a one-time process. Continuous evaluation is necessary to ensure that changes actually reduce complexity and improve taxpayer services.

Recommendations

The following measures can further strengthen India's changing tax system.

1. Simplify Tax Procedures: Tax laws and compliance procedures should be written in simple and understandable language.

2. Reduce Unnecessary Compliance: Small taxpayers should not face the same administrative burden as large corporations where the risk and scale of activity are substantially different.

3. Strengthen Digital Infrastructure: GST and income-tax platforms should be reliable, user-friendly and capable of handling high transaction volumes.

4. Improve Taxpayer Education: Regular awareness programmes should be conducted for students, employees, farmers, traders, entrepreneurs and small businesses.

5. Provide Better Rural Support: Taxpayer facilitation centres and digital assistance should be strengthened in rural and semi-urban areas.

6. Reduce Tax Litigation: Clear rules, advance guidance and faster dispute-resolution mechanisms can reduce prolonged tax disputes.

7. Maintain Policy Stability: Businesses require predictable taxation to make long-term investment decisions.

8. Strengthen Data Security: As tax administration becomes increasingly digital, strong safeguards are necessary to protect taxpayer information.

9. Improve Refund Mechanisms: Legitimate refunds should be processed efficiently so that taxpayers do not face unnecessary delays.

10. Balance Revenue and Compliance: Tax administration should seek revenue mobilisation while avoiding unnecessary compliance costs for taxpayers.

Conclusion:

India's tax system is undergoing a significant transformation. The journey from multiple indirect taxes towards GST, the rapid expansion of digital tax administration and the introduction of the Income Tax Act, 2025 demonstrate a broader movement towards an integrated, technology-based and simplified tax framework.

The Income Tax Department describes the 2025 Act as an effort to simplify the structure, reduce complexity and improve taxpayer understanding. At the same time, the experience of GST demonstrates that major tax reforms can create transitional difficulties, particularly in relation to technology, compliance, reconciliation and taxpayer awareness.

The future of India's taxation system will therefore depend not only on the introduction of new laws but also on **effective implementation, taxpayer education, digital accessibility, administrative efficiency, policy stability and timely dispute resolution**. A successful tax system should generate adequate public revenue while remaining understandable, predictable and reasonably accessible to taxpayers.

India's changing tax system is consequently not simply a story of new tax laws. It represents a broader transition in the relationship between the **government, taxpayers, technology and the economy**. The continuing challenge is to ensure that tax modernisation produces both effective revenue administration and a better compliance experience for citizens and businesses.

References:

1. Central Board of Indirect Taxes and Customs. *Goods and Services Tax: Concept and Status*. Government of India.
2. Central Board of Indirect Taxes and Customs. *Know About GST*. Government of India.
3. Income Tax Department. *Objective and Scope of the New Act: Income Tax Act, 2025*. Government of India.
4. Income Tax Department. *Income Tax Act, 2025*. Government of India.
5. Income Tax Department. *FAQs on New Tax vs Old Tax Regime*. Government of India.
6. Income Tax Department. *Income Tax Returns FAQs*. Government of India.

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Artificial Intelligence in Entrepreneurship: Transforming Innovation and Business Growth towards Viksit Bharat@2047

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Abstract:

Artificial Intelligence (AI) is increasingly becoming a business-enabling technology that can influence opportunity identification, innovation, operational efficiency, customer engagement and strategic decision-making. For Indian entrepreneurs, particularly startups and Micro, Small and Medium Enterprises (MSMEs), AI can lower the cost of accessing analytical and digital capabilities while creating new possibilities for products, services and business models. At the same time, AI adoption is not automatically beneficial; outcomes depend on data quality, organisational capability, human expertise, infrastructure, governance and the nature of the task. Recent OECD evidence highlights the importance of human–AI collaboration, while the World Economic Forum identifies AI and big data among the fastest-growing skill areas and reports substantial training requirements in India. This conceptual study examines the role of AI in entrepreneurship in the context of Viksit Bharat@2047. It uses secondary evidence from academic literature, Government of India sources, the OECD and the World Economic Forum. The study maps major entrepreneurial applications of AI, examines opportunities and adoption barriers, and discusses policy measures for inclusive and responsible AI-enabled entrepreneurship. The analysis suggests that India's expanding startup ecosystem and growing demand for AI-related capabilities provide a significant context for AI-enabled entrepreneurship; however, sustained benefits require investment in skills, digital infrastructure, data governance, cybersecurity, industry–academia collaboration and responsible AI practices.

Keywords: Artificial Intelligence; Entrepreneurship; Startups; MSMEs; Innovation; Generative AI; Digital Transformation; Viksit Bharat@2047.

Introduction:

Entrepreneurship contributes to economic development by creating enterprises, employment, innovation and new sources of value. Digital technologies have changed how entrepreneurs discover opportunities, reach customers, manage resources and scale operations. Among these technologies, Artificial Intelligence (AI) has become increasingly relevant because it can process large volumes of information, identify patterns, generate content, support prediction and automate selected tasks. These capabilities can assist entrepreneurs in activities ranging from market research and customer service to financial planning, supply-chain management and product development.

The entrepreneurial relevance of AI is broader than automation alone. Generative AI can support ideation, communication and knowledge work; predictive systems can assist forecasting; recommendation systems can personalise customer interactions; and analytical tools can help entrepreneurs interpret business data. However, AI is best understood as a capability

that complements managerial judgement rather than as a substitute for entrepreneurial responsibility. OECD evidence indicates that the effects of generative AI vary according to the user, the task and the way the technology is integrated into work, making meaningful human–AI collaboration important for productive outcomes (Calvino, Reijerink, & Samek, 2025).

India's Viksit Bharat@2047 vision provides a long-term development context in which economic development, innovation, technological capability and inclusive growth are important considerations. In this setting, AI-enabled entrepreneurship can be examined not only through firm-level productivity but also through its potential contribution to innovation ecosystems, MSME competitiveness, employment and skill development. The central issue is how India can capture the productive benefits of AI while managing risks related to skills, data, cyber security, unequal access and responsible use.

Review of Literature:

Research increasingly treats AI as a factor in entrepreneurial opportunity recognition, innovation and venture development. Chalmers, MacKenzie and Carter (2021) discuss the implications of AI for venture creation in the Fourth Industrial Revolution. Siddiqui, Mumtaz and Ahmad (2024) map the growth of research on AI and entrepreneurship through bibliometric analysis. Uriarte et al. (2026) further examine the relationship between AI technologies and entrepreneurial opportunity identification, business-model innovation and strategic decision-making.

Recent OECD evidence provides a complementary perspective. Calvino, Reijerink and Samek (2025) review experimental research on generative AI and identify potential benefits for productivity, innovation and entrepreneurship, while emphasizing that outcomes depend on user experience, task characteristics and human oversight. The OECD also notes that generative AI can support idea generation and product or service development, but that AI-generated outputs may require expert validation because they can lack practicality, depth or diversity.

The World Economic Forum's Future of Jobs Report 2025 provides a labour-market perspective. Its India analysis reports that approximately 63% of Indian workers are expected to require training by 2030, while 12% are unlikely to receive the training they need. The report also states that 67% of companies in India expect to tap more diverse talent pools and 30% anticipate using skills-based hiring approaches. These indicators underline the importance of human capital in AI-enabled entrepreneurship (World Economic Forum, 2025).

Overall, the reviewed literature indicates that AI can influence entrepreneurship through opportunity recognition, innovation, productivity, business-model development and decision support. However, the literature also highlights that entrepreneurial value depends on the context in which AI is deployed, including user capability, task characteristics, data availability, organizational readiness and human oversight. The existing literature therefore supports a balanced perspective in which AI is treated as an enabling capability rather than an automatic determinant of entrepreneurial performance. This study builds on that perspective by connecting AI-enabled entrepreneurship with India's startup and MSME ecosystem and the broader development context of Viksit Bharat@2047.

Objectives of the Study:

1. To examine the role of Artificial Intelligence in entrepreneurship and innovation.

2. To identify major entrepreneurial applications and opportunities created by AI for startups and MSMEs.
3. To analyse the principal challenges associated with AI adoption in entrepreneurial activities.
4. To examine the potential contribution of AI-enabled entrepreneurship to development objectives associated with Viksit Bharat@2047.
5. To suggest practical and policy-oriented measures for strengthening an inclusive, skilled and responsible AI entrepreneurship ecosystem in India.

Research Methodology:

The study is conceptual and is based on secondary data. Evidence was drawn from peer-reviewed academic literature, Government of India sources, Startup India/DPIIT publications, IndiaAI Mission materials, OECD publications and the World Economic Forum's Future of Jobs Report 2025. The literature and institutional evidence were reviewed using descriptive and qualitative analysis to examine the relationship between AI applications, entrepreneurship, innovation, skills and development objectives. The study focuses on identifying major applications, opportunities, challenges and enabling conditions associated with AI-enabled entrepreneurship in India.

No primary survey or interview data were collected. Therefore, the study does not estimate the causal effect of AI adoption on the performance of Indian firms, employment, GDP or other macroeconomic outcomes. Numerical figures are presented with their relevant year or reference date wherever available, while qualitative arguments are treated as conceptual interpretations of the reviewed evidence rather than as causal estimates.

Scope and Limitations:

The study focuses on AI in entrepreneurship, with particular attention to startups and MSMEs in India and the wider development context of Viksit Bharat@2047. It covers opportunity recognition, marketing, customer service, finance, human resources, supply chains, analytics and product development.

- The study relies on secondary sources and does not contain primary survey evidence.
- The evidence base is rapidly evolving because AI technologies and business practices are changing quickly.
- Startup counts represent DPIIT recognition milestones and should not be interpreted automatically as counts of currently operating firms.
- The study discusses potential contributions of AI to entrepreneurship but does not estimate a causal impact on national GDP, employment or individual firm performance.
- The study draws on heterogeneous secondary sources, including academic studies, government reports and institutional reports; therefore, differences in definitions, reference periods and measurement approaches may limit direct comparability across indicators.

AI and Entrepreneurship:

AI can influence entrepreneurship across the business lifecycle. At the opportunity-identification stage, entrepreneurs can use data analysis, search, customer feedback and predictive tools to identify patterns in demand and competition. During business planning, analytical systems can support scenario analysis, pricing, resource allocation and forecasting. In operations, automation can assist repetitive workflows,

inventory monitoring and selected supply-chain activities. In marketing and customer management, AI can support segmentation, personalisation, chatbots, content generation and sentiment analysis. In finance, it can assist forecasting, anomaly detection and selected risk-management activities. In product development, generative and analytical systems can accelerate ideation, prototyping and testing, although human validation remains essential.

These applications are especially relevant to smaller firms because cloud-based services can provide access to capabilities that previously required larger internal teams. Nevertheless, the business value of an AI tool depends on implementation. Entrepreneurs need to assess whether the problem is suitable for AI, whether reliable data are available, whether the expected benefit justifies the cost, and whether the use of AI creates privacy, security, bias or intellectual-property risks.

Applications:

Table 1. Major Applications of AI in Entrepreneurship

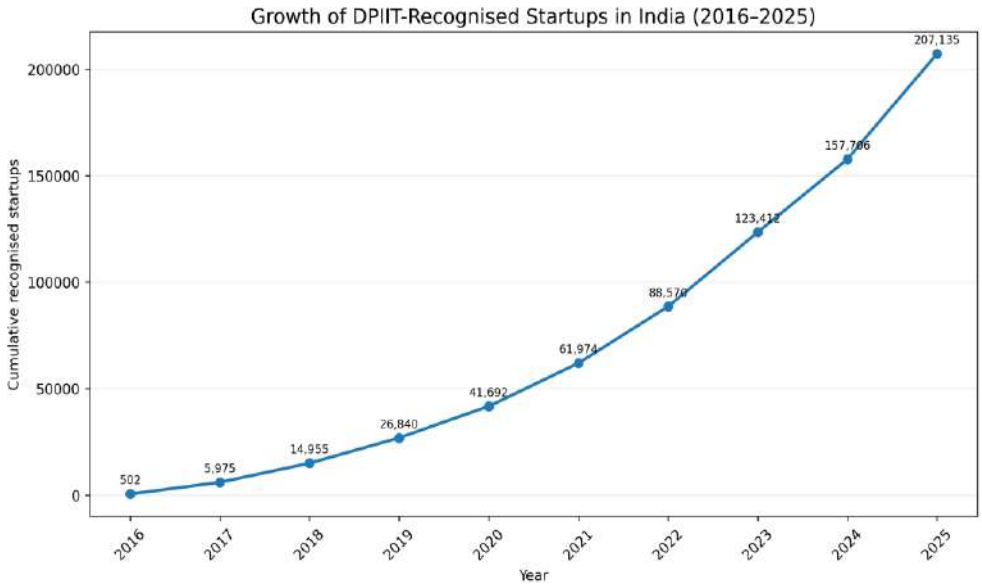
Business Function	AI Application	Potential Entrepreneurial Value
Market research & opportunity identification	Pattern analysis, forecasting, customer-data analysis	Faster evidence-based opportunity assessment
Marketing & sales	Segmentation, recommendations, content assistance, campaign analytics	More targeted communication and efficient marketing-resource use
Customer service	Chatbots, virtual assistants, sentiment analysis	Faster responses and support availability
Finance	Forecasting, anomaly detection, analytical decision support	Improved planning and risk monitoring
Human resources	Candidate screening and workforce analytics	Reduced administrative workload and more structured processes
Supply chain	Demand forecasting, inventory analytics	Better planning and resource utilisation
Product/service development	Generative AI, analytics, prototyping support	Faster ideation and experimentation
Business analytics	Data mining and predictive analytics	Improved managerial information

Source: Compiled by the author based on Chalmers, MacKenzie and Carter (2021), OECD (2025), and Siddiqui, Mumtaz and Ahmad (2024).

Indian Startup Evidence:

India's startup ecosystem has expanded substantially in terms of DPIIT recognition. Government of India data reported more than 2.23 lakh DPIIT-recognised startups as of 31 March 2026, generating more than 23.36 lakh direct jobs. More than 1.07 lakh recognised startups had at least one woman director or partner, representing approximately 48% of recognised startups. These figures describe the scale of the recognised entrepreneurial ecosystem and provide context for AI-enabled entrepreneurship; they do not establish that AI caused startup growth or employment generation.

Figure 1. Growth of DPIIT-Recognised Startups in India (2016–2025)



Source: Government of India, Press Information Bureau (PIB), 13 February 2026, Annexure-I. Cumulative values calculated by the author from year-wise DPIIT recognition figures as of 31 December 2025.

Note: The line chart presents cumulative DPIIT-recognised startup milestones derived from annual recognition figures. The 2025 point refers to 31 December 2025 and should not be interpreted as a measure of AI-caused startup growth or as a count of currently operating firms.

Table 2. Selected Startup Ecosystem Indicators

Indicator	Reported Figure	Reference Point
DPIIT-recognised startups	More than 2.23 lakh	31 March 2026
Recognised startups with at least one woman director or partner	More than 1.07 lakh	31 March 2026
Direct jobs created by recognised startups	More than 23.36 lakh	31 March 2026

Source: Government of India, Press Information Bureau (PIB), 17 April 2026.

Viksit Bharat@2047:

AI can be linked to Viksit Bharat@2047 through several channels: productivity improvement, innovation, digital transformation, entrepreneurship, skills and more efficient use of resources. The relationship should, however, be stated as a potential contribution rather than a guaranteed outcome. For example, AI-enabled forecasting may improve inventory decisions, but the result depends on data quality and implementation. Similarly, generative AI can lower the cost of producing prototypes or business content, but human review is needed to manage errors and inappropriate outputs.

Table 3. Potential Contribution of AI to Development Objectives

Development Area	Potential Contribution of AI	Important Condition
Productivity	Automation and analytical decision support	Appropriate task selection and process redesign
Entrepreneurship	Lower barriers to experimentation and access to digital capabilities	Affordable tools, skills and business support
Innovation	Ideation, prototyping and data-supported product development	Human validation and intellectual-property awareness
MSME development	Forecasting, customer analytics and workflow support	Cost-effective deployment and digital readiness
Employment & skills	New roles in AI, data, cyber security and analytics	Continuous reskilling and inclusive access
Sustainability	Resource optimization, monitoring and predictive systems	Reliable data and measurable environmental outcomes
Digital economy	Personalised services, e-commerce and intelligent digital processes	Connectivity, trust and cybersecurity

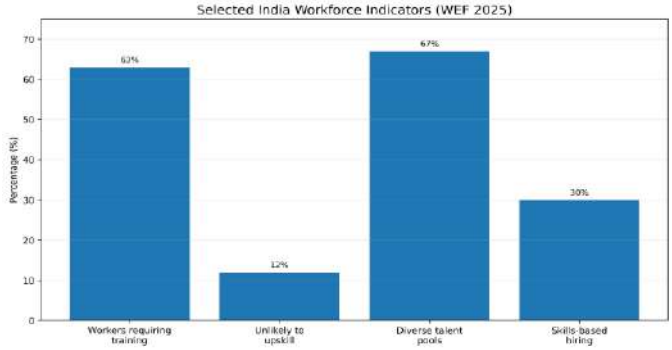
Source: Compiled by the author based on OECD (2025), Government of India/IndiaAI Mission, and World Economic Forum (2025).

Skills and Human Capital:

AI-enabled entrepreneurship depends on human capability as much as on technology. The World Economic Forum's 2025 findings indicate that approximately 63% of Indian workers are expected to require training by 2030, while 12% are unlikely to receive the training they need. The India analysis also reports that 67% of companies expect to tap more diverse talent pools and around 30% plan to use skills-based hiring approaches. These indicators suggest that entrepreneurship education should combine digital literacy with business judgment, analytical thinking and the ability to evaluate AI outputs.

For entrepreneurs, practical capability includes digital literacy, data literacy, prompting and AI-output verification skills, cyber security awareness, analytical thinking and domain knowledge. The objective is not merely to teach people how to operate AI tools, but to develop the ability to judge when AI should be used, verify outputs and integrate AI into sound business processes.

Figure 2. Selected India Workforce Indicators



Source: World Economic Forum (2025), Future of Jobs Report 2025. Figures refer to employer-reported expectations for India and should not be interpreted as causal estimates of AI's effect on employment.

Challenges in AI Adoption:

The adoption of AI presents several barriers for entrepreneurs. Cost can be a constraint when firms require cloud services, specialized software, data preparation or external expertise. Skill shortages can limit implementation quality. Data privacy and cyber security risks become more significant as businesses process customer and operational information. Ethical concerns include bias, explain ability, accountability and inappropriate automation. Smaller firms may also face difficulties accessing high-quality data, computing resources and specialized talent. OECD analysis also identifies trust, human expertise and access to data and computing resources as important considerations.

Table 4. Challenges and Suggested Responses

Challenge	Possible Impact	Suggested Response
Implementation cost	Delayed or partial adoption	Affordable cloud tools, shared infrastructure and targeted financial support
AI skill shortage	Poor implementation and dependence on external vendors	AI education, reskilling and practical entrepreneurship training
Data privacy	Loss of trust and regulatory exposure	Data-governance policies, access controls and privacy-by-design
Cybers ecurity	Business disruption and data loss	Security controls, awareness training and incident-response planning
Bias and lack of transparency	Unfair or unreliable decisions	Human oversight, testing, documentation and responsible-AI governance
Digital infrastructure gaps	Unequal access to AI capabilities	Connectivity, cloud access and digital public infrastructure
Vendor/data dependence	Higher switching costs and concentration risk	Interoperability, diversified suppliers and capability building

Source: Compiled by the author based on OECD (2025), Government of India/IndiaAI Mission, and literature on responsible AI.

India AI Mission: Financial and Infrastructure Context:

The India AI Mission provides an important policy-level context for AI-enabled entrepreneurship. The Union Cabinet approved the mission in March 2024 with a total approved outlay of ₹10,371.92 crore over five years. The mission covers compute capacity, foundation models, datasets, application development, Future Skills, startup financing and safe and trusted AI. Government reporting has subsequently indicated that more than 38,000 GPUs had been on boarded under the common compute facility, compared with the initial target of 10,000 GPUs. These developments illustrate the potential importance of public infrastructure and policy support in reducing barriers to AI access.

The reported financial figures represent approved allocations or outlay and should not be interpreted as expenditure already incurred unless the cited source explicitly reports actual expenditure.

Table 5. India AI Mission Financial Allocation

IndiaAI Mission Component	Outlay (crore)
IndiaAI Compute Capacity	4,563.36
IndiaAI Foundation Models	1,971.37
IndiaAI Datasets Platform	199.55
IndiaAI Application Development Initiative	689.05
IndiaAI FutureSkills	882.94
IndiaAI Startup Financing	1,942.50
Safe & Trusted AI	20.46
Overheads and contingency	102.69
Total	10,371.92

Source: Ministry of Electronics and Information Technology (MeitY), Government of India, IndiaAI Mission; Government of India/PIB, 2025–2026.

Table 6. Selected AI Infrastructure and Workforce Indicators for India

Indicator	Value	Reference Point
Original IndiaAI compute target	10,000+ GPUs	March 2024 approval
National compute capacity reported under IndiaAI	More than 38,000 GPUs	Government updates, 2025–2026
Indian workers expected to require training	63%	By 2030
Workers unlikely to upskill	12%	By 2030
Indian companies expecting to tap diverse talent pools	67%	WEF 2025
Indian companies planning skills-based hiring	30%	WEF 2025

Source: Government of India/IndiaAI Mission and World Economic Forum (2025), Future of Jobs Report 2025.

Major Findings:

- AI is relevant to entrepreneurship because it can support opportunity identification, decision-making, customer engagement, innovation and selected operational tasks.
- The potential value of AI is greater when it is integrated with entrepreneurial judgement, domain knowledge and well-designed business processes rather than used as an isolated technology.
- India's startup ecosystem has expanded substantially, creating a broad context in which AI-enabled ventures and AI adoption by existing startups can develop.
- Workforce capability is a major enabling factor, and current evidence points to substantial reskilling and upskilling requirements in India.
- The main barriers are not purely technical; they include cost, skills, data governance, cybersecurity, ethics, infrastructure and access to computing and quality data.
- AI can contribute to objectives associated with Viksit Bharat@2047, but such contribution depends on inclusive infrastructure, human capital, responsible governance and measurable business and social outcomes.

Policy and Practical Recommendations:

- **Strengthen AI education and skill development:** Universities, colleges, entrepreneurship centres and industry should combine AI literacy with practical business use cases, AI-output verification skills and domain knowledge.
- **Support AI adoption by startups and MSMEs:** Policy support should focus on affordable access, shared infrastructure, digital advisory services and financing mechanisms that reduce the initial adoption burden.
- **Promote industry–academia collaboration:** Colleges, research institutions, startups and established firms can collaborate on applied AI projects, internships, incubation and technology transfer.
- **Improve digital infrastructure:** Reliable broadband, cloud access and digital public infrastructure are important for extending AI-enabled entrepreneurship beyond major urban centres.
- **Strengthen responsible AI governance:** Entrepreneurs should establish clear practices for privacy, cybersecurity, human oversight, documentation, bias testing and accountability.
- **Build AI-focused innovation ecosystems:** Incubators, accelerators and innovation hubs can help entrepreneurs test AI applications while receiving technical and business mentoring.
- **Encourage public–private partnerships:** Government, industry and educational institutions can jointly develop training, datasets, sandboxes and responsible innovation programmes.

Discussion:

The evidence reviewed in this study supports a balanced interpretation of AI in entrepreneurship. AI can reduce the time and cost associated with information processing, content generation, forecasting and selected routine digital tasks. It can also support opportunity identification, customer engagement, product development and analytical decision-making. However, these potential benefits do not arise automatically from the adoption of an AI tool. They depend on the relevance of the business problem, the quality and availability of data, user capability, workflow integration and appropriate human oversight.

The findings also indicate that the entrepreneurial implications of AI extend beyond individual firms. India's growing startup ecosystem provides a broad environment for experimentation, while public initiatives such as the IndiaAI Mission can potentially reduce some infrastructure and capability barriers. At the same time, unequal access to skills, computing resources, quality data and digital infrastructure may limit the distribution of these benefits.

The workforce evidence reinforces the importance of human capital. AI-enabled entrepreneurship requires more than the ability to operate AI tools; entrepreneurs and employees need digital and data literacy, analytical thinking, domain knowledge, prompting and verification skills, cybersecurity awareness and the ability to exercise judgement over AI-generated outputs. This is consistent with the broader OECD emphasis on human–AI collaboration and the World Economic Forum's evidence on India's future training requirements.

The relationship between AI and Viksit Bharat@2047 should therefore be understood as a potential contribution rather than a guaranteed development outcome. AI can support

productivity, innovation, entrepreneurship, MSME development, skills and digital transformation, but the magnitude and distribution of these benefits depend on infrastructure, affordability, governance, human capability and responsible implementation. The central policy challenge is consequently not simply to expand AI adoption, but to build the institutional and human capabilities required to use AI productively and responsibly.

Conclusion:

Artificial Intelligence is emerging as an important enabling technology for entrepreneurship. Its applications extend across opportunity identification, marketing, customer service, finance, operations, analytics and product development. For startups and MSMEs, cloud-based AI services can widen access to analytical and digital capabilities that may previously have required specialised teams. India's expanding startup ecosystem and growing demand for AI-related skills provide an important context for further entrepreneurial experimentation.

However, AI should not be presented as a guaranteed source of business or economic growth. Its contribution depends on business relevance, data quality, human expertise, infrastructure, cybersecurity and responsible governance. In the context of Viksit Bharat@2047, the strategic priority is therefore to build an ecosystem in which entrepreneurs can access AI affordably, develop the skills required to use it effectively, and deploy it responsibly.

Coordinated investment in skills, digital infrastructure, innovation ecosystems, MSME support and trustworthy AI governance can help translate technological capability into sustainable entrepreneurial value. Future research should complement this conceptual analysis with firm-level and sector-specific empirical studies examining AI adoption, productivity, innovation, employment, investment and business performance among Indian startups and MSMEs.

References:

1. Calvino, F., Haerle, D., & Liu, S. (2025). Is generative AI a general purpose technology? Implications for productivity and policy. OECD Artificial Intelligence Papers, No. 40. OECD Publishing. https://doi.org/10.1787/704e2d12-en.
2. Government of India, Press Information Bureau. (2026). Government recognises more than 55,200 startups during FY 2025-26; total recognised startups cross 2.23 lakh. Ministry of Commerce & Industry.
3. Government of India, Press Information Bureau. (2026). IndiaAI Mission: updates on compute capacity and AI ecosystem development. Ministry of Electronics and Information Technology.
4. NITI Aayog. (2018). National Strategy for Artificial Intelligence (#AIforAll). Government of India.
5. Siddiqui, D., Mumtaz, U., & Ahmad, N. (2024). Artificial intelligence in entrepreneurship: A bibliometric analysis of the literature. Journal of Global Entrepreneurship Research, 14, Article 13. https://doi.org/10.1007/s40497-024-00385-5
6. Uriarte, S., Baier-Fuentes, H., Espinoza-Benavides, J., & Inzunza-Mendoza, W. (2026). Artificial intelligence technologies and entrepreneurship: A hybrid literature review. Review of Managerial Science, 20(1), 251–299. https://doi.org/10.1007/s11846-025-00839-4
7. World Economic Forum. (2025). The Future of Jobs Report 2025. World Economic Forum.

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The Future of Commerce in The Age of AI: Opportunities, Challenges and Emerging Trends

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Abstract:

Artificial Intelligence (AI) is increasingly influencing the Indian commerce sector by changing how businesses operate, make decisions, interact with customers, manage transactions, and deliver products and services. India provides a distinctive environment for AI-enabled commerce because the country combines a large digital consumer base with public digital infrastructure such as Unified Payments Interface (UPI) and the Open Network for Digital Commerce (ONDC), as well as national AI initiatives under the IndiaAI Mission. This paper examines the future of commerce in India with particular focus on emerging trends, opportunities, applications, and challenges. AI is relevant to Indian e-commerce, digital marketing, banking, finance, accounting, customer service, inventory management, supply-chain management, fraud detection, and business analytics. Recent official data show the scale of the digital environment: NPCI reported 24.51 billion UPI transactions in August 2026, while ONDC reported more than 500 million cumulative transactions by 25 July 2026. The Ministry of Electronics and Information Technology also reported that the IndiaAI Mission had established access to more than 38,000 GPUs and onboarded 3,011 datasets and 243 AI models by 2025–26. These developments create opportunities for productivity, inclusion, innovation, and data-driven decision-making, while also raising concerns about privacy, cybersecurity, ethics, employment, affordability, digital skills, and responsible use. The study concludes that India's AI-enabled commerce future will depend on combining technological innovation with human expertise, customer trust, skills, and effective governance.

Keywords: Artificial Intelligence, Indian Commerce, E-Commerce, UPI, ONDC, IndiaAI, Digital Transformation, Automation, Business Analytics.

Introduction:

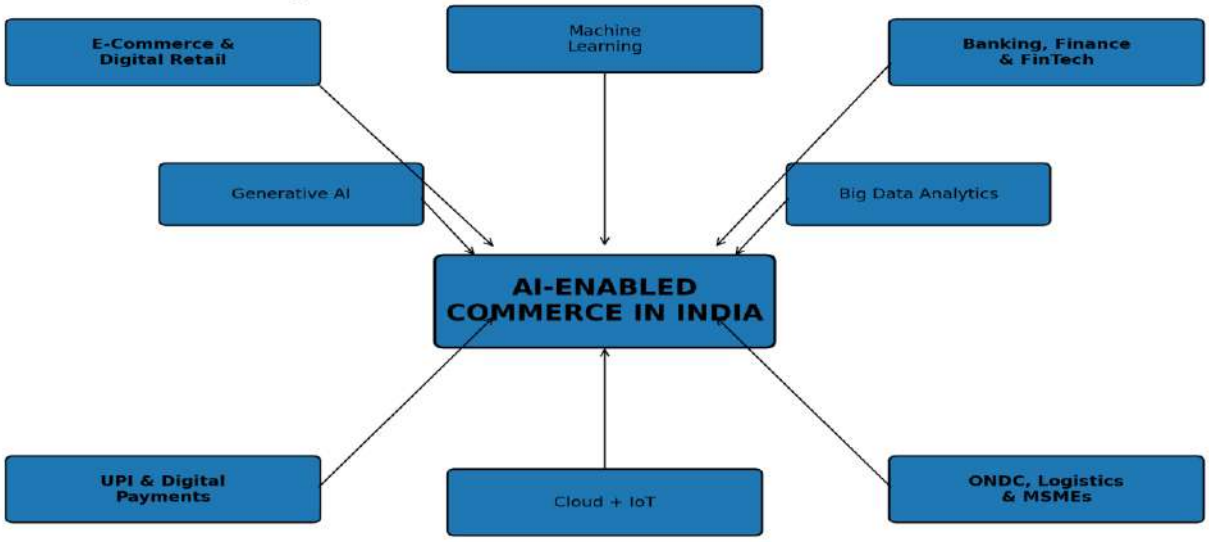
Artificial Intelligence (AI) refers to technologies that enable computers and machines to perform tasks associated with human intelligence, including learning from data, recognising patterns, generating content, making predictions, understanding language, and supporting decisions. AI is becoming increasingly relevant to commerce because modern businesses generate large amounts of transaction, customer, product, and operational data that can be processed using digital systems.

In India, AI-enabled commerce is developing alongside a strong digital payments ecosystem and expanding digital commerce infrastructure. The country's Unified Payments Interface (UPI) has become a major component of retail digital payments, while ONDC is being developed as open digital infrastructure for commerce. These systems create a large digital base within which AI applications can be used for fraud detection, recommendation systems, demand forecasting, customer service, marketing,

credit assessment, logistics, and business analytics.

India is also building national AI capacity. The IndiaAI Mission, approved by the Government of India in 2024, is designed around seven pillars covering compute capacity, datasets, foundation models, applications, future skills, startup financing, and safe and trusted AI. The Ministry of Electronics and Information Technology's 2025–26 annual report states that more than 38,000 GPUs and 14 cloud partners had been established, with 3,011 datasets and 243 AI models onboarded on AIKosh from 39 organisations across 20 sectors. Commerce is specifically included among the sectors represented in the dataset ecosystem.

Figure 1. AI-enabled Commerce Ecosystem in India



This figure illustrates how AI can connect India's digital commerce ecosystem with e-commerce, UPI-based payments, banking and finance, ONDC, logistics, MSMEs, and enabling technologies such as machine learning, generative AI, big data, cloud computing, and IoT.

Need of the Study:

The study is needed to understand how AI is shaping commerce in India and how Indian businesses can use the technology in a rapidly digitalising environment. India's commerce ecosystem includes organised retailers, e-commerce companies, banks, fintech firms, MSMEs, local merchants, logistics providers, marketplaces, and increasingly digital public infrastructure. AI can create opportunities across this broad ecosystem, but the effects are not uniform across sectors, regions, business sizes, or levels of digital readiness.

The study is also necessary because India is simultaneously expanding its digital payment infrastructure, open digital commerce infrastructure, and national AI capabilities. This creates an important setting for examining how AI can contribute to productivity, customer experience, fraud management, supply-chain efficiency, financial inclusion, and business analytics.

At the same time, data privacy, cybersecurity, algorithmic bias, implementation costs, digital divides, and the need for skilled professionals require careful consideration.

A further need is educational. Commerce students and professionals in India increasingly need to understand not only accounting, finance,

marketing, and management, but also digital payments, data analytics, automation, AI-assisted decision-making, and responsible technology use. This study therefore links technological trends with the changing requirements of commerce education and professional practice.

Objectives of the Study:

1. To understand the role of Artificial Intelligence in Indian commerce.
2. To examine the impact of AI on e-commerce and digital business in India.
3. To identify the opportunities and emerging trends created by AI, UPI, ONDC, and other digital technologies in India.
4. To examine the challenges of AI adoption and the changing skill requirements of commerce professionals in India.

Artificial Intelligence in Indian Commerce:

In Indian commerce, AI can be applied wherever large amounts of structured or unstructured data need to be interpreted or where routine tasks can be automated. Banking institutions can use AI to support fraud detection and customer service. E-commerce firms can use recommendation systems and demand forecasting. Retailers can use predictive analytics for inventory planning. Accounting functions can use automation for transaction processing and reconciliation support. Marketing teams can use AI to segment customers and develop content. Logistics businesses can use AI to improve routing and delivery planning.

Generative AI also creates new possibilities. Indian businesses can use multilingual AI systems to assist customers, generate product descriptions, summarise documents, support internal knowledge search, and help employees interact with business information in natural language. India's linguistic diversity makes multilingual AI particularly relevant to customer service and market access, although accuracy and quality assurance remain essential.

The value of AI depends on business readiness. High-quality data, suitable digital infrastructure, clear processes, cybersecurity controls, employee training, and human oversight are necessary for AI applications to produce reliable outcomes.

Commerce in India:

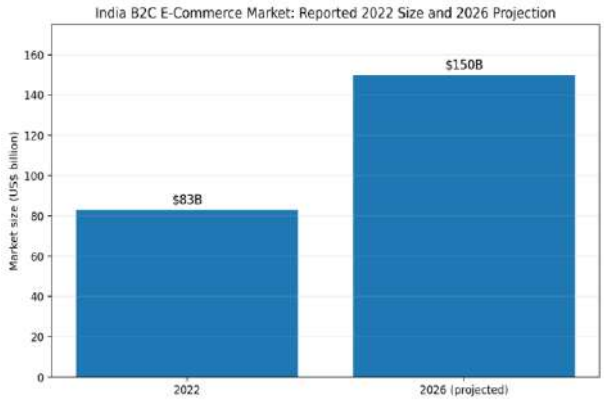
Commerce in India includes retail and wholesale trade, banking and finance, insurance, logistics, marketing, transportation, digital payments, e-commerce, and a large ecosystem of MSMEs and local businesses. Digital technologies are increasingly connecting these activities.

Area	AI / Digital Application in India
E-Commerce	Product recommendations, search, customer support, demand forecasting
Banking & FinTech	Fraud detection, risk assessment, automated customer service
Digital Payments	Transaction monitoring, fraud analytics and payment security
Accounting	Data processing, invoice workflows, reconciliation support
Marketing	Customer segmentation, content creation and personalisation
Retail & MSMEs	Demand planning, digital catalogues and inventory support
Logistics	Route optimisation, demand prediction and delivery management
Business Analytics	Forecasting, performance monitoring and decision support

E-Commerce in India:

E-commerce in India has expanded with greater internet access, digital payments, smartphones, logistics networks, and consumer adoption of online shopping.

The Economic Survey 2024–25 cites an estimate that India's business-to-consumer (B2C) e-commerce market was worth US$83 billion in 2022 and was expected to reach US$150 billion by 2026, representing a reported compound annual growth rate of 15.9 per cent. Because this is a report-based market estimate and a projection from the Economic Survey, it should be treated as a reference estimate rather than a current measured figure for 2026.



This figure India B2C e-commerce market: reported 2022 size and 2026 projection cited by the Economic Survey 2024–25. Source: Government of India, Economic Survey 2024–25.

AI can strengthen Indian e-commerce by improving product discovery, personalisation, demand forecasting, customer service, fraud detection, inventory management, and pricing support. The benefits are especially relevant in a large and diverse market where customers differ by language, location, income, product preferences, and digital behaviour.

However, AI-based personalisation also increases the importance of data governance. Businesses must consider the lawful and responsible collection and use of customer data, security of payment and account information, and the need to maintain customer trust.

UPI and Digital Payments:

Digital payments are a major part of India's commerce transformation. The Unified Payments Interface (UPI), operated by NPCI, supports instant bank-account-based payments through participating apps and banks. It can be used for person-to-person as well as person-to-merchant transactions, making it directly relevant to retail commerce and small-business payments.



This figure illustrates UPI transaction volume in India, April–August 2026.
Source: National Payments Corporation of India (NPCI).

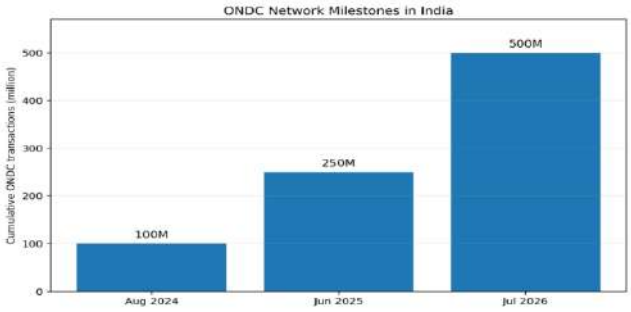
NPCI reported 22.35 billion UPI transactions in April 2026, 23.20 billion in May, 22.72 billion in June, 23.66 billion in July, and 24.51 billion in August 2026. In August 2026 alone, the reported transaction value was approximately ₹29.82 lakh crore. These numbers show the scale of India's digital transaction environment and the importance of secure, reliable data-driven systems for commerce.

AI can support this ecosystem through fraud monitoring, anomaly detection, customer-service automation, risk analytics, and transaction pattern analysis. These applications must be

designed with strong security and privacy controls because payment data are commercially and personally sensitive.

ONDC and Open Digital Commerce:

The Open Network for Digital Commerce (ONDC) is a Government of India-backed initiative designed as digital infrastructure rather than as a single shopping application. Its open-network model is intended to enable broader participation by buyers, sellers, service providers, logistics firms, and other participants across commerce domains.



This figure illustrates ONDC cumulative transaction milestones.

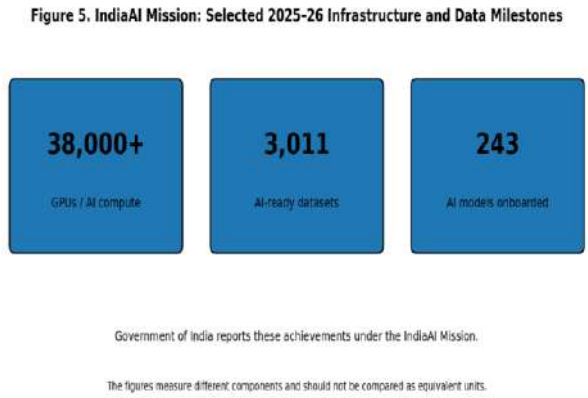
Source: ONDC. Milestones shown are 100M+ by August 2024, 250M+ by June 2025, and 500M+ by 25 July 2026.

ONDC reports that the network crossed 100 million transactions in August 2024, 250 million in June 2025, and 500 million on 25 July 2026. Its current network information also reports more than 250,000 sellers and more than 300 network participants. ONDC describes its purpose as building India's digital commerce infrastructure and increasing participation across retail, logistics, mobility, transit, travel, and financial services.

For commerce, the importance of ONDC lies not only in transaction volume but also in the possibility of bringing more businesses and local sellers into interoperable digital networks. AI can potentially support demand forecasting, catalogue enrichment, customer assistance, logistics optimisation, and business intelligence within such networks.

IndiaAI Mission and Emerging Technologies:

India's AI development is increasingly supported by national infrastructure and policy. MeitY's 2025–26 annual report describes the IndiaAI Mission as a national programme intended to build a robust AI ecosystem through seven pillars: IndiaAI Compute Capacity, IndiaAI Foundation Models, AIKosh, the IndiaAI Application Development Initiative, IndiaAI FutureSkills, IndiaAI Startup Financing, and Safe & Trusted AI.



This figure illustrates Selected India AI Mission milestones reported by MeitY for 2025–26.

The same annual report reports that more than 38,000 GPUs and 14 cloud partners had been established; AIKosh had 3,011 datasets and 243 AI models from 39 organisations across 20 sectors; and the mission was expanding AI skills and laboratories. Commerce is among the sectors covered by the AIKosh datasets. These developments can support Indian businesses, researchers, start-ups, educational institutions, and public-sector organisations, subject to applicable access conditions and programme rules.

Other emerging technologies are also important to Indian commerce. Machine learning supports prediction and classification. Generative

AI supports content and customer-service applications. Big data analytics helps organisations understand large datasets. Cloud computing provides scalable digital infrastructure. IoT can connect devices and business assets to data systems. Blockchain can support traceability and distributed records. Robotic Process Automation (RPA) can automate repetitive, rule-based work.

Digital Transformation in India:

Digital transformation in India involves more than moving paper processes online. It includes redesigning business processes around digital payments, data, mobile applications, cloud services, e-commerce, interoperable networks, analytics, and AI. For a traditional small retailer, transformation may begin with digital catalogues and UPI acceptance. A more advanced business may integrate e-commerce, inventory software, analytics, automated customer service, and AI-based forecasting.

The Indian context is particularly significant because large technology platforms coexist with millions of MSMEs, local retailers, service providers, and informal or semi-formal businesses. Digital public infrastructure and open networks can reduce some barriers to participation, while AI can potentially improve the efficiency of the businesses that join these digital systems.

Automation:

Automation means using technology to perform tasks with limited human intervention. In Indian commerce, automation can be applied to invoice processing, accounting workflows, customer support, transaction monitoring, stock updates, marketing messages, document processing, and reporting. AI makes automation more flexible because systems can interpret information rather than simply follow fixed rules.

Automation can save time and reduce repetitive work, but its effects on employment require careful management. Some routine tasks may require fewer workers, while new roles can emerge in analytics, technology management, AI supervision, digital marketing, cybersecurity, and business process design. Reskilling and upskilling are therefore essential for commerce professionals and for educational institutions preparing students for digital employment.

Business Analytics:

Business analytics is the process of using data and analytical methods to understand business performance and support decisions. AI can strengthen business analytics by identifying patterns, generating forecasts, classifying customers, detecting anomalies, and assisting with natural-language queries.

For example, an Indian retailer can use descriptive analytics to study historical sales, diagnostic analytics to identify why sales declined, predictive analytics to forecast demand, and prescriptive analytics to evaluate inventory actions. A bank can use analytics to identify unusual transaction patterns, while a logistics company can analyse delivery times and routes to improve operational efficiency.

The growing scale of India's digital transactions and digital commerce makes analytics increasingly important. At the same time, organisations need strong data-quality practices because poor or biased input data can produce unreliable analytical results.

Opportunities for Indian Commerce:

1. Improved customer experience through personalised recommendations and faster service.
2. Higher operational efficiency through automation of repetitive processes.

3. Better demand forecasting, inventory management, and supply-chain planning.
4. Improved fraud detection and transaction monitoring.
5. New opportunities for MSMEs to participate in digital commerce.
6. Multilingual digital services that can support broader customer access.
7. New business models and services based on data, platforms and AI.
8. Development of new employment opportunities in AI, analytics, digital marketing, cybersecurity and technology management.

Challenges of AI Adoption in India:

AI adoption in India also creates challenges. Data privacy and security are important because AI systems may process customer, employee, payment, and business information. Cybersecurity risks can increase as more commerce processes become digital. Ethical concerns may arise when automated systems produce biased results or when users cannot understand how important decisions are made.

Cost is another challenge, particularly for MSMEs. Businesses may need to invest in software, data preparation, cloud infrastructure, cybersecurity, integration, training, and ongoing maintenance. Skills shortages can also slow adoption. In addition, differences in language, connectivity, digital literacy, and regional infrastructure can affect how effectively AI services are used across the country.

Employment effects require careful attention. The impact of AI will vary by occupation and task rather than being identical across the entire labour market. Training, job redesign, and continuous learning are therefore important responses to technological change.

Changing Role of Commerce Professionals in India:

Commerce professionals in India increasingly need a combination of domain knowledge and digital capability. Accountants, bankers, finance professionals, auditors, marketers, managers, and entrepreneurs may work with AI-supported systems even when they are not AI specialists. They should therefore understand basic data interpretation, automation, cybersecurity awareness, digital payments, and the limitations of AI outputs.

Professional judgement remains important. AI-generated information should be reviewed before it is relied upon for significant accounting, financial, legal, tax, customer, or managerial decisions. Human professionals are also important for communication, ethics, negotiation, accountability, and dealing with unusual cases that fall outside the patterns represented in training data.

Responsible AI Adoption in India:

Responsible AI adoption requires attention to privacy, security, transparency, fairness, accountability, and human oversight. Indian organisations should establish clear internal policies for the use of AI, define responsibilities for important decisions, protect confidential information and test systems for errors and bias, and monitor performance over time. Customers and employees should receive appropriate information when AI materially affects a service or decision.

The IndiaAI Mission itself includes Safe & Trusted AI as one of its seven pillars, reflecting the importance placed on responsible development. Responsible adoption is particularly relevant to commerce because customer trust is closely linked to payment security, correct information, fair treatment, and protection of personal data.

Conclusion:

The future of commerce in India is likely to be shaped by the combined development of Artificial Intelligence (AI), digital payments, e-commerce, open digital networks, cloud computing, data analytics, and automation. India's UPI ecosystem demonstrates the scale of digital transactions, ONDC demonstrates the expansion of open digital commerce infrastructure, and the IndiaAI Mission demonstrates growing national investment in AI capabilities, infrastructure, and skills.

AI provides significant opportunities to improve customer experience, automate routine work, detect fraud, forecast demand, strengthen business analytics, support logistics, personalize marketing, and expand digital participation. AI-based tools can also help businesses understand customer preferences, improve inventory management, reduce operational costs, and make faster data-driven decisions. Small and medium-sized businesses can increasingly use digital and AI-enabled solutions to compete in wider markets.

At the same time, the adoption of AI brings challenges related to data privacy, cyber security, high implementation costs, shortage of skilled professionals, employment changes, algorithmic bias, and responsible use of technology. Businesses need to establish appropriate safeguards to ensure that customer data is protected and AI systems are used transparently and ethically. The benefits of AI will therefore depend not only on technological advancement but also on effective implementation, regulation, and human oversight.

AI is also expected to transform the roles and skills of commerce professionals. Professionals in accounting, finance, marketing, banking, auditing, taxation, and business management will increasingly need to understand digital technologies and analytical tools. Rather than replacing all human roles, AI can support professionals by handling repetitive tasks and providing information, allowing greater focus on decision-making, problem-solving, creativity, communication, and strategic planning.

For Indian commerce professionals, the central requirement is therefore a combination of business knowledge, digital skills, analytical ability, ethical awareness, and continuous learning. Educational institutions also have an important role in preparing students for an AI-enabled business environment by integrating AI awareness, data analytics, digital finance, cyber security, and practical technology skills into commerce education.

In conclusion, AI has the potential to become an important driver of innovation, productivity, and competitiveness in Indian commerce. However, sustainable development will require a balanced approach in which technological progress is combined with human judgment, customer trust, responsible data management, effective governance, skill development, and inclusive digital growth. The future of commerce will therefore not depend on AI alone, but on how effectively businesses, professionals, educational institutions, and policymakers use AI to create value while maintaining ethical and human-centered practices.

References:

1. Gupta, S. (2022). *Digital marketing* (3rd ed.). McGraw Hill Education
2. Kumar, U. D. (2024). *Business analytics: The science of data-driven decision making* (2nd ed.). Wiley India
3. Yegnanarayana, B. (2009). *Artificial neural networks*. PHI Learning.
4. Kulkarni, P., & Joshi, P. (2020). *Artificial intelligence: Building intelligent systems*. PHI Learning.

5. Government of India, Ministry of Electronics and Information Technology. (2026). Annual report 2025–2026. https://www.meity.gov.in/
6. Government of India, Ministry of Finance. (2025). Economic Survey 2024–25. https://www.indiabudget.gov.in/economicsurvey/
7. National Payments Corporation of India. (2026). Unified Payments Interface (UPI) product statistics. https://www.npci.org.in/product/upi/product-statistics

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Artificial Intelligence: Opportunities And Challenges in The Indian Financial Sector

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Abstract:

Artificial Intelligence (AI) is increasingly transforming the Indian financial sector through automation, predictive analytics, intelligent customer services, fraud detection, credit assessment, risk management and personalised financial services. This study examines the major opportunities and challenges associated with AI adoption across banking, FinTech, insurance, investment and other financial services in India. The study adopts a descriptive and analytical research design based on secondary data from academic literature, regulatory publications, institutional reports and other reliable sources. The findings indicate that AI can improve operational efficiency, decision-making, customer experience, risk management and financial inclusion. However, data privacy, cybersecurity, algorithmic bias, explainability, regulatory uncertainty, model risk and skill requirements remain significant concerns. The study highlights the need for responsible AI governance, human oversight, employee reskilling and strong data-management practices for sustainable AI adoption.

Keywords: Artificial Intelligence; Indian Financial Sector; FinTech; Financial Inclusion; AI Governance.

Introduction:

Artificial Intelligence (AI) has emerged as one of the most significant technological developments influencing modern economic and business activities. AI refers to the ability of computer systems and machines to perform tasks that generally require human intelligence, such as learning, problem-solving, pattern recognition, prediction and decision-making. Rapid developments in machine learning, big data analytics, natural language processing and generative AI have expanded the application of AI across industries. The financial sector is particularly suitable for AI adoption because financial institutions generate and process large volumes of structured and unstructured data. AI can therefore support faster analysis, automation, prediction and decision-making across a wide range of financial activities. NITI Aayog has identified the potential of AI to improve productivity, decision-making and service delivery, while also highlighting concerns relating to data, privacy, skills and responsible adoption.

The Indian financial sector has undergone substantial technological transformation over the past decade, supported by digital banking, mobile payments, FinTech development, electronic financial services and increasing use of data-driven technologies. Within this environment, AI is becoming relevant to banking, insurance,

investment management, lending, payments, financial markets and regulatory activities. Financial institutions can use AI for credit assessment, fraud detection, customer service, risk management, regulatory compliance, investment analysis and personalised financial services. The Reserve Bank of India (RBI) has noted that AI and machine learning are already being applied in areas such as fraud detection, credit scoring and customer assistance, with further potential in regulatory compliance, investment advisory and algorithmic trading.

The growing adoption of AI creates significant opportunities for the Indian financial sector. Automation can improve operational efficiency, reduce processing time and support cost management, while predictive analytics can assist institutions in identifying financial risks and unusual transactions. AI-based systems can also facilitate personalised financial products and services by analysing customer behaviour and preferences. In lending, data-driven models may support faster and more informed credit decisions, while AI-enabled technologies can contribute to expanding access to financial services. Recent analysis by NITI Aayog identifies banking and financial services as an important area for AI-led productivity improvement, particularly through applications in fraud detection, compliance, credit decision-making, portfolio management and customer engagement.

However, the increasing use of AI also introduces significant challenges. Financial institutions deal with highly sensitive personal and financial information, making data privacy and cybersecurity important concerns. AI models may also produce biased or inaccurate outcomes when they are developed using incomplete, poor-quality or unrepresentative data. The complexity of some AI systems can create difficulties in explaining how particular financial decisions are reached, raising questions of transparency and accountability. Other concerns include model risk, dependence on technology providers, regulatory uncertainty, workforce skill requirements and potential consumer harm. RBI has specifically highlighted concerns relating to algorithmic bias, explainability and data privacy in the context of AI adoption in financial services.

Therefore, the adoption of AI in the Indian financial sector represents both an opportunity for technological and operational transformation and a challenge requiring appropriate governance and responsible implementation. The increasing attention of Indian financial regulators to responsible and ethical AI further demonstrates the importance of balancing innovation with financial stability, consumer protection, privacy and accountability. Against this background, the present study, titled "Artificial Intelligence: Opportunities and Challenges in the Indian Financial Sector," examines the major applications and potential benefits of AI in Indian finance while also analysing the technological, regulatory, ethical, operational and human challenges associated with its adoption. The study pursues to provide a comprehensive understanding of how AI can contribute to the development of the Indian financial sector while ensuring responsible and sustainable use of the technology.

Review of Literature:

Singh, Mishra, Kumar and Bag (2025) systematically reviewed 157 studies on AI applications in banking and finance. The authors identified customer service, financial inclusion, regulation, customer readiness and explainability as major themes. Their study also highlighted operational efficiency, cost reduction and barriers to AI adoption, providing directions for future research.

Kumar, Kuhar and Sharma (2025) examined the development of Artificial Intelligence in the

Indian banking system through a systematic literature review. The authors focused on AI adoption, significance, implementation and associated challenges. Their study demonstrated the growing importance of AI in Indian banking and identified opportunities for technological transformation alongside implementation-related concerns.

Patil, Raidas and Dhoot (2024) examined the role of Artificial Intelligence in transforming Indian financial services. The authors discussed AI's growing influence on financial operations and customer experiences. Their study highlighted the transformative potential of AI while emphasising the need to understand its implications for financial-service delivery and the changing technological environment.

Sharma and Singh (2024) empirically investigated the determinants influencing customers' intention to adopt AI-based banking services in India using 286 valid responses. The authors found that AI adoption is influenced by multiple factors associated with technology acceptance. Their findings demonstrate the importance of customer perceptions when implementing AI-based financial services.

Deepthi and Bansal (2024) examined AI adoption in the Indian banking and financial industry, focusing on its current status and future opportunities. The authors observed that rapid digitisation and technological development are increasing the importance of AI and machine learning in financial activities. Their study highlighted the continuing transformation of financial services through AI.

Kumari (2025) examined AI applications in the Indian banking sector, particularly customer services, fraud prevention and data processing. The author discussed technologies including chatbots, blockchain and AI-based systems and highlighted both opportunities and challenges associated with adoption. The study emphasised AI's potential to improve banking efficiency while requiring appropriate management of emerging risks.

Afzal, Meraj and Ansari (2026) examined AI governance in India's financial sector using stakeholder interviews, surveys and comparative policy analysis. The authors identified algorithmic bias, data privacy and regulatory fragmentation as important governance challenges. Their study emphasised the need for an appropriate regulatory framework to balance AI innovation with responsible financial-sector adoption.

Bhadauria, Kumari and Bhadauriya (2026) investigated AI applications in financial decision-making among Indian banks using questionnaire responses from banking professionals and supporting secondary information. The authors examined applications including credit appraisal, fraud detection, investment planning and customer relationship management, highlighting AI's growing role in important banking decisions and associated implementation challenges.

Research Gap:

Existing studies have examined Artificial Intelligence mainly in specific areas such as banking, customer service, credit assessment, fraud detection and FinTech. However, limited research provides an integrated assessment of both the opportunities and challenges of AI across the broader Indian financial sector, including banking, insurance, investment services and financial technology. Further, concerns relating to data privacy, algorithmic bias, cybersecurity, employment and regulatory governance require greater attention. Therefore, the present study addresses this gap by examining AI adoption from both opportunity and challenge perspectives.

Objectives of the Study:

1. To examine the major applications and opportunities of Artificial Intelligence in the Indian financial sector.
2. To identify the major technological, operational, ethical and regulatory challenges associated with AI adoption.

Research Methodology:

The present study adopts a descriptive and analytical research design to examine the opportunities and challenges associated with Artificial Intelligence in the Indian financial sector. The study is primarily based on secondary data collected from reliable and authoritative sources, including publications and reports of the Reserve Bank of India (RBI), Securities and Exchange Board of India (SEBI), Insurance Regulatory and Development Authority of India (IRDAI), Government of India, NITI Aayog, international financial institutions, financial institutions, industry reports and peer-reviewed academic journals. Recent literature and institutional reports are given greater importance to capture the current developments in AI adoption. The study covers major segments of the Indian financial sector, including banking, insurance, FinTech, investment and capital-market services, lending and digital financial services. The collected information is systematically reviewed and classified into major dimensions of AI applications, opportunities and challenges. The opportunities are examined in terms of operational efficiency, cost reduction, customer service, fraud detection, credit assessment, risk management, financial inclusion and personalised financial services. The challenges are analysed with reference to data privacy, cybersecurity, algorithmic bias, transparency, explainability, regulatory uncertainty, technological dependence and workforce requirements. A thematic and comparative approach is used to interpret the available evidence and identify common patterns across financial segments. The study also examines the regulatory and ethical dimensions of AI adoption in India. Based on the analysis, the study presents findings and suggests measures for responsible, secure and sustainable adoption of Artificial Intelligence in the Indian financial sector.

Results and Discussion:

1. Major Applications and Opportunities of Artificial Intelligence in the Indian Financial Sector:

The review indicates that AI has applications across almost every major function of financial institutions. Its role extends beyond customer-service chatbots to credit assessment, fraud prevention, risk management, investment management, compliance and personalized financial services. NITI Aayog's recent assessment identifies front-office, middle-office and back-office applications as important areas for AI-led transformation in banking.

Table 1: Major Applications of AI in the Indian Financial Sector

Area	Major AI Application	Potential Opportunity
Banking	Chatbots and virtual assistants	24×7 customer support
Lending	AI-based credit assessment	Faster credit decisions
Fraud Management	Pattern and anomaly detection	Early identification of fraud
Risk Management	Predictive analytics	Improved risk monitoring
Investment	Algorithmic analysis and robo-advisory	Data-driven investment services

Insurance	Underwriting and claims analysis	Faster and more efficient processing
Compliance	AI-enabled monitoring	Improved regulatory compliance
Customer Management	Personalized recommendations	Better customer engagement
Financial Inclusion	Alternative-data analysis	Wider access to financial services
Capital Markets	AI/ML-based analytical tools	Faster analysis and decision support

The table demonstrates that AI is not restricted to one particular financial activity. It can support the front, middle and back offices of financial institutions. In particular, fraud detection, credit decision-making, compliance and customer engagement represent important application areas. AI can therefore contribute to improvements in both operational processes and customer-facing services. NITI Aayog has also identified AI-led productivity and efficiency improvements as a significant opportunity for Indian financial services.

2. Opportunities Created by AI:

The analysis identifies several major opportunities arising from AI adoption. These opportunities can be grouped into operational, customer-related, risk-management and financial-inclusion dimensions.

Table 2: Opportunities of AI in the Indian Financial Sector

Opportunity	**Contribution of AI**	**Expected Outcome**
Operational efficiency	Automation of repetitive activities	Faster processing
Cost efficiency	Reduction of manual processes	Potential reduction in operating costs
Fraud detection	Real-time identification of unusual patterns	Improved fraud prevention
Credit assessment	Analysis of multiple data sources	Faster and potentially broader credit assessment
Customer service	AI assistants and chatbots	Continuous customer support
Personalisation	Analysis of customer behaviour	Tailored financial products
Risk management	Predictive and anomaly analytics	Improved risk identification
Financial inclusion	Alternative-data analysis	Potential access for underserved customers
Investment services	AI-supported analysis	Faster decision support
Compliance	Automated monitoring	Improved regulatory oversight

The findings indicate that the principal opportunity from AI is the ability to combine large-scale data processing with automation and predictive analysis. AI can reduce the time required for routine financial activities while supporting more data-driven decisions. It may also help institutions extend services to underserved customers by enabling alternative approaches to credit assessment. NITI Aayog specifically identifies AI applications in credit

decisioning, fraud detection, risk management and personalized customer interaction as important opportunities for Indian banking.

3. AI and Financial Inclusion:

AI has potential implications for financial inclusion because conventional financial decisions often depend on established credit histories and formal financial records. AI-based systems can analyse additional information, subject to applicable legal and regulatory requirements, to support credit assessment and customer segmentation.NITI Aayog notes that AI-enabled credit decisioning can use alternative data sources to support more dynamic and potentially inclusive lending decisions.

The potential contribution of AI to financial inclusion is particularly relevant to India, where differences in access to formal financial services continue to exist. However, alternative-data-based decisions must be accompanied by appropriate consent, privacy protection, fairness and explainability mechanisms. Therefore, AI can support financial inclusion only when technological expansion is accompanied by responsible data governance.

4. Major Challenges Associated with AI Adoption:

The second objective of the study is to identify the major challenges associated with AI adoption. The analysis shows that these challenges are not limited to technology. They also involve data, infrastructure, human resources, governance, privacy and regulation.

Table 3: Major Challenges of AI Adoption

Challenge	Nature of the Problem	Possible Implication
Data privacy	Financial data are highly sensitive	Privacy and trust concerns
Data quality	Incomplete or inaccurate data can affect models	Incorrect outputs
Algorithmic bias	Models may reproduce biases in data	Unfair decisions
Explainability	Complex models may be difficult to interpret	Accountability concerns
Cybersecurity	AI systems may create new attack surfaces	Financial and operational risks
Legacy systems	Existing systems may not easily integrate with AI	High implementation costs
Skilled manpower	Shortage of specialised AI and finance skills	Slow adoption
Regulatory uncertainty	Technology develops faster than regulations	Compliance difficulties
Model risk	AI outputs may be inaccurate or unreliable	Poor financial decisions
Unequal access	Smaller institutions may lack resources	Digital divide
Workforce transformation	Automation changes existing job roles	Reskilling requirements

The findings show that AI adoption involves a trade-off between technological opportunities and associated risks. NITI Aayog's recent assessment identifies legacy infrastructure, data-quality limitations, privacy and consent concerns, unequal access to AI talent and the need for employee upskilling as important barriers for Indian banking.

5. Regulatory and Ethical Challenges:

AI adoption in finance requires greater attention to accountability because financial decisions can directly affect customers and investors. Issues such as transparency, fairness, data protection, accuracy and responsibility for AI-generated outcomes become important when AI is used for lending, investment advice, trading or customer services.SEBI issued a consultation paper in June 2025 concerning responsible use of AI/ML in Indian securities markets. Subsequently, the 2025 amendments to SEBI's regulations placed responsibility on regulated entities for the use of AI/ML tools, including safeguarding data and ensuring the accuracy of their outputs. The regulatory developments indicate that AI adoption cannot be considered solely as a technological issue. Financial institutions remain responsible for the outcomes associated with their AI systems, including systems obtained from third-party providers. This increases the importance of human oversight, data governance, model validation, transparency and accountability.

6. AI and Risk Management:

Risk management is one of the important areas in which AI can contribute to the financial sector. AI can process large volumes of transactions and identify patterns that may not be easily detected through conventional manual approaches. Potential applications include fraud detection, anti-money-laundering monitoring, credit-risk assessment and early identification of unusual activities.

NITI Aayog identifies advanced anomaly detection, automated compliance and risk management among the important AI applications in financial services.AI can strengthen the speed and scale of financial-risk monitoring. However, financial institutions cannot rely entirely on automated outputs because incorrect model predictions can themselves create financial and regulatory risks. Consequently, AI-supported risk management should incorporate continuous model monitoring and appropriate human intervention.

7. AI, Employment and Skills:

The increasing use of AI is likely to change the nature of work in financial institutions. Routine and repetitive activities may increasingly be automated, while demand may increase for employees with skills in data analytics, AI, cybersecurity, model validation and technology governance.NITI Aayog identifies **AI talent, employee upskilling and change management** as important enablers for financial-sector AI adoption. It also notes that insufficient training and unclear roles can create errors and compliance risks when AI systems are deployed.The evidence suggests that AI should not be viewed only in terms of replacing human labour. Its adoption is also likely to transform existing roles and create demand for new technical and interdisciplinary skills. Therefore, reskilling and continuous professional development are important for ensuring that employees can effectively work with AI-based systems.

Conclusion:

Artificial Intelligence is emerging as an important technological force in the transformation of the Indian financial sector. The study finds that AI has applications across banking, FinTech, insurance, investment services, lending, capital markets and regulatory activities. Its growing application in fraud detection, credit assessment, customer service, risk management, compliance, investment analysis and personalised financial services demonstrates its potential to improve the efficiency and responsiveness of financial institutions. AI can process large volumes of information rapidly, identify patterns and support data-driven decisions, thereby

creating opportunities for improved operational performance and customer-oriented financial services. The findings indicate that AI can contribute to operational efficiency through automation and can reduce the time required for several repetitive financial activities. AI-based analytical tools can support credit assessment, fraud detection and risk monitoring, while intelligent customer-service systems can provide continuous assistance. AI also has potential to contribute to financial inclusion by supporting alternative approaches to credit assessment and enabling financial institutions to serve customers who may have limited conventional financial histories. In investment and wealth management, AI can assist with data analysis, portfolio monitoring and personalised services. However, the benefits of AI adoption are accompanied by significant technological, ethical, operational and regulatory challenges. Data privacy and cybersecurity are particularly important because financial institutions handle sensitive personal and financial information. Algorithmic bias, poor-quality data and limited explainability may affect the fairness and reliability of AI-supported decisions. Model risk, dependence on technology providers, legacy systems and shortages of specialised skills can further complicate implementation. The increasing use of AI also requires employees to develop new technical, analytical and interdisciplinary competencies.

The study therefore concludes that effective AI adoption requires more than technological investment. Financial institutions need strong data governance, cybersecurity mechanisms, model validation, transparency, human oversight and continuous monitoring. Regulatory institutions also have an important role in establishing appropriate frameworks that encourage innovation while protecting consumers, investors and the stability of financial markets. Recent Indian regulatory developments, including SEBI's 2025 measures concerning responsible use of AI/ML, demonstrate the growing importance of accountability and responsible deployment.

References:

1. Deepthi, B., & Bansal, V. (2024). Artificial intelligence adoption in the Indian banking and financial industry. In A. K. Mishra, S. Anand, N. C. Debnath, P. Pokhariyal, & A. Patel (Eds.), *Artificial intelligence for risk mitigation in the financial industry*. Wiley. https://doi.org/10.1002/9781394175574.ch4
2. Garg, N. (2024). A systematic literature review on artificial intelligence technology in banking. *Academy of Strategic Management Journal, 23*(Special Issue 1), 1–20.
3. Singh, R. K., Mishra, R., Kumar, S., & Bag, S. (2025). Applications of artificial intelligence for optimizing banking and financial operations: A systematic literature review and future research agenda. *Journal of Economic Surveys, 39*(5), 2284–2302. https://doi.org/10.1111/joes.12693
4. Kumar, K., Kuhar, N., & Sharma, M. (2025). *Artificial intelligence in the Indian banking system: A systematic literature review*. SSRN. https://doi.org/10.2139/ssrn.5088937
5. Vuković, D. B., Dekpo-Adza, S., &Matović, S. (2025). AI integration in financial services: A systematic review of trends and regulatory challenges. *Humanities and Social Sciences Communications, 12*, 562. https://doi.org/10.1057/s41599-025-04850-8
6. Kadam, [Authors as listed in publication]. (2026). Assessing the transformative role of artificial intelligence in financial services: A systematic review and implications for

future research. *Journal of Economic Surveys, 40*(3), 1330–1357. https://doi.org/10.1111/joes.70044

7. Reserve Bank of India. (2024). *Report of the committee on framework for responsible and ethical enablement of artificial intelligence in the financial sector (FREE-AI Committee).* Reserve Bank of India.
8. Reserve Bank of India. (2024). *Annual report 2023–24*. Reserve Bank of India.
9. Reserve Bank of India. (2025). *Annual report 2024–25*. Reserve Bank of India.
10. Securities and Exchange Board of India. (2025). *Consultation paper on guidelines for responsible usage of AI/ML in Indian securities markets*. SEBI.

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National Strategy for Financial Inclusion 2025–2030: A Critical Assessment of the Policy Framework, Progress, Challenges and Strategic Pathways

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Abstract:

Financial inclusion has evolved in India from a policy objective centered on opening bank accounts to a broader development strategy concerned with effective usage, financial resilience, digital capability, consumer protection and livelihood enhancement. The ***National Strategy for Financial Inclusion (NSFI) 2025–30****, released by the Reserve Bank of India (RBI) on 1 December 2025, represents the next phase of this transition. It builds on the achievements of NSFI 2019–24 and adopts an ecosystem-oriented approach designed to provide equitable, responsible, suitable and affordable financial services supported by financial literacy, digital public infrastructure, livelihood opportunities and customer protection. (Reserve Bank of India)*

This article analyses the architecture of NSFI 2025–30 using secondary data from RBI, Government of India, NPCI, World Bank and PMJDY sources. The evidence demonstrates substantial progress: the RBI Financial Inclusion Index increased from ***49.9 in 2019 to 67.0 in March 2025****; banking outlets in villages increased from* ***5.97 lakh in March 2019 to 15.98 lakh in March 2024****; Basic Savings Bank Deposit Accounts increased from* ***57.42 crore to 70.59 crore****; and PMJDY beneficiaries reached about* ***59.31 crore by September 2026****. (Reserve Bank of India) Nevertheless, challenges remain concerning active usage, gender differences in digital connectivity and formal savings/borrowing, quality of last-mile services, cyber fraud, credit access and regional disparities. The study concludes that the success of NSFI 2025–30 should increasingly be measured by* ***financial outcomes and resilience rather than merely account ownership****.*

Keywords: Financial Inclusion, NSFI 2025–30, RBI, PMJDY, Digital Financial Inclusion, UPI, Financial Literacy, Women-led Financial Inclusion, Financial Resilience, India.

Introduction:

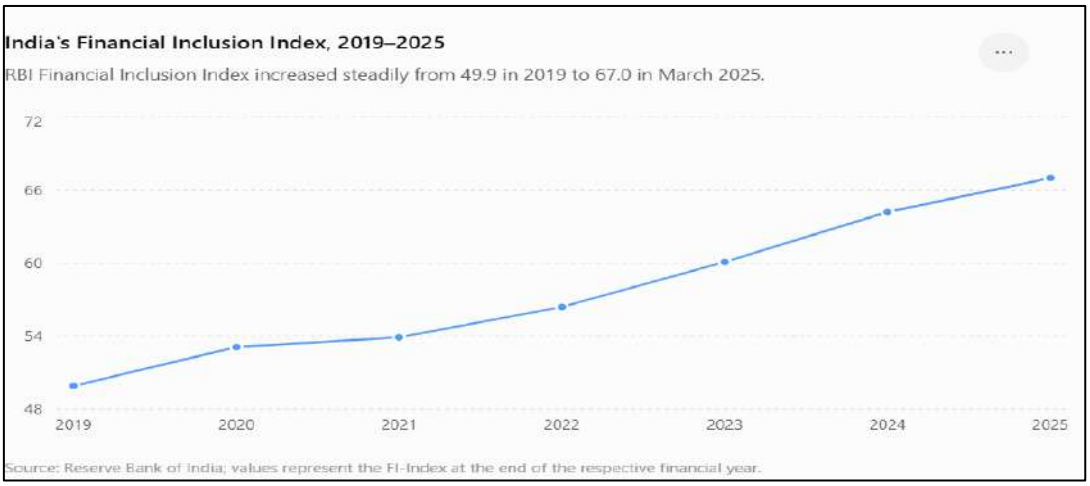
Financial inclusion refers to the availability and effective use of affordable, appropriate and regulated financial services by individuals and enterprises, particularly vulnerable and underserved groups. In India, the policy agenda has progressively moved from physical banking expansion to digital financial inclusion and, more recently, toward **financial wellbeing**.

The RBI's NSFI 2025–30 was published in December 2025 as the successor to NSFI 2019–24. The strategy synchronises its five-year period with the **2030 Sustainable Development Agenda** and adopts the principle of *"Leave No One Behind."* The RBI explicitly states that financial inclusion should not be viewed merely as access to accounts; effective usage should contribute to financial safety, financial security, financial resilience and financial discipline. (Reserve Bank of India)The transition is significant. Under NSFI 2019–24, the emphasis was strongly placed on expanding access. Under NSFI 2025–30, the emphasis shifts toward

quality, usage, suitability, gender sensitivity, livelihood linkages and customer protection.The importance of this transition is demonstrated by the RBI Financial Inclusion Index (FI-Index). It increased from **49.9 in 2019 to 64.2 in March 2024 and 67.0 in March 2025**. (Reserve Bank of India)

Growth of India's Financial Inclusion Index:

Figure 1. Growth of India's Financial Inclusion Index



The increase of **17.1 index points between 2019 and 2025** indicates substantial cumulative improvement, although the index should not be interpreted as meaning that 67% of Indians are financially included; it is a composite index rather than a population percentage. The FI-Index incorporates Access, Usage and Quality dimensions. (Press Information Bureau)

Review of Literature and Policy Background:

The international literature generally treats account ownership as an important gateway to savings, payments, credit and risk management. The World Bank's Global Findex 2025 provides nationally representative demand-side evidence from 141 economies based on surveys conducted during 2024. (World Bank)

For India, the Global Findex 2025 reports **89% account ownership among both women and men**, demonstrating that the gender gap in account ownership has become very small. However, differences remain in the *use* of financial services. For example, formal saving and formal borrowing remain lower among women than men, while mobile-phone and internet access also show gender differences. (World Bank)

The earlier Global Findex 2021 had already identified the distinction between **access and usage** as an important Indian challenge. In 2021, 78% of Indian adults had an account, but 35% reported using accounts for digital payments and 35% of accounts were classified as inactive. (The World Bank)

The NSFI 2025–30 therefore responds to an important policy question: **How can India convert widespread access into meaningful, safe and productive financial usage?**

Objectives of the Study:

The study has the following objectives:

1. To examine the conceptual framework of NSFI 2025–30.
2. To analyse India's financial inclusion progress using selected numerical indicators.

3. To examine the five strategic objectives of NSFI 2025–30.
4. To identify major regional, gender, digital and institutional challenges.
5. To examine the role of PMJDY, UPI, Business Correspondents, financial literacy and Digital Public Infrastructure.
6. To suggest measurable indicators for evaluating implementation during 2025–30.

Research Methodology:

The study follows a **descriptive and analytical research design** based entirely on secondary data.

Sources of data:

- Reserve Bank of India – NSFI 2025–30
- RBI Annual Reports
- RBI Financial Inclusion Index
- Department of Financial Services – PMJDY
- National Payments Corporation of India – UPI statistics
- World Bank – Global Findex 2025
- Government of India/PIB publications

The analysis covers principally **2019–2025**, with selected PMJDY data updated to September 2026 where appropriate to illustrate continuing implementation. The study uses percentage changes, comparative tables, trend analysis and regional evidence. Since the NSFI 2025–30 is itself a policy strategy, the article distinguishes between **official targets/action points** and **researcher's proposed performance indicators**.

Financial Inclusion in India: Empirical Evidence:

Table 1. Selected indicators of financial inclusion

Indicator	Earlier position	Later position	Change
FI-Index	49.9 (2019)	67.0 (2025)	+17.1 points
Banking outlets in villages	5.97 lakh (2019)	15.98 lakh (2024)	+168% approx.
BSBDA accounts	57.42 crore (2019)	70.59 crore (2024)	+23% approx.
PMJJBY enrolment	5.34 crore (2019)	16 crore (2024)	~3 times
PMSBY enrolment	13.52 crore (2019)	33.78 crore (2024)	~2.5 times
APY subscribers	97 lakh (2019)	555 lakh (2024)	~5.7 times
RBI-DPI	153.47 (Mar. 2019)	445.50 (Mar. 2024)	+190% approx.

Source: RBI, NSFI 2025–30. (Reserve Bank of India)

The figures reveal that the previous strategy substantially expanded the supply-side financial infrastructure. Village banking outlets increased by approximately **168%**, while the RBI Digital Payments Index increased nearly threefold between March 2019 and March 2024. (Reserve Bank of India)

1. Growth of PMJDY:

PMJDY remains one of India's most important financial-inclusion platforms. It provides basic savings accounts, RuPay cards, overdraft facilities for eligible customers and linkages with insurance, pension and Direct Benefit Transfer programmes. (Pradhan Mantri Jan Dhan Yojana)

As of **16 September 2026**, PMJDY reported approximately **59.31 crore beneficiaries**, deposits of **₹3.20 lakh crore**, and **41.51 crore RuPay cards**. Women beneficiaries numbered approximately **33.04 crore**. (Pradhan Mantri Jan Dhan Yojana)

Table 2. PMJDY position as of 16 September 2026

Indicator	Number/value
Total beneficiaries	59.31 crore
Rural/semi-urban beneficiaries	46.10 crore
Urban/metro beneficiaries	13.20 crore
Female beneficiaries	33.04 crore
Deposits	₹3,20,105.85 crore
RuPay cards	41.51 crore

Source: Department of Financial Services, PMJDY.

The data indicate that PMJDY has moved considerably beyond its original account-opening phase. However, the next challenge is to ensure that accounts are **actively used for saving, insurance, pension, credit, payments and household financial planning**.

Regional Dimension of Financial Inclusion:

Financial inclusion is not geographically uniform. PMJDY data demonstrate considerable differences in absolute account numbers across states.

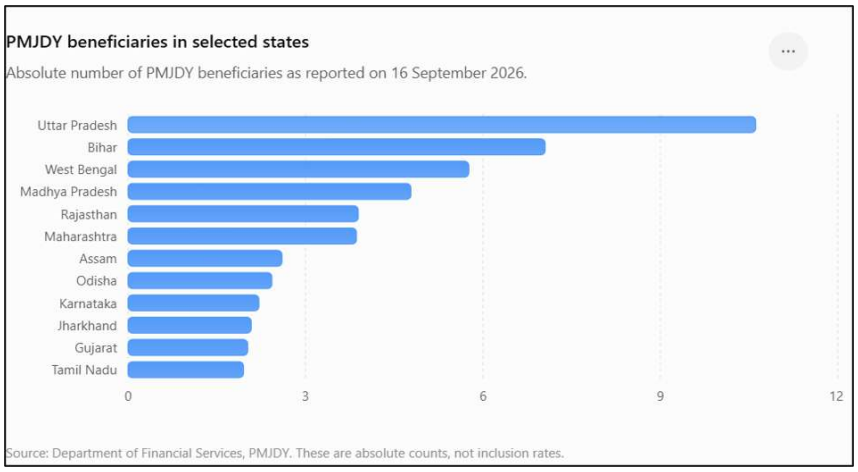
Table 3. Selected states: PMJDY beneficiaries, 16 September 2026

RANK	State	PMJDY beneficiaries
1	Uttar Pradesh	10.61 crore
2	Bihar	7.05 crore
3	West Bengal	5.76 crore
4	Madhya Pradesh	4.78 crore
5	Rajasthan	3.89 crore
6	Maharashtra	3.86 crore
7	Assam	2.60 crore
8	Karnataka	2.21 crore
9	Odisha	2.43 crore
10	Jharkhand	2.08 crore

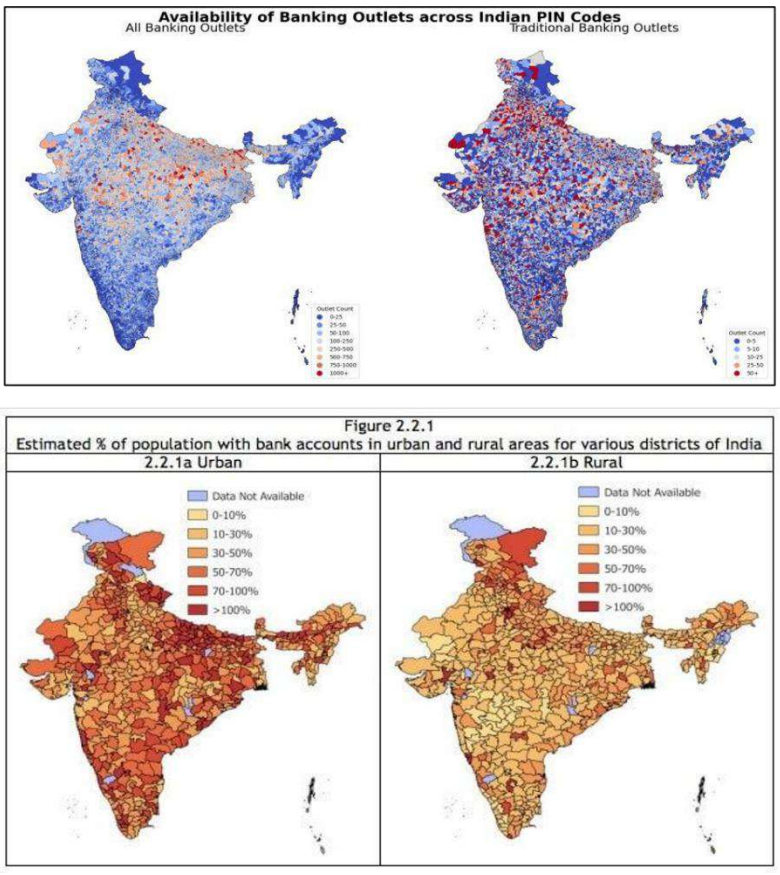
Source: Department of Financial Services, PMJDY.

These are **absolute beneficiary counts**, not state-level inclusion rates. Therefore, they should not be interpreted as rankings of financial inclusion performance because population size and demographic structure differ substantially between states.

Figure 2. Selected PMJDY beneficiary counts



Map 1. Financial-infrastructure mapping for NSFI implementation



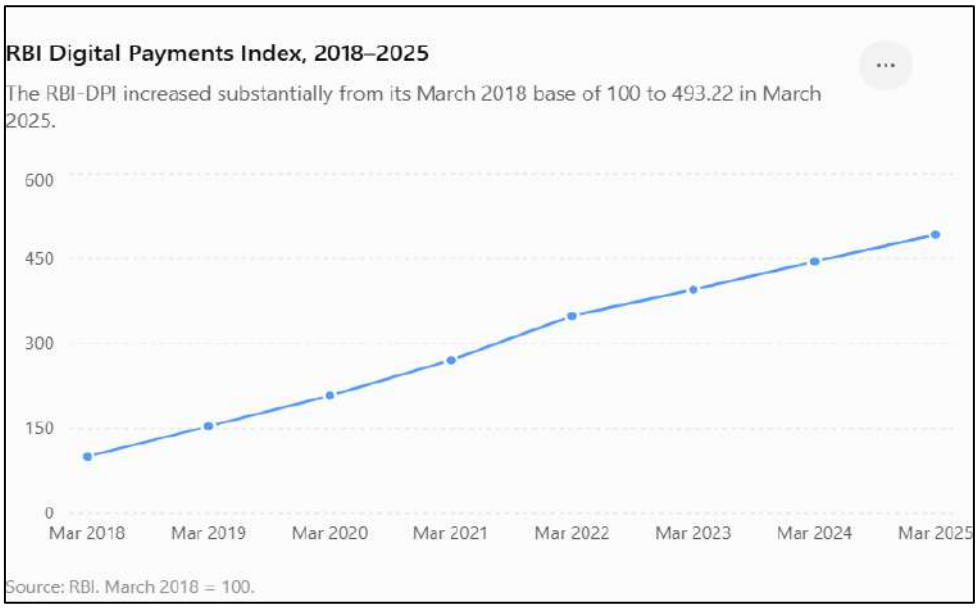
The Government's **Bank GIS 2.0** provides a geographical framework for mapping bank branches, Bank Mitras, ATMs and India Post Payments Bank infrastructure. Such GIS-based mapping is particularly relevant to NSFI 2025–30 because the strategy calls for improved last-mile access and proposes a more granular state/district measurement framework. (webgis2.nic.in)

Research implication: Future empirical studies should use district-level GIS data rather than relying exclusively on national averages. The NSFI itself recommends development of a **State/UT-level disaggregated FI-Index**. (Reserve Bank of India)

Digital Financial Inclusion:

Digital payments have become one of the major mechanisms through which financial inclusion can be deepened. UPI recorded approximately **16.7 billion transactions in December 2024**, while the NSFI 2025–30 identifies a goal of reaching **one billion users in the digital payments ecosystem by December 2029**. The strategy also envisages expansion of the EDDPE programme to achieve 100% coverage in 80% of districts by March 2026 and all identified districts by March 2027. (Reserve Bank of India)The RBI Digital Payments Index rose from **100 in March 2018**, its base period, to **445.50 in March 2024** and **493.22 in March 2025**. The September 2024 value was 465.33. (Reserve Bank of India)Digitalisation, however, creates a parallel requirement for cybersecurity, consumer protection, digital literacy, accessible interfaces and effective grievance redressal.

Figure 3. RBI Digital Payments Index



The Five Strategic Objectives of NSFI 2025–30:

The NSFI 2025–30 structures its strategy around **Panch-Jyoti**, consisting of five interconnected objectives. The RBI identifies **47 action points**, with 19 relating to Usage, 19 to Quality, 6 to Access and 3 to Monitoring and Measurement. (Reserve Bank of India)

Table 4. Panch-Jyoti framework

Strategic objective	Major focus
1. Equitable, responsible, suitable and affordable finance	Last-mile access, BCs, digital finance, credit
2. Gender-sensitive inclusion	Women BCs, differentiated products, vulnerable groups
3. Livelihood–skill–finance linkages	Employment, entrepreneurship, skill loans, market linkages
4. Financial education	Financial discipline, digital literacy, planning and sustainable borrowing
5. Customer protection	Grievance redressal, cyber-fraud protection, dark-pattern safeguards

Source: RBI, NSFI 2025–30. (Reserve Bank of India)

1. Equitable and Affordable Financial Services:

The first objective seeks to improve the **quality and consistency of last-mile financial access**. NSFI 2025–30 proposes at least one banking outlet—branch, Digital Banking Unit or fixed-point Business Correspondent—in each revenue centre.This represents an important shift from measuring only geographical proximity to measuring the **availability of a minimum bouquet of services** such as deposits, withdrawals, remittances, account servicing, insurance, pension and loan applications. (Reserve Bank of India)The strategy also proposes improved BC remuneration, stronger BC registries and incentives for rural and hilly areas.

2. Women-led Financial Inclusion:

The NSFI identifies women's participation as both a usage and agency issue.One concrete action point is to increase the share of women Business Correspondents from approximately **15% to at least 30% by December 2028**. (Reserve Bank of India)This is particularly important because the World Bank's 2025 data show that India has achieved near-parity in account ownership—**89% for women and 89% for men**—but differences remain in formal saving, borrowing and digital connectivity. (World Bank)Thus, the policy challenge is no longer simply:**"Does a woman have a bank account?"**but increasingly:**"Does she control, understand and effectively use financial services?"**

3. Livelihood, Skills and Finance:

A major innovation of NSFI 2025–30 is the explicit linkage between financial inclusion and **income-generating capacity**.The strategy recognises that an account may remain underutilised if households lack regular income or economic opportunities. Accordingly, it proposes stronger linkages among:

Skill Development → Employment/Entrepreneurship → Income → Savings → Credit → Insurance/Pension → Financial Resilience

The strategy proposes integration with Skill India Digital Hub, RSETIs, PMKVY, JSS, ITIs, SHGs and other institutions. It also proposes community-based organisations as intermediaries between skill providers, banks, employers and beneficiaries. (Reserve Bank of India)This is especially relevant for rural youth, women entrepreneurs, micro-enterprises and informal-sector workers.

Financial Literacy and Financial Discipline:

Financial literacy is treated by NSFI 2025–30 as an instrument for **behavioural change**, rather than merely awareness creation.The strategy identifies five dimensions:

1. Financial knowledge;
2. Sustainable indebtedness;
3. Realistic financial goal-setting;
4. Financial planning; and
5. Diversification of savings and investments.

The RBI proposes differentiated financial-literacy content for students, elderly persons, migrants, persons with disabilities and other target groups. It also recommends digital-literacy campaigns to help users identify financial fraud. (Reserve Bank of India)

By March 2025, **2,421 Centres for Financial Literacy** had been operationalised, while 1,508 Financial Literacy Centres conducted **1,31,220 camps during April–December 2024**. (Reserve Bank of India)The research implication is that future evaluation should measure **learning outcomes and behavioural outcomes**, rather than simply counting the number of camps.

Credit Inclusion and MSMEs:

Credit is an essential component of financial inclusion because access to savings without productive credit may have limited developmental impact.During 2024–25, scheduled commercial banks' priority-sector lending stood at **43.1% of adjusted net bank credit/credit equivalent of off-balance-sheet exposure**, above the overall prescribed 40% target. MSME credit outstanding increased to approximately **₹31.3 lakh crore** in 2024–25, compared with ₹27.3 lakh crore in 2023–24. (Reserve Bank of India)The RBI has also emphasised faster processing for MSE loans up to ₹25 lakh, with a recommended uniform turnaround time of 14 days, credit proposal tracking and greater transparency regarding rejected applications. (Reserve Bank of India)

NSFI 2025–30 further identifies **Unified Lending Interface (ULI)** as a mechanism that could facilitate frictionless digital credit by connecting relevant data sources with lenders. (Reserve Bank of India)

Customer Protection and Cybersecurity:

Digital financial inclusion can create new risks, including:

- phishing and social engineering;
- fraudulent UPI transactions;
- identity theft;
- unauthorised digital lending;
- data misuse;
- misleading interfaces;
- dark patterns;
- inadequate grievance resolution.

NSFI 2025–30 therefore proposes stronger use of the **Citizen Financial Cyber Frauds Reporting and Management System (CFCFRMS)**, regional-language complaint mechanisms, customer grievance policies, payment-fraud intelligence and safeguards against dark patterns. The strategy identifies a Digital Payments Intelligence Platform for mitigating payment fraud risks. (Reserve Bank of India)This establishes an important policy principle:**Digital access without digital safety is incomplete financial inclusion.**

Major Challenges:

Table 5. Key challenges and policy responses

Challenge	Evidence/issue	NSFI 2025–30 response
Dormant/underused accounts	Access does not automatically produce usage	Usage-focused interventions
Regional disparity	Infrastructure and transaction density vary geographically	Revenue-centre access and granular data
Gender gap in usage	Gender differences persist in saving, borrowing and connectivity	Women-led FI and women BCs
Digital exclusion	Device, connectivity and digital-literacy barriers	Digital literacy and vernacular interfaces
Cyber fraud	Growing digital financial ecosystem creates risks	CFCFRMS and payment intelligence
Informal credit dependence	Small borrowers may face documentation and access barriers	Suitable small-ticket and emergency credit
Weak livelihood linkages	Irregular income reduces financial-service usage	Skill–livelihood–finance convergence
Consumer vulnerability	Complex products/interfaces can impair informed choice	Customer protection and anti-dark-pattern measures

Proposed Measurement Framework for 2025–30:

A key research finding is that **account ownership alone is insufficient as a measure of financial inclusion**. A comprehensive NSFI evaluation framework could therefore monitor six dimensions:

Table 6. Suggested NSFI 2025–30 research indicators

Dimension	Suggested indicators
Access	Banking outlets, BCs, DBUs per population; distance to access point
Usage	Active accounts, digital-payment frequency, savings, credit utilisation
Quality	Complaint resolution, fraud incidence, customer satisfaction
Gender	Women account usage, women BCs, women borrowers
Resilience	Insurance, pension, emergency savings, sustainable debt
Livelihood	Skill-to-credit conversion, enterprise finance, employment outcomes

This framework is consistent with the NSFI's recommendation for more granular data by **district, gender, age, income and geography** and development of a State/UT-level FI-Index. (Reserve Bank of India)

Research Findings:

The analysis produces five major findings.

First, India has achieved a substantial expansion of financial access. The increase in village banking outlets and BSBDA accounts demonstrates the scale of infrastructure creation. (Reserve Bank of India)

Second, the FI-Index shows that financial inclusion is increasingly moving from access toward usage and quality. The index reached **67.0 in March 2025**, compared with 64.2 a year earlier. (Press Information Bureau)

Third, digital public infrastructure has fundamentally changed the delivery mechanism. UPI and other digital systems have made financial transactions faster and geographically less dependent on physical branches.

Fourth, gender equality in account ownership has improved substantially, but equality of **usage, formal saving, borrowing and digital connectivity** remains an important policy issue. (World Bank)

Fifth, NSFI 2025–30 represents a conceptual shift from **"banking the unbanked" to "improving financial wellbeing."** Its emphasis on safety, security, resilience and discipline is therefore analytically important. (Reserve Bank of India)

Policy and Research Implications:

The following measures could strengthen implementation and future evaluation:

1. **Move from account-based to outcome-based measurement:** Active usage, savings, insurance, pension and responsible credit should receive greater analytical attention.
2. **Develop district-level financial inclusion maps:** GIS-based mapping can identify areas with insufficient branches, BCs, ATMs, digital infrastructure and financial-literacy services.
3. **Create a gender-sensitive financial inclusion dashboard:** Female account ownership should be supplemented with indicators on usage, savings, borrowing, entrepreneurship and digital access.
4. **Measure financial literacy outcomes:** Pre-test/post-test assessments can determine whether financial-literacy programmes actually improve financial behaviour.
5. **Strengthen rural digital inclusion:** Vernacular interfaces, assisted digital services and offline-capable payment systems are important where connectivity remains weak.

6. **Link financial inclusion to livelihood programmes:** Credit should be linked with skill development, entrepreneurship, market access and business mentoring.
7. **Improve consumer protection:** As digital finance expands, fraud detection, grievance redressal and customer education should develop simultaneously.
8. **Build an annual NSFI research database:** Researchers should receive comparable district/state-level data to evaluate progress scientifically.

Conclusion:

The **National Strategy for Financial Inclusion 2025–30** represents an important second-generation financial-inclusion framework for India. The numerical evidence shows that India has already achieved considerable progress in expanding banking infrastructure, account ownership, digital payments, insurance, pension coverage and financial literacy.

The RBI Financial Inclusion Index increased from **49.9 in 2019 to 67.0 in March 2025**, while PMJDY had reached approximately **59.31 crore beneficiaries by September 2026**. At the same time, the RBI Digital Payments Index increased to **493.22 in March 2025**, illustrating the rapid digitalisation of India's financial ecosystem. (Reserve Bank of India)

The central research finding is that the next phase of financial inclusion cannot be judged simply by the number of bank accounts opened. The critical questions concern whether households **use financial services effectively, save regularly, borrow responsibly, insure themselves, plan for retirement, withstand financial shocks and receive fair treatment from financial-service providers**.

NSFI 2025–30 addresses this transition through its five-part **Panch-Jyoti** framework: equitable and suitable financial services; women-led and differentiated inclusion; livelihood and skill linkages; financial education; and customer protection. The strategy also contains **47 action points**, with a relatively strong emphasis on usage and quality. (Reserve Bank of India)

Consequently, the 2025–30 period can be empirically evaluated as a movement from **access → usage → quality → resilience → financial wellbeing**. Future research should therefore combine RBI administrative data, household surveys, GIS mapping and gender-disaggregated indicators to determine whether India's extensive financial infrastructure is translating into sustained improvements in household and micro-enterprise financial resilience.

References:

1. Reserve Bank of India. (2025). *National Strategy for Financial Inclusion 2025–30 (Revised).* Reserve Bank of India, Mumbai. (Reserve Bank of India)
2. Reserve Bank of India. (2025). *Annual Report 2024–25: Credit Delivery and Financial Inclusion.* (Reserve Bank of India)
3. Reserve Bank of India. (2025). *Financial Inclusion Index for March 2025.*
4. Reserve Bank of India. (2025). *Digital Payments Index for March 2025.* (Scribd)
5. Department of Financial Services, Government of India. *Pradhan Mantri Jan-Dhan Yojana: Progress Report.* (Pradhan Mantri Jan Dhan Yojana)
6. National Payments Corporation of India. *UPI Product Statistics.* (NPCI)
7. World Bank. (2025). *The Global Findex Database 2025: Connectivity and Financial Inclusion in the Digital Economy.* (World Bank)
8. World Bank. (2025). *India: Financial and Digital Inclusion—Fall 2025 Edition.* (World Bank)
9. Government of India. *Bank GIS 2.0: Mapping Financial Infrastructure for Financial Inclusion.* (webgis2.nic.in)

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Reading the Face to Curate the Playlist: An Expression-Driven Approach to Music Recommendation

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Abstract:

Choosing what to play next is a small decision that most listeners make dozens of times a day, and yet the tools built to help with it - genre tags, listening-history models, thumbs-up ratings - all look backward at what a person has liked before rather than at how that person feels right now. This paper works through the design of a system that closes that gap by reading the listener's face instead of their history. A webcam frame is passed through a face detector, a small convolutional network scores the cropped face against seven expression categories, and the resulting label drives a playlist selector that blends rule-based mood matching with a lighter collaborative-filtering pass over the user's own library. We walk through each stage of this pipeline - detection, classification, mood mapping and retrieval - explain the design choices behind it, and place it against the handful of comparable systems that have been reported in recent conference and journal venues, whose expression-recognition accuracy generally sits between roughly 80 and 87 percent. Rather than claiming a finished, benchmarked product, the paper's contribution is a clearly reasoned architecture and an honest discussion of where such systems still struggle - lighting, occlusion, and the gap between a visible expression and an actual felt emotion - along with concrete directions for closing that gap in future work.

Keywords: Affective Computing, Facial Expression Recognition, Music Recommendation, Convolutional Neural Networks, Human-Computer Interaction.

Why Look at the Face at All?

Ask someone to describe their mood in a word and they will usually manage it - 'tired,' 'wound up,' 'fine, I guess.' Ask them to translate that word into a genre or a specific song, though, and most people stall. That stalling point is where a lot of time gets lost on music apps: scrolling, skipping, restarting the same three playlists. The apps themselves are not to blame for this so much as their inputs are - almost every mainstream recommender leans on what a listener has already streamed, skipped, or rated, which is a good proxy for taste but a poor proxy for the state someone is in at 11pm on a Tuesday.

Faces, on the other hand, are unusually good at leaking present-tense information. Long before someone can name what they are feeling, their brow, mouth and eyes have often already shown it - this is well documented in affective-computing and psychology research, and it is precisely why facial analysis has become a practical entry point for systems that want to react to a person's current state rather than their past behaviour. Cameras are now standard on laptops and phones, and convolutional networks have gotten light enough to run expression classification in real time on modest hardware, so

the pieces needed to build such a system are no longer exotic.

This paper puts those pieces together and reasons through the result. Section 2 looks at what others have already tried in this space and what those attempts suggest about where the hard problems lie. Section 3 lays out the architecture we propose - detector, classifier, mood mapper, recommender - and the reasoning behind each stage. Section 4 gets into implementation choices: what libraries, what dataset, what interface. Section 5 compares expected performance against the systems surveyed in Section 2. Section 6 is deliberately candid about limitations before Section 7 closes the paper.

What Others Have Tried:

Interest in pairing facial cues with music selection has grown steadily over the last several years, and the resulting body of work, while varied in implementation detail, converges on a fairly consistent recipe: detect the face, classify its expression with a trained network, then hand the label to a recommendation layer of some kind.

Parmar's 2026 contribution to the ASSET conference proceedings framed the problem less as a modelling exercise and more as a systems-integration one, spending real attention on where such a pipeline would break in practice - privacy questions around always-on cameras, and the latency budget needed for the experience to feel instant rather than laggy.

A 2024 arXiv paper by Rajesh and colleagues took a different tack, building their classifier on a ResNet50 backbone trained against the FER dataset and reporting classification accuracy near 82 percent. What sets that work apart is its use of GRAD-CAM to visualise which regions of a face the network actually attended to - a small addition that matters a great deal if such a system is ever going to be trusted rather than just tolerated.

An IEEE-published prototype relying only on a built-in laptop camera and a conventionally trained classifier reported 84.82 percent accuracy across the combined tasks of reading the expression and matching it to music, which is a useful data point precisely because it used no specialised hardware at all.

Singh and co-authors, publishing through Springer's ICDSNE proceedings in 2024, framed their motivation around cost and speed rather than accuracy alone, arguing that most consumer music apps still ignore present mood entirely in favour of browsing history, and designing their pipeline specifically to keep computation cheap enough for lightweight deployment.

Earlier efforts by Tambe and colleagues folded activity recognition in alongside emotion, on the reasoning that what someone is doing changes what 'matching music' even means, while Jha and colleagues showed that a full deep-learning stack is not strictly necessary - their system used more classical image-processing techniques and still produced usable results. A survey by Florence and Uma catalogued this wider spread of techniques, and more recent hybrid work has started folding audio-feature analysis into the mix alongside the facial signal, suggesting the field is moving toward multi-signal rather than face-only systems.

Taken together, these efforts share three things: a CNN trained on FER-2013 or a comparable labelled dataset, a mapping step from expression to some notion of mood, and reported accuracy clustering in the low-to-mid 80s. The system proposed here follows that same general shape but is organised as a clean four-stage pipeline with an explicit, adjustable mood-mapping layer rather than a single hard-coded rule set.

Proposed Pipeline:

The system is built from four stages that hand off to one another in sequence: capturing and locating the face, classifying its expression, translating that expression into a mood category, and finally retrieving music that fits.

1. Locating the Face:

Frames are pulled from the device camera through OpenCV at a modest frame rate - there is no benefit to running detection faster than the classifier downstream can keep up with. Each frame is converted to grayscale and searched with a Haar Cascade detector for a first pass; where higher robustness to pose and lighting is needed, an MTCNN-based detector can be swapped in at some extra computational cost. The detected region is cropped and resized to 48x48 pixels, matching the input size the classifier expects.

2. Classifying the Expression:

The cropped face is scored by a compact CNN - a handful of convolution and pooling blocks followed by dense layers and a softmax head - trained on FER-2013, a dataset of roughly 35,000 labelled grayscale faces spanning seven categories: angry, disgust, fear, happy, sad, surprise and neutral. Dropout and batch normalisation sit between the blocks mainly to keep the network from memorising the training set, which is a real risk given FER-2013's modest size relative to modern vision datasets.

3. Turning an Expression into a Mood:

This is the stage most existing papers treat as an afterthought and where we think there is real room to be deliberate. A static table is the simplest option - happy and surprise route to an upbeat mood bucket, sad and fear route to something calmer, anger routes to music chosen to de-escalate rather than match. But a static table cannot account for the fact that people relate to genres differently: not everyone wants upbeat music when they are already happy. We propose letting this layer adapt - logging whether a user skips or keeps what gets recommended, and nudging the mapping for that individual over time rather than trusting one table for everyone.

4. Finding and Playing the Music:

Once a mood bucket is chosen, the recommender filters a song library tagged by mood and genre - either a local set of files or tracks pulled dynamically from a streaming API - and layers in a lightweight collaborative-filtering pass that also weighs what the specific user has previously kept versus skipped. The resulting shortlist is handed to a simple playback interface.

Building It:

A working prototype does not need much beyond a standard Python stack: OpenCV for capture and pre-processing, TensorFlow/Keras or PyTorch for training and running the classifier, and a thin front end - Streamlit for a quick internal demo, or a Flask-plus-React combination if a proper web app is the goal. The trained model is exported once and loaded at start-up, so per-frame inference only involves a forward pass, which is what keeps the experience close to real time on ordinary laptop hardware rather than requiring a GPU server.

For the music side, a local folder of mood-tagged tracks is the fastest way to get a demo running, but wiring the recommender to a streaming service's API is a natural next step once the classifier is stable, since it removes the ceiling on catalogue size without needing local storage.

Pipeline Stage	Approach Used in This Design
Face localisation	Haar Cascade (baseline) or MTCNN (higher robustness)
Expression scoring	Compact CNN trained on FER-2013
Mood mapping	Adjustable lookup table, refined per user over time
Track selection	Mood-tagged filtering plus lightweight collaborative filtering
Front end	Streamlit / Flask+React / Tkinter, depending on target

Table 1. The four pipeline stages and the specific approach chosen for each

How This Compares:

None of the figures below come from running this exact prototype end-to-end; they are drawn from the comparable systems discussed in Section 2 and are presented here as a reasonable expectation for a system built the same way. Expression-classification accuracy in that body of work lands consistently in the 80-87 percent band, with the IEEE camera-only prototype's 84.82 percent figure standing out as evidence that dedicated sensors are not a precondition for reasonable performance. Where these systems tend to slip is in confusing expressions that look alike on a still frame - fear against surprise, neutral against mild sadness - a pattern that shows up across nearly every paper surveyed here and is likely a property of FER-2013's own labelling ambiguity rather than any one architecture's weakness.

The practical case for a face-only approach becomes clearest next to the alternative: emotion sensing through EEG headbands or wearable heart-rate monitors. Those methods can be more precise, but they require hardware a listener has to actually put on, which is a real barrier to casual, everyday use. A webcam that is already sitting on top of the screen has no such barrier - its trade-off is a higher sensitivity to lighting, glasses, camera angle and partial occlusion, all of which are software problems rather than adoption problems.

Where This Could Go, and Where It Falls Short:

1. Realistic Uses:

- A mood-aware layer inside existing music-streaming apps, sitting alongside rather than replacing history-based recommendations
- Playlist generation for study, workout or wind-down apps that already assume a camera is available
- Longitudinal mood tracking inside wellness apps, where the music recommendation is a secondary benefit of the underlying expression data
- In-vehicle systems that shift music selection based on driver affect, with obvious safety motivations

2. Where It Struggles:

- Accuracy drops under poor lighting, extreme camera angles, or when the face is partly hidden
- A visible expression is not proof of an internal emotional state - people perform faces for cameras, and this system has no way to tell the difference
- Continuous camera use raises real privacy questions that need explicit consent and, ideally, on-device processing rather than any server round-trip

3. Sensible Next Steps:

The most promising direction is probably not a better face classifier alone but a system that

stops relying on the face in isolation - folding in voice tone or the sentiment of what someone just typed into a search box would catch cases where the face is ambiguous or the camera is unavailable. Moving inference on-device rather than to a server would also address the privacy concern directly instead of just documenting it, and would likely cut latency further, which matters more than most papers in this space acknowledge.

Closing Thoughts:

The case for reading a listener's face rather than their history is not that it is more accurate in some abstract sense, but that it responds to something a purely historical model structurally cannot see: the state someone is in right now. The four-stage pipeline described here - detect, classify, map, retrieve - is deliberately unremarkable in its individual parts, each of which has precedent in the systems surveyed in Section 2, but the adjustable mood-mapping layer and the explicit acknowledgement of where face-only systems fall short are where this design tries to add something. Built out fully, a system like this would sit well alongside existing recommendation engines rather than replacing them, catching the moments where a listener's mood has simply moved faster than their listening history has caught up.

References:

1. Parmar, P. (2026). Music Recommendation System Using Facial Expression Recognition. Proceedings of the International Conference on AI Systems and Sustainable Technologies (ASSET 2025), Lecture Notes in Networks and Systems, vol. 1580, Springer, Singapore.
2. Rajesh, B., et al. (2024). Music Recommendation Based on Facial Emotion Recognition. arXiv:2404.04654.
3. Facial Emotion Based Song Recommendation System. IEEE Conference Publication, IEEE Xplore, Document ID 10183606, 2023.
4. Singh, A., Sharma, R., Pandey, M.S., Asthana, S., Gitanjali, Vishwakarma, A. (2024). Facial Expression Based Music Recommendation System Using Deep Learning. Data Science and Network Engineering (ICDSNE 2023), Lecture Notes in Networks and Systems, vol. 791, Springer, Singapore.
5. Emotional Detection and Music Recommendation System Based on User Facial Expression. ResearchGate Publication 344869977, 2020.
6. Music Recommendation Based on Face Emotion Recognition. ResearchGate Publication 354855186, 2021.
7. Emotion Detection and Music Recommendation System. arXiv:2503.20739.
8. Emotion-driven Music Recommendation System Based on Fully Convolutional Recurrent Attention Networks and Collaborative Filtering. ScienceDirect, 2025.
9. Goodfellow, I., et al. (2013). Challenges in Representation Learning: A Report on Three Machine Learning Contests (source of the FER-2013 dataset).

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Digital Transformation in Indian Agriculture: Awareness, Adoption, Challenges, and Future Perspectives

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Abstract:

Digital technologies are increasingly positioned as instruments of structural change in Indian agriculture, a sector that still supports nearly half of the country's workforce while contributing a shrinking share of national income. This paper examines the awareness, adoption, challenges, and future trajectory of digital transformation in Indian agriculture, drawing on secondary data from government sources, policy documents, and published literature. It traces the evolution of digital initiatives from early market-information services such as e-NAM to the more recent Digital Agriculture Mission and its AgriStack architecture, which aims to give every farmer a verifiable digital identity linked to land and crop records. The paper finds that awareness of digital tools has expanded rapidly in absolute terms, with crores of farmers registered on flagship platforms, yet actual, sustained adoption remains uneven across states, crops, and social groups. Persistent constraints, including limited rural connectivity, low digital and financial literacy, small and fragmented landholdings, and concerns about data privacy, continue to slow the translation of awareness into routine use. The paper concludes that digital transformation in Indian agriculture is best understood as a gradual, infrastructure-dependent process rather than a one-time technological leap, and it outlines policy-relevant directions for making digital agriculture more inclusive, interoperable, and farmer-centric.

Keywords: Digital Agriculture; Agristack; E-NAM; Farmer Awareness; Technology Adoption; Rural India; Agri-Tech Policy.

Introduction:

Agriculture remains the backbone of the Indian economy in social and demographic terms, engaging close to half of the country's workforce even though its share of gross value added has fallen well below one-fifth. This structural imbalance between employment share and income share has long been identified as a core development challenge, and successive governments have looked to technology as one lever for narrowing the gap. Over the last decade, the conversation around agricultural technology in India has shifted from isolated pilot projects toward a systemic, infrastructure-led approach commonly described as digital agriculture.

Digital agriculture, in the Indian context, spans a wide spectrum of interventions: mobile-based weather and price advisories, online commodity trading platforms, satellite and remote-sensing-based crop monitoring, digital land and farmer identity records, artificial-intelligence-driven advisory chatbots, and financial-technology tools for credit and insurance. The government's Digital Agriculture Mission, approved in September 2024 with an outlay of roughly Rs. 2,817 crore, has brought many of these strands together under a single

umbrella, with AgriStack functioning as the underlying digital public infrastructure. The stated ambition is to create a farmer registry, a geo-referenced village map, and a crop-sown registry that together allow government schemes, credit, and insurance to be delivered with greater speed and accuracy.

Despite the scale of these efforts, there is an important distinction between a farmer merely being aware that a digital tool exists, actually enrolling in it, and routinely using it to make better decisions or earn better prices. This paper is organised around that distinction. It reviews the major digital initiatives shaping Indian agriculture, assesses available evidence on awareness and adoption, catalogues the principal challenges that separate registration from meaningful use, and outlines the directions in which the ecosystem appears to be moving.

Literature Review:

Early scholarship on information and communication technology in Indian agriculture focused on the diffusion of mobile telephony and its effect on price information asymmetry between farmers and traders. Studies from the 2000s and early 2010s generally found that access to price information through mobile phones improved farmers' bargaining position in local markets, though the effect was smaller for farmers with limited literacy or weak network coverage. This early literature established a recurring theme that continues to shape the field: the benefit of a digital tool is conditional on complementary factors such as literacy, infrastructure, and market structure, and cannot be assumed from the mere existence of the technology.

A second strand of literature examines platform-based reforms, most notably the electronic National Agriculture Market. Research on e-NAM's state-wise performance has generally reported a mixed picture: core functions such as electronic gate passes, online bidding, and e-payments have been adopted relatively widely, while complementary infrastructure such as assaying laboratories, electronic display boards, and integrated warehousing have lagged behind, limiting the platform's full potential in several states. This body of work underscores that digital reform of agricultural marketing is as much an institutional and infrastructural undertaking as a technological one.

A more recent strand addresses the Digital Public Infrastructure paradigm, in which AgriStack is frequently compared to the Aadhaar biometric identity system on account of its ambition to create a unique, interoperable identifier, in this case a Farmer ID, for every cultivator in the country. Analysts note that such infrastructure can, in principle, simplify and speed up the delivery of credit, insurance, and subsidy, but they also flag risks around data ownership, consent, and the potential exclusion of tenant farmers, sharecroppers, and others whose land records are unclear or contested. This tension between efficiency gains and inclusion risks forms a recurring concern across the literature on digital public infrastructure in agriculture.

Taken together, the literature suggests three broad conclusions that inform the present paper: first, awareness and registration figures, while useful, tend to overstate the depth of genuine adoption; second, infrastructural and human-capital constraints are more binding than the availability of the technology itself; and third, governance questions around data and inclusion are becoming as central to the digital agriculture debate as questions of technical design.

Objectives of the Study:

1. To review the major digital initiatives introduced in Indian agriculture and trace their evolution.

2. To assess the current levels of farmer awareness and adoption of key digital agricultural platforms.
3. To identify and categorise the principal challenges limiting the depth and inclusiveness of digital adoption.
4. To outline emerging trends and policy-relevant future perspectives for digital agriculture in India.

Research Methodology:

This paper adopts a descriptive and analytical research design based entirely on secondary data. Information has been drawn from official government sources, including press releases and parliamentary responses of the Ministry of Agriculture and Farmers Welfare and the Small Farmers Agribusiness Consortium, together with peer-reviewed journal articles, working papers, and reputable agricultural policy publications. Data on scheme coverage, such as the number of farmers registered on e-NAM or the number of Farmer IDs created under AgriStack, has been cross-checked across multiple official releases to ensure consistency. Given the fast-changing nature of scheme implementation, figures are treated as indicative of scale and direction rather than as precise real-time counts.

Overview of Key Digital Initiatives:

India's digital agriculture ecosystem has developed in layers rather than as a single programme. Figure 4 presents a conceptual architecture showing how the identity, advisory, market, and delivery layers connect to farmer-facing outcomes. Table 1 summarises the principal initiatives referenced in this paper, spanning market platforms, identity infrastructure, decision-support systems, and advisory services.

Figure 4. Conceptual Architecture of India's Digital Agriculture Ecosystem

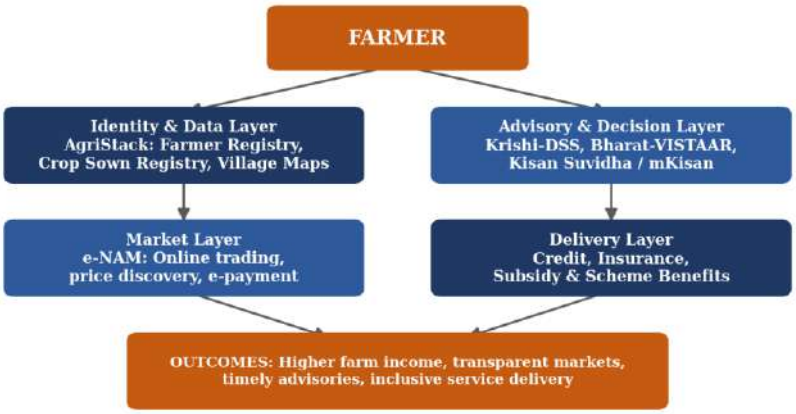


Figure 4. Conceptual architecture linking AgriStack, e-NAM, and advisory platforms to farmer outcomes.

Initiative	Launch / Approval	Core Function
e-NAM (Electronic National Agriculture Market)	2016	Online trading platform integrating APMC mandis
Digital Agriculture Mission	September 2024	Umbrella mission for digital public infrastructure in agriculture
AgriStack (Farmer Registry, Crop	2024 onward	Unified farmer identity and land/crop database

Initiative	Launch / Approval	Core Function
Sown Registry, Geo-referenced Maps)		
Krishi Decision Support System (Krishi-DSS)	2024 onward	Geospatial integration of remote-sensing, soil, and weather data
Bharat-VISTAAR	2026	AI-enabled farm advisory and extension platform
Kisan Suvidha / mKisan / Kisan Call Centre	2013 onward	Mobile-based weather, price, and advisory alerts

Table 1. Selected digital initiatives in Indian agriculture.

1. Electronic National Agriculture Market (e-NAM):

Launched in 2016, e-NAM was among the earliest large-scale attempts to digitise agricultural marketing by linking regulated wholesale markets on a common online platform. Mandi integration has grown steadily, from around 250 markets shortly after launch to 962 by mid-2020, 1,389 by late 2023, and 1,656 markets across 23 states and 4 Union Territories by March 2026, as shown in Figure 1. Registration has followed a similar trajectory: by March 2026, more than 1.80 crore farmers, 2.73 lakh traders, and 4,724 Farmer Producer Organisations had registered on the platform, with cumulative trade value reaching about Rs. 4.84 lakh crore since inception. The platform offers multilingual mobile access, real-time price discovery, online bidding, and electronic payment, features that collectively aim to reduce farmers' dependence on intermediaries and improve price realisation.

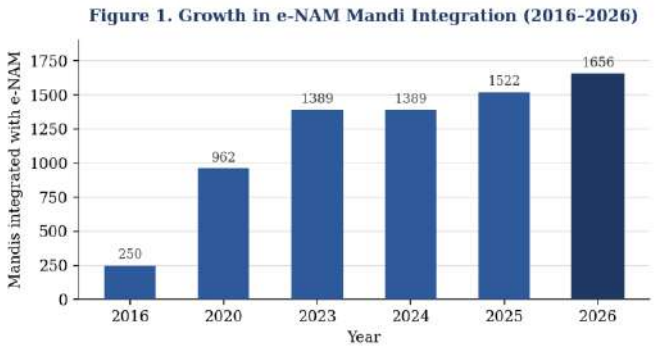


Figure 1. Growth in e-NAM mandi integration, 2016–2026 (source: Ministry of Agriculture and Farmers Welfare / PIB releases).

2. Digital Agriculture Mission and AgriStack:

Approved in September 2024, the Digital Agriculture Mission represents a consolidation of India's digital agriculture strategy under a single, better-funded programme. Its centrepiece, AgriStack, rests on three foundational registries: a Farmer Registry that assigns each cultivator a unique Farmer ID linked to digitised land records, a Geo-Referenced Village Map, and a Crop Sown Registry compiled through Digital Crop Surveys. The Mission set a phased target of creating digital identities for 11 crore farmers over three years; against this target, more than 10.31 crore Farmer IDs had been created nationally by August 2026, as illustrated in Figure 2. Digital Crop Survey coverage has expanded in parallel, from 436 districts during the Kharif 2024 season to 648 districts covering over 31.3 crore plots during the 2025-26 Rabi season (Figure 3). Nineteen states had signed memoranda of understanding with the Ministry of Agriculture to implement the mission, reflecting a federated model in which states retain ownership of the underlying data while the Centre provides technical standards and funding support.

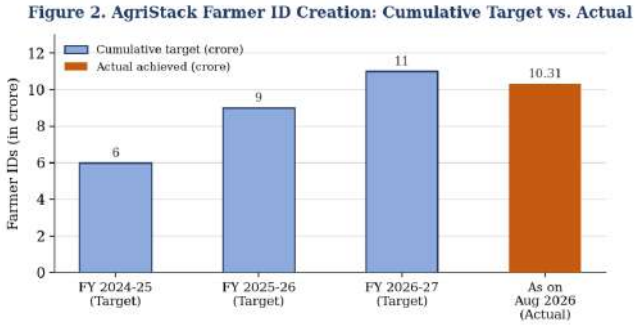


Figure 2. AgriStack Farmer ID creation: phased cumulative target versus actual achievement.

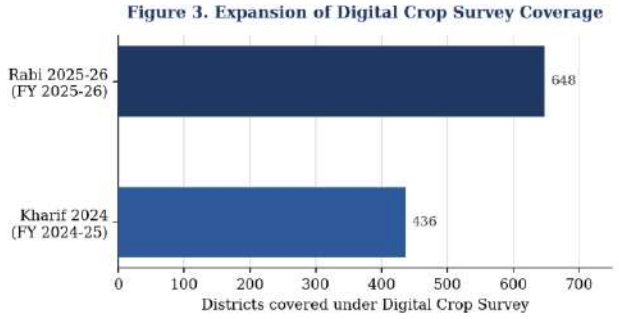


Figure 3. Expansion of Digital Crop Survey district coverage, Kharif 2024 to Rabi 2025-26.

3. Advisory and Decision-Support Platforms:

Complementing the identity and marketing layers, the Krishi Decision Support System is designed to integrate remote-sensing, soil, weather, and water-resource data into a unified geospatial platform for planning and advisory purposes. More recently, the Bharat-VISTAAR initiative has introduced artificial-intelligence-enabled farm advisory services, reflecting a broader shift from static information dissemination toward interactive, personalised guidance delivered through mobile applications and call centres.

Awareness and Adoption: Findings and Discussion:

1. Awareness:

Registration figures suggest that awareness of headline digital schemes has grown substantially. The scale of e-NAM registration and the rapid rise in Farmer ID creation under AgriStack indicate that government outreach, often combined with the requirement that a Farmer ID is necessary to access certain benefits, has succeeded in bringing large numbers of farmers into contact with digital systems. However, awareness is not evenly distributed: uptake tends to be concentrated in states with stronger agricultural marketing infrastructure and more active extension networks, such as parts of western and southern India, while awareness in remote, hilly, or conflict-affected regions remains comparatively limited. Awareness also varies by crop and market orientation, with farmers producing commercial, market-oriented crops generally more exposed to digital marketing tools than subsistence-oriented smallholders.

2. Adoption:

Adoption, understood as sustained and functional use rather than one-time registration, presents a more uneven picture. Evidence on e-NAM's state-level performance shows that core transactional features, including electronic gate passes, online bidding, and e-payments, have been adopted relatively widely, but ancillary infrastructure such as assaying laboratories, electronic display boards, and integrated warehousing has lagged, which in turn constrains how fully farmers can rely on the platform for quality-based price discovery. A similar gap between registration and active use appears to be emerging around AgriStack: while Farmer ID creation is progressing rapidly, the extent to which farmers actively use their digital identity to access credit, insurance, or scheme benefits will depend on how well the registry is linked to those downstream services.

Adoption also depends heavily on the type of technology involved. Simple, low-cost tools that piggyback on existing mobile phone use, such as SMS-based price alerts or voice-based advisories, tend to see faster uptake than tools requiring smartphones, stable data connections, or specialised digital literacy, such as satellite-based advisory dashboards or online

bidding interfaces. This pattern is consistent with the broader finding in the literature that the marginal cost of adoption, in terms of money, time, and learning, is a stronger predictor of use than the theoretical usefulness of a technology.

Challenges to Digital Transformation:

The gap between awareness and functional adoption can be traced to a set of interlinked structural challenges, summarised by category in Table 2.

Category	Representative Barrier	Illustrative Effect
Infrastructural	Uneven rural broadband and unreliable electricity	Interrupted access to advisory and market apps
Socio-economic	Low landholding size, limited disposable income	Reduced willingness to invest in devices or subscriptions
Educational	Low digital and financial literacy	Difficulty navigating apps, e-payment, and portals
Demographic	Ageing farmer population, gender gap in device ownership	Lower uptake among women and older cultivators
Institutional	Fragmented state-wise implementation, limited extension staff	Inconsistent onboarding and after-use support
Data & Trust	Concerns over data privacy and land-record errors	Reluctance to register on Farmer ID / AgriStack

Table 2. Categorised barriers to digital adoption in Indian agriculture.

Infrastructural constraints remain among the most binding barriers. Although rural internet penetration has expanded considerably over the past several years, coverage quality and reliability remain uneven, and electricity supply interruptions in many rural areas continue to disrupt sustained digital engagement. Socio-economic constraints compound this problem: with a large share of Indian holdings classified as small or marginal, many farmers operate on thin margins that leave little room for discretionary spending on smartphones, data plans, or subscription-based advisory services.

Educational and demographic factors add a further layer of difficulty. Digital and financial literacy levels vary widely across rural India, and farmers who are older, less formally educated, or unfamiliar with English or standard digital interfaces often struggle to navigate registration portals, mobile applications, and online payment systems without assistance. Gender disparities in device ownership and decision-making authority mean that women farmers, despite playing a substantial role in agricultural labour, are frequently underrepresented in digital scheme registration.

Institutional and governance challenges are equally significant. Because implementation of AgriStack and related schemes is federated across states, the pace, quality, and design of rollout differ considerably from one state to another, producing an uneven national picture. Extension services, which have traditionally served as the human interface between farmers and new technology, remain understaffed relative to the scale of the farming population, limiting the on-the-ground support available to first-time users.

Future Perspectives:

Several trends suggest how digital transformation in Indian agriculture is likely to evolve. First, the shift from siloed applications toward integrated digital public infrastructure is expected to continue, with AgriStack positioned as the common backbone linking credit, insurance, procurement, and advisory services. If this integration is executed well, a single Farmer ID could reduce the paperwork burden farmers currently face when applying separately for each scheme, though realising this benefit will require sustained investment in interoperability between central and state systems.

Second, artificial intelligence and advisory platforms such as Bharat-VISTAAR indicate a move from static, one-way information dissemination toward more interactive and personalised farm advisory services, potentially in regional languages and voice-based formats that lower the literacy threshold for use. Third, continued expansion of the Digital Crop Survey and geospatial decision-support systems is likely to improve the accuracy of yield estimation, crop insurance claims, and early warning for pest or weather-related risks, provided that ground-truthing keeps pace with the scale of digital mapping.

At the same time, the sustainability of these gains will depend on addressing the structural challenges identified in this paper. Expanding reliable rural connectivity and electricity, investing in localised digital-literacy training delivered through existing extension networks and Farmer Producer Organisations, and building clear, farmer-friendly data-protection and grievance-redressal mechanisms are likely to matter as much as, if not more than, the addition of new digital features.

Conclusion:

Digital transformation has become a defining feature of contemporary agricultural policy in India, moving from early, narrowly scoped interventions such as mobile price alerts toward an ambitious, integrated digital public infrastructure anchored by AgriStack and the Digital Agriculture Mission. The evidence reviewed in this paper indicates that awareness of these initiatives has expanded rapidly, reflected in large-scale registration on platforms such as e-NAM and the fast pace of Farmer ID creation. For digital transformation to translate into meaningfully higher farm incomes and more efficient service delivery, future efforts will need to focus as much on the human, institutional, and infrastructural foundations of adoption as on the sophistication of the technology itself. Approached this way, digital agriculture in India is less a single technological event than an ongoing, incremental process of capacity-building that must be paired with continued investment in rural connectivity, extension support, and inclusive, trustworthy data governance.

References:

1. Department of Agriculture and Farmers Welfare. (2024). Digital Agriculture Mission approved with an outlay of Rs. 2,817 crore. Press Information Bureau, Government of India.
2. Ministry of Agriculture and Farmers Welfare. (2025). AgriStack: Digital Public Infrastructure for Agriculture — Farmer Registry, Crop Sown Registry, and Geo-Referenced Village Maps. Government of India.
3. Small Farmers Agribusiness Consortium. (2025). Parliamentary replies on the status and coverage of the electronic National Agriculture Market (e-NAM), various dates

(January–June 2025). Ministry of Agriculture and Farmers Welfare, Government of India.

4. National Agriculture Market. (2026). e-NAM platform statistics: registered farmers, traders, mandis, and Farmer Producer Organisations (as of March 2026). Press Information Bureau, Government of India.
5. Keerthi, S., & Basavaraj, K. (2024). Farmer Producer Organisations and digital agricultural marketing: Opportunities and constraints. Journal of Agricultural Economics and Extension.
6. Reddy, A. A. (2016). e-NAM and the reform of agricultural markets in India: An assessment. Indian Journal of Agricultural Marketing.
7. Dalwai Committee. (2018). Report of the Committee on Doubling Farmers' Income: Role of digital technology. Ministry of Agriculture and Farmers Welfare, Government of India.
8. Global Agriculture. (2026). Implementation of AgriStack and Digital Agriculture Mission: Progress update. Global Agriculture News.
9. KPIAS Academy. (2026). Digital Agriculture Mission: Benefits, challenges, and initiatives. Policy Brief.

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Digital Transformation: Emerging Technologies in the Indian Education System

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Abstract:

The research delves into the impact of digital media on teaching and learning in Indian schools through a mixed-methods study involving 1,000 students, teachers, and administrators. Quantitative findings show widespread use of online learning platforms, particularly video lectures, enhancing student engagement and outcomes. Teachers are effectively incorporating digital tools despite connectivity challenges. Interviews reveal benefits like interactive learning but raise concerns about screen time and equitable access. The study underscores digital media's potential in reshaping Indian education, emphasising the need for infrastructure, teacher training, and digital literacy improvements to ensure inclusive digitisation. A balanced approach is advocated to optimise technology benefits while mitigating drawbacks, guiding policymakers in advancing Education 2.0 for enhanced learning opportunities for all students in India.

Keywords: Visual Communication, Digital Media, Indian Social Culture, Cultural Preservation, Globalization, Media Content Analysis, Cultural Identity, Attitudinal Shifts.

Introduction:

Digital transformation is changing the way education is delivered, accessed, and experienced across the world. In India, the rapid growth of internet connectivity, smartphones, digital platforms, and emerging technologies has created new opportunities for students, teachers, and educational institutions. Traditional classroom-based education is increasingly being supported by digital tools that make learning more flexible, interactive, personalized, and accessible.

The COVID-19 pandemic accelerated this transformation as schools and colleges were forced to adopt online learning. Even after the return to physical classrooms, many of the technologies introduced during this period have continued to influence the Indian education system.

Emerging Technologies in Education:

1. Artificial Intelligence:

Artificial Intelligence (AI) is one of the most important emerging technologies in education. AI-powered systems can analyze students' learning patterns and provide personalized learning materials according to their strengths and weaknesses. AI chatbots and virtual tutors can also help students understand difficult concepts and answer questions outside regular classroom hours.

Teachers can use AI-based tools to automate certain administrative tasks, generate learning resources, and identify areas where students may need additional support.

2. Online Learning Platforms:

Online learning platforms have made education accessible beyond the traditional

classroom. Students can attend lectures, access study materials, complete assignments, and take examinations through digital platforms.

Platforms offering recorded lectures and online courses also allow students to learn at their own pace. This is particularly useful for students who live far from major educational institutions or who want to develop additional skills alongside their regular education.

3. Virtual Reality and Augmented Reality:

Virtual Reality (VR) and Augmented Reality (AR) can make learning more immersive. Instead of simply reading about historical locations, scientific experiments, or complex engineering concepts, students can experience interactive simulations.

For example, medical students can use virtual simulations to understand anatomy, while engineering students can explore three-dimensional models of machines and structures. These technologies have the potential to make difficult concepts easier to visualize and understand.

4. Cloud Computing:

Cloud technology allows educational institutions to store and access information through the internet. Students and teachers can access documents, assignments, presentations, and other educational resources from different devices.

Cloud-based systems also support collaboration between students and teachers. Educational institutions can reduce their dependence on physical storage and improve the accessibility of academic resources.

5. Learning Analytics and Big Data:

Educational institutions generate large amounts of data related to attendance, examination results, assignments, and student participation. Learning analytics can help institutions analyze this information and identify patterns.

For example, data can be used to identify students who are struggling academically and provide them with timely support. It can also help institutions evaluate teaching methods and improve academic planning.

6. Internet of Things:

The Internet of Things (IoT) connects physical devices to the internet. In educational institutions, IoT can be used to develop smart classrooms, automated attendance systems, connected laboratories, and intelligent campus facilities.

Smart devices can also help institutions monitor energy consumption, improve security, and manage resources more efficiently.

Government Initiatives:

India has taken several steps toward promoting digital education. Initiatives such as **Digital India**, **DIKSHA**, **SWAYAM**, and the digital education provisions of the **National Education Policy (NEP) 2020** have contributed to the development of digital learning infrastructure.

These initiatives aim to improve access to educational resources, encourage technology-enabled learning, and support students and teachers across different parts of the country.

Benefits of Digital Transformation:

Digital transformation offers several benefits to the Indian education system. It can:

- Improve access to educational resources.
- Enable students to learn at their own pace.
- Support personalized learning.
- Make lessons more interactive and engaging.
- Connect students with teachers and experts beyond geographical boundaries.
- Reduce dependence on physical learning materials.

- Help teachers and institutions analyze student performance.
- Provide opportunities for continuous skill development.

Digital education can be particularly valuable in a large and diverse country like India, where students have different educational needs and levels of access to institutions.

Challenges:

Despite its advantages, digital transformation also presents several challenges. The **digital divide** remains an important issue, as not every student has reliable internet access, smartphones, computers, or other digital devices.

There are also concerns related to data privacy, cybersecurity, excessive dependence on technology, and the quality of online educational content. Teachers may require additional training to effectively use new technologies in the classroom.

Another challenge is maintaining human interaction. Technology should support teachers rather than completely replace them, because communication, mentorship, emotional support, and classroom interaction remain important aspects of education.

The Future of Digital Education in India:

The future of education in India is likely to involve a combination of traditional classroom teaching and digital technologies. Rather than completely replacing physical classrooms, emerging technologies can complement them through blended and hybrid learning models.

Artificial Intelligence, immersive technologies, cloud computing, learning analytics, and other innovations are expected to become increasingly integrated into education. However, successful digital transformation will require affordable connectivity, digital literacy, teacher training, strong cybersecurity, and equal access to technology.

Conclusion:

Digital transformation is reshaping the Indian education system by introducing new ways of teaching and learning. Emerging technologies such as Artificial Intelligence, Virtual Reality, Augmented Reality, cloud computing, IoT, and learning analytics can make education more accessible, personalized, and interactive.

However, technology alone cannot solve every educational challenge. Its successful implementation requires a balanced approach in which technology works together with teachers, institutions, students, and effective educational policies. With the right infrastructure and inclusive strategies, digital transformation can play an important role in building a more flexible, innovative, and accessible education system in India.

References:

1. Omer, Oz, (2018), Academicians view on Digital Transformation in Education. https://www.researchgate.net/publication/333354818_Academicians'views_on_digital_transformation_in_education
2. R. Raja, (2018). Impact of modern technology in Education, Journal of Applied and Advanced research, Journal of Applied and Advanced Research, Issue:3, Pp.33-39.
3. Vial, G. (2019). Understanding digital transformation: A review and a research agenda. The Journal of Strategic Information Systems.
4. Iivari, N., Molin-Juustila, T., and Kinnula, M. (2016). The future digital innovators: Empowering the young generation with digital fabrication and making. Proc. ICIS.

5. Papagiannidis, S., Harris, J., and Morton, D. (2020). WHO led the digital transformation of your company? A reflection of IT related challenges during the pandemic. International Journal of Information Management Article 102166.
6. Arnab Kundu, Dr. KedarNathDey, (2018). A Contemporary Study on the Flourishing Elearning Scenarios in India, IJCRT Journal, Volume 6, Issue 02, https://www.researchgate.net/publication/327671945_A_Contemporary_Study_on_the_Flouris hing_E-7.
7. Shirshendu Roy, (2020). e-learning Scope and Trend in India, https://www.researchgate.net/publication/338913710_elearning_Scope_and_Trend_in_India
8. Dr.Kapoor Radhika, (2018), Challenges in Indian Higher Education-Indian Context. Research Gate. Learn
9. R. Agarwal, G. Gao, and A. K. Jha, (2010) "Research commentary the digital transformation of healthcare: Current status and the road ahead," Information Systems Research, Vol. 21, No. 4, pp. 796-809.
10. C. Dede, (2011). "Emerging technologies, ubiquitous learning, and educational transformation," in European Conference on Technology Enhanced Learning. Springer, pp. 1– 8.
11. N. Cuellar, (2002). "The transition from classroom to online teaching," in Nursing Forum, vol. 37(3). Blackwell Publishing Ltd., pp. 5-12.

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Digital India and the Role of Digital Technology in Rural Development

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Abstract:

Digital technology has become an important instrument for promoting inclusive economic and social development in India. Digital technologies such as smartphones, internet connectivity, digital payments, online government services, e-learning platforms, telemedicine, digital banking and agricultural information services are increasingly connecting rural communities with opportunities that were previously difficult to access.

This concept is of Digital India that explores the role of digital technology in rural development. It discusses how digital technology contributes to education, healthcare, agriculture, financial inclusion, employment, entrepreneurship, governance and women's empowerment in rural areas. The paper also identifies challenges such as the digital divide, poor connectivity, lack of digital literacy, affordability, cyber security and language barriers. It suggests measures to make digital transformation more accessible, secure and inclusive for rural communities.

Keywords: Digital India, Digital Technology, Rural Development, Digital Literacy, E-Governance, Rural Connectivity, Digital Inclusion.

Introduction:

India is a country with a large rural population, and rural development is essential for the overall economic and social progress of the nation. Traditionally, people living in rural areas have faced challenges such as limited access to quality education, healthcare, banking facilities, markets, employment opportunities and government services. The rapid development of Information and Communication Technology (ICT) has created new possibilities for addressing many of these challenges. Internet connectivity, smartphones, cloud computing, artificial intelligence, digital payment systems and online platforms can connect rural citizens with information and services regardless of geographical distance.

The Digital India programme was launched with the vision of transforming India into a digitally empowered society and knowledge economy. The programme focuses on digital infrastructure, delivery of government services digitally and digital empowerment of citizens. Digital transformation is particularly significant for rural India because technology can reduce geographical barriers and provide people with faster access to information, services and economic opportunities.

Objectives of the Study:

1. To understand the concept of Digital India.
2. To examine the role of digital technology in rural development.
3. To study the impact of digital technology on rural education and healthcare.

4. To understand the role of digital technology in agriculture and rural employment.
5. To identify major challenges to rural digital transformation.
6. To suggest measures for improving digital inclusion in rural India.

Digital India Programme:

Digital India is a programme of the Government of India intended to improve digital infrastructure, digital service delivery and digital empowerment.

Digital Infrastructure as a Utility to Every Citizen:

Digital infrastructure aims to provide citizens with access to High-speed internet, Digital identity, Mobile connectivity, Banking facilities, Digital documents, Secure digital platforms

Digital Empowerment of Citizens:

Digital empowerment focuses on enabling citizens to use technology effectively that includes Digital literacy, Access to information, Digital education, Local-language digital content, Electronic access to government services

Role of Digital Technology in Rural Development:

Digital Technology in Agriculture:

Agriculture is one of the most important sources of livelihood in rural India. Farmers require timely information about weather, crop prices, agricultural practices, government schemes and markets.

Digital technology can provide farmers with Market-price information, Crop advisory services, Information about government schemes, Online agricultural marketplaces etc.

Ex: Platforms such as e-NAM (National Agriculture Market) aim to facilitate electronic trading and improve farmers' access to agricultural markets.

Digital Education:

Education is a major area where digital technology can help rural communities. Students in rural areas may have limited access to specialized teachers, educational materials and laboratories. Digital platforms can supplement traditional classroom education through Online classes, Educational videos, Digital textbooks, Online examinations, Virtual laboratories, E-learning applications, Open educational resources etc. Platforms such as SWAYAM and DIKSHA provide digital learning resources that can support students and teachers.

Digital education can also help teachers access training materials and improve their professional skills.

Digital Technology and Rural Healthcare:

Digital technologies can help connect rural patients with doctors and healthcare institutions through Telemedicine. Telemedicine allows patients to consult healthcare professionals remotely using digital communication technologies.

Benefits include:

- ✓ Reduced travel requirements
- ✓ Access to specialist consultations
- ✓ Faster medical advice
- ✓ Better connectivity between rural healthcare centres and specialists

Ex: The eSanjeevani telemedicine

Digital Banking:

Many rural communities have historically faced difficulties accessing formal banking services because of distance from bank branches and limited financial awareness. Digital banking has changed this situation through Mobile banking, Internet banking, Aadhaar-enabled services, Digital wallets, UPI payments, Banking correspondents, Micro-ATMs, Unified Payments

Interface (UPI) has made digital payments easier by allowing users to transfer money electronically using mobile devices.Digital financial services can help rural citizens receive government benefits, make payments and access banking services without travelling long distances.

Digital Technology and Rural Employment:

Digital technology can create new employment opportunities in rural areas like Online freelancing, Digital marketing, E-commerce, Online tutoring, Data-entry work, Digital service centres, Rural BPO services, Online entrepreneurship. The growth of e-commerce also allows rural artisans and small entrepreneurs to reach customers outside their local markets. Digital platforms can therefore help rural businesses move beyond geographical limitations.

E-Governance and Rural Development:

E-governance refers to the use of information and communication technologies to provide government services to citizens. Digital governance can make government services Faster, More accessible, More transparent and Easier to track. Rural citizens can increasingly access information about government schemes, certificates, applications and welfare services through online platforms and Common Service Centres (CSCs).

CSCs are particularly important because they can act as local digital access points for citizens who may not have the skills or infrastructure to access online services independently.

Role of Digital Technology in Women Empowerment:

Digital technology can contribute to the economic and social empowerment of rural women. Women can use smartphones and digital platforms for Online education, Digital banking, Entrepreneurship, Self-help group activities, Online marketing, Skill development and Accessing government information.Women-led self-help groups can use digital platforms to promote and sell products such as handicrafts, food products, clothing and other locally produced goods. Digital literacy can therefore support greater participation of women in economic activities.

Digital Technology and Rural Entrepreneurship:

Technology provides opportunities for rural entrepreneurs to start and expand businesses. A small rural entrepreneur can use Social media for promotion, Digital payment systems for transactions, E-commerce platforms for sales, Online banking for financial management and Digital advertising for customer acquisition

Major Challenges:

Despite its benefits, digital transformation in rural India faces several challenges.

Digital Divide: There is still a gap between people who have access to digital technology and those who do not.

The gap can arise due to Income, Geography, Education, Gender, Age, Infrastructure

Poor Internet Connectivity: Some rural and remote areas continue to experience problems with network coverage, internet speed and reliability.

Lack of Digital Literacy: Having a smartphone does not necessarily mean that a person can safely and effectively use digital services.

Users need knowledge about Online transactions, Password security, Digital applications, Online government services and Cybersecurity.

Cybersecurity and Online Fraud: Increasing digital transactions also increase exposure to Phishing, Fake links, OTP fraud, Identity theft, Financial scams. Therefore, cybersecurity awareness is essential.

Affordability: Smartphones, computers and reliable internet services may still be expensive for economically weaker households.

Measures to Improve Digital Inclusion:

The following measures can strengthen digital development in rural India:

- Improve rural broadband connectivity.
- Increase digital literacy programmes.
- Provide digital training in regional languages.
- Promote affordable smartphones and internet services.
- Strengthen Common Service Centres.
- Improve cybersecurity awareness.
- Encourage women and senior citizens to participate in digital-literacy programmes.
- Develop more local-language digital content.
- Provide digital-skills training for rural youth.
- Promote digital entrepreneurship and e-commerce.

Future Scope:

The future of rural digital development is closely connected with emerging technologies. Artificial Intelligence

(AI) can support agriculture, healthcare, education and government services through intelligent advisory systems and automated services.

Conclusion:

Digital technology has become an important tool for rural development in India. The Digital India programme has contributed to the expansion of digital infrastructure, online services and digital empowerment.

Technology can provide rural communities with better access to education, healthcare, agriculture-related information, banking, government services, employment and entrepreneurship. Digital platforms can also help overcome geographical barriers and connect rural citizens with wider markets and institutions.

However, digital transformation should not be measured only by the availability of technology. Digital inclusion requires connectivity, affordability, digital literacy, accessibility, cybersecurity and meaningful use of technology.

The future of rural development will therefore depend not only on providing digital infrastructure but also on ensuring that rural citizens have the knowledge, skills and confidence to use technology effectively. A digitally inclusive rural India can contribute significantly to India's broader goal of inclusive and sustainable development.

References:

1. Government of India – Digital India Programme, Ministry of Electronics and Information Technology.
2. Government of India – Digital India, Ministry of Electronics and Information Technology.
3. Government of India – e-NAM (National Agriculture Market).
4. Government of India – DIKSHA: Digital Infrastructure for Knowledge Sharing.
5. Government of India – SWAYAM: Study Webs of Active Learning for Young Aspiring Minds.
6. Government of India – eSanjeevani Telemedicine Service.
7. Government of India – Common Services Centres (CSC).

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Digital Transformation and Emerging Technologies in the Indian Education System: Opportunities, Challenges, and the Road Ahead

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Abstract:

The Indian education system is undergoing one of the most consequential shifts in its history, driven by the convergence of national policy reform and rapidly maturing digital technologies. The National Education Policy (NEP) 2020 has placed technology-enabled learning at the centre of its vision for an equitable, flexible, and future-ready education system, while government platforms such as DIKSHA, SWAYAM, PM eVidya, and the National Digital Education Architecture (NDEAR) have sought to translate that vision into infrastructure. At the same time, emerging technologies including artificial intelligence, virtual and augmented reality, blockchain, cloud computing, and learning analytics are beginning to reshape how content is delivered, how learners are assessed, and how institutions are administered. This paper examines the trajectory of digital transformation in Indian education, tracing the major policy and platform initiatives, surveying the emerging technologies being piloted across schools and higher education institutions, and critically analysing the opportunities and structural barriers that accompany this shift. Drawing on secondary data from government reports, industry surveys, and recent scholarly literature, the study finds that while digital adoption has expanded access and enabled new pedagogical models, persistent problems of infrastructure, digital literacy, affordability, and ruralurban disparity continue to limit the depth and equity of transformation. The paper concludes with a set of practical recommendations for policymakers, institutions, and educators to make India's digital education journey more inclusive and sustainable.

Keywords: Digital Transformation, Emerging Technologies, Indian Education System, National Education Policy 2020, Artificial Intelligence, EdTech, Digital Divide

Introduction:

Education in India stands at an inflection point. For decades, the sector was organised around physical classrooms, printed textbooks, and largely uniform pedagogy. Over the last ten years, however, three forces have converged to alter this landscape: the rapid spread of affordable smartphones and low-cost mobile data, a deliberate national policy push toward digitisation, and a global wave of innovation in artificial intelligence and cloud-based learning tools. The COVID19 pandemic acted as an unplanned accelerant, compelling schools, colleges, and universities that had never used a learning management system to move entire semesters online within weeks. What began as an emergency response has, in many institutions, hardened into a permanent hybrid model of teaching and learning.

The Government of India has treated this shift not merely as a technical upgrade but as a policy priority. The National Education Policy (NEP) 2020 explicitly frames technology as a 'means to bridge the digital divide' and dedicates

an entire chapter to online and digital education, calling for a dedicated unit within the Ministry of Education to coordinate the creation of digital infrastructure, content, and capacity across the country. This is complemented by a decade of Digital India initiatives that have expanded broadband connectivity, promoted digital payments, and built shared public digital platforms that education has been able to draw upon.

Yet the promise of digital transformation sits alongside a set of stubborn structural realities. India is a vast and unequal country, and access to a smartphone or a stable internet connection is still far from universal, particularly in rural households, among girls, and among economically weaker sections. A transformation that is not designed with this diversity in mind risks widening, rather than narrowing, existing educational inequalities. This paper attempts a balanced examination of both dimensions of this story: the genuine technological progress being made and the equity challenges that must be resolved if that progress is to benefit all learners.

Literature Review:

A growing body of research has examined the intersection of technology and education policy in India. Several recent studies published around the fifth anniversary of NEP 2020 note that the policy marked a conceptual shift in how technology is positioned in Indian education policy: rather than treating digital tools as a peripheral aid, NEP 2020 frames them as a systemic enabler of universal, inclusive, and future-ready learning, though implementation has been uneven across states and institution types.

Studies on higher education institutions similarly report that the adoption of Learning Management Systems, artificial intelligence-based tools, and hybrid classroom formats has accelerated markedly since 2020, and that this adoption has had a measurable positive association with student accessibility, engagement, and, in several cases, academic performance. At the same time, researchers examining governance and equity dimensions of the reform note that the success of technology integration is closely tied to teacher readiness, institutional autonomy, and the extent to which digital infrastructure investment reaches beyond well-resourced urban institutions.

A separate strand of literature focuses on connectivity and access. Industry survey data compiled by the Internet and Mobile Association of India in partnership with Kantar indicates that active internet users in the country crossed the 880-million mark by late 2024, with rural India now contributing a larger share of new users than urban India, although a meaningful gap in the depth and quality of usage between the two remains. Other analyses of mobile and digital access point out that while mobile connections are now widespread, actual regular internet usage, ownership of a personal (rather than shared, family) device, and comfort with digital tools vary considerably by gender, income, and geography. Taken together, this literature suggests that India's digital education transformation is best understood not as a single, uniform process but as several overlapping and unevenly paced transitions occurring across different regions, institution types, and socio-economic groups.

Objectives of the Study:

1. To examine the key policy and platform initiatives driving digital transformation in the Indian education system.
2. To identify and analyse the emerging technologies being adopted in Indian schools and higher education institutions.

3. To assess the opportunities that digital transformation creates for access, quality, and personalisation of learning.
4. To critically evaluate the structural challenges — infrastructural, financial, and human — that constrain equitable digital adoption.
5. To propose practical recommendations for policymakers, institutions, and educators to strengthen inclusive digital transformation.

Research Methodology:

This study adopts a descriptive and analytical research design based entirely on secondary sources. Data and insights have been drawn from government policy documents (including the National Education Policy 2020), reports and press releases from the Ministry of Education and Ministry of Electronics and Information Technology, industry survey reports (including the Internet and Mobile Association of India–Kantar 'Internet in India' report series), and peer-reviewed and conference literature on digital transformation in Indian higher education published between 2020 and 2025. The paper does not present new primary survey data; instead, it synthesises and critically interprets existing evidence to build a coherent picture of where India's digital education transformation currently stands, and applies qualitative thematic analysis to organise the discussion around policy, technology, opportunity, and challenge.

Policy Foundations of Digital Transformation in Indian Education:

1. National Education Policy 2020: NEP 2020 is the most significant education policy reform in India in over three decades, replacing the National Policy on Education of 1986. Its chapter on online and digital education calls for building a dedicated body to look after the digital infrastructure, content, and capacity-building needs of school and higher education, for creating a national repository of learning content in regional languages, and for using technology to widen access for learners with disabilities and for those in remote areas. Crucially, the policy also mandates the introduction of coding and computational thinking from the middle-school stage, signalling an intent to make technological literacy a foundational, rather than optional, part of Indian schooling.

2. Digital Platforms and Missions: Several public digital platforms now underpin the government's approach to technology-enabled learning. DIKSHA (Digital Infrastructure for Knowledge Sharing) offers curriculum-aligned econtent for school students and teachers across states in multiple languages. SWAYAM (Study Webs of Active Learning for Young Aspiring Minds) provides free massive open online courses for higher education, many of which are now creditable toward university degrees. PM eVidya was launched to unify various digital, television, and radio-based education efforts into a single programme, particularly to support continuity of learning during and after the pandemic. The National Digital Education Architecture (NDEAR) aims to provide a shared technological backbone that states and private players can build upon, rather than each institution building its own systems from scratch. Alongside these, the broader Digital India programme has expanded rural broadband, promoted low-cost data, and supported the rollout of 4G and 5G networks, all of which form the connectivity backbone that education technology depends upon.

Emerging Technologies Reshaping Indian Education:

1. Artificial Intelligence and Learning Analytics: Artificial intelligence is increasingly used in Indian classrooms and ed-tech platforms for adaptive learning, where the difficulty and

sequence of content adjusts to a learner's demonstrated ability; for automated assessment and instant feedback; and for learning analytics dashboards that help teachers identify students who are falling behind. Several state education departments and private ed-tech providers have begun piloting AI-based tools for personalised remediation in foundational literacy and numeracy, an area explicitly prioritised under NEP 2020.

2. Virtual and Augmented Reality: Virtual reality (VR) and augmented reality (AR) are being used, though still on a limited scale, to simulate laboratory experiments, historical environments, and complex scientific processes that are difficult or expensive to demonstrate physically. Such simulations are particularly valuable for institutions that lack well-equipped science laboratories, offering a partial substitute for hands-on experimentation.

3. Cloud Computing and Learning Management Systems: Cloud-based Learning Management Systems (LMS) now form the backbone of hybrid and online instruction in a large share of Indian higher education institutions, enabling content delivery, assignment submission, plagiarism checking, and continuous assessment without dependence on physical infrastructure. Cloud adoption has also allowed smaller institutions to access enterprisegrade administrative and academic tools without heavy upfront investment in on-site servers.

4. Blockchain and Digital Credentialing: Blockchain technology is being explored for the secure issuance and verification of academic credentials, reducing certificate fraud and easing the verification burden for employers and other universities. The Academic Bank of Credits envisioned under NEP 2020, which allows students to accumulate and transfer academic credits across institutions, relies on precisely this kind of tamper-resistant digital record-keeping.

Opportunities Created by Digital Transformation:

- Expanded access: Digital platforms allow learners in remote or underserved areas to access quality content that would otherwise require relocation to urban centres.
- Personalisation: Adaptive and AI-driven tools allow instruction to be tailored to individual pace and ability, rather than a single uniform classroom speed.
- Flexibility for non-traditional learners: Working professionals, women managing domestic responsibilities, and students with disabilities benefit from asynchronous, selfpaced learning options.
- Multilingual reach: Platforms such as DIKSHA and SWAYAM increasingly offer content in regional languages, aligning with NEP 2020's emphasis on mother-tonguebased instruction and widening the reach of quality content beyond English-speaking learners.
- Institutional efficiency: Cloud-based administration and analytics reduce paperwork and allow institutions to identify at-risk students earlier.
- New credentialing and mobility models: Digital Academic Bank of Credits and blockchain-based certificates make it easier for students to move between institutions and combine formal and vocational learning pathways.

Challenges and Structural Barriers:

1. The Persistent Digital Divide Despite India crossing the milestone of roughly 900 million internet users, meaningful gaps remain. Urban internet penetration continues to run well ahead of rural penetration, and many rural and low-income households share a single smartphone among several family members, which disproportionately

restricts access for children and for women. States such as Bihar, Uttar Pradesh,
and Jharkhand continue to report lower internet penetration than states like Kerala, Goa, and Maharashtra, illustrating that the divide is not only rural-versus-urban but also strongly regional.
2. Infrastructure and Device Constraints Many government schools, particularly in rural areas, still lack reliable electricity, adequate computer laboratories, or stable broadband connections, which limits the practical use of even the digital content that has already been developed. Even where devices are present, the ratio of usable devices to students is often too low for individual, hands-on engagement with technology-based learning tools.
3. Digital Literacy Among Teachers and Students Technology adoption is only as effective as the ability of teachers to use it meaningfully in pedagogy, rather than merely digitising the same lecture-based methods. Large-scale teacher training in digital pedagogy remains incomplete in many states, and student digital literacy — the ability to evaluate, create with, and safely use digital tools — also varies widely.
4. Data Privacy and Cybersecurity As more student data moves onto digital platforms, concerns around data privacy, consent (particularly for minors), and cybersecurity become more significant. Many institutions, especially smaller and rural ones, lack dedicated capacity to manage these risks responsibly.
5. Quality Assurance and Content Standardisation The rapid proliferation of ed-tech content and platforms has occasionally outpaced quality control, resulting in uneven pedagogical quality across different digital resources and a risk of content that is technologically polished but pedagogically weak.

Discussion:

The evidence reviewed in this paper suggests that India's digital transformation in education is genuinely substantial in scale and policy intent, but still incomplete and uneven in its reach. Policy architecture — NEP 2020, DIKSHA, SWAYAM, PM eVidya, and NDEAR — provides a reasonably coherent national vision, and connectivity indicators are improving quickly in absolute terms. However, the qualitative depth of digital learning — whether a student merely has occasional access to a shared smartphone versus consistent, personal access to a reliable device and a digitally literate teacher — still differs enormously by geography, gender, and household income. This means that digital transformation, left unmanaged, has the potential to widen educational inequality even as it expands average access. The countries and states that have made the most progress on this front tend to combine three elements simultaneously: expanded connectivity infrastructure, sustained investment in teacher capacity, and a deliberate focus on the most disadvantaged learners rather than an assumption that benefits will trickle down naturally. India's future trajectory will likely depend on how consistently these three elements are pursued together, rather than any single technology or platform.

Conclusion:

Digital transformation and emerging technologies are reshaping the Indian education system in ways that would have been difficult to imagine a decade ago, moving the sector from a largely physical, uniform model toward one that is more flexible, data-informed, and potentially more personalised. The policy scaffolding provided by NEP 2020 and the platform ecosystem built around DIKSHA, SWAYAM, and PM eVidya represent a serious and sustained national commitment to this shift. At the same

time, the transformation remains a work in progress: infrastructural gaps, uneven digital literacy, affordability constraints, and regional disparities continue to determine who benefits fully from these changes and who is left at the margins. For India's digital education transformation to fulfil its promise of equitable, quality education for all, technology adoption must be pursued alongside, and not as a substitute for, sustained investment in teachers, infrastructure, and targeted support for the most disadvantaged learners. Future research would benefit from primary, field-level data on learning outcomes in technology-enabled classrooms across different state and income contexts, which would allow the impact of these initiatives to be assessed with greater precision than secondary policy analysis alone can offer.

References:

1. Government of India, Ministry of Education. (2020). National Education Policy 2020. New Delhi: Ministry of Education.
2. Internet and Mobile Association of India (IAMAI) & Kantar. (2024). Internet in India Report 2024. Mumbai: IAMAI–Kantar.
3. Parti, N. (2025, July 28). Five years of NEP 2020 and the promise of EdTech. ORF Expert Speak, Observer Research Foundation.
4. Punitha, S. A. (2024). Digital transformation and its impact on student learning outcomes in higher education institutions in Tamil Nadu, India. Journal of applied and advanced studies (aasv12n1).
5. Holmes, W., Bialik, M., & Fadel, C. (2021). Artificial Intelligence in Education: Promises and Implications for Teaching and Learning. Center for Curriculum Redesign.
6. Selwyn, N. (2016). Education and Technology: Key Issues and Debates (2nd ed.). Bloomsbury Academic.
7. Ministry of Electronics and Information Technology, Government of India. Digital India Programme — Overview and Progress Reports.

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Artificial Intelligence and the Future of Employment

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Abstract:

Artificial Intelligence (AI), particularly Generative Artificial Intelligence (GenAI), is rapidly changing the nature of employment, workplace tasks and the skills required by organizations. This paper examines the future of employment through a systematic review and synthesis of secondary data from international institutions and established research studies, with particular attention to the International Labour Organization (ILO), Organisation for Economic Co-operation and Development (OECD), World Economic Forum (WEF), World Bank and peer-reviewed academic research. No primary field survey was conducted; consequently, the paper does not report fabricated respondent-level findings.

The evidence shows that AI exposure is substantial but uneven across occupations, countries and worker groups. The ILO's 2025 refined global index estimates that about one in four workers globally are in occupations with some degree of GenAI exposure, while 3.3% of global employment is in the highest exposure category. The ILO emphasizes that job transformation is more likely than complete redundancy because most occupations continue to contain tasks requiring human input. OECD evidence also indicates substantial workplace benefits alongside risks relating to work intensity, data use, inequality and automation. The WEF's 2025 employer survey identifies AI and big data among the fastest-growing skills and reports major expected labour-market disruption through 2030.

The paper finds, from secondary evidence, that AI should be understood as a technology of automation, augmentation and job redesign rather than as a simple substitute for human labour. The future of employment will depend on the interaction between technological capability, organizational adoption, worker skills, education, labour-market institutions and responsible governance. The paper recommends strengthening AI literacy, digital and analytical capabilities, critical thinking, domain expertise, reskilling, human oversight, data protection and institutional preparedness.

Keywords: Artificial Intelligence, Generative AI, Employment, Job Transformation, Automation, Augmentation, Reskilling, AI Literacy, Human-AI Collaboration, Secondary Data.

Introduction:

Artificial Intelligence has moved from a specialized area of computer science into a widely used general-purpose technology. AI-enabled systems are now being incorporated into education, software development, finance, healthcare, administration, customer service, media, research and business operations. The rapid spread of Generative AI has intensified this process because users can obtain assistance with writing, coding, summarization, translation, analysis and content creation through accessible interfaces.

The expansion of AI has also renewed a long-standing question about technology and employment: will machines replace human workers? A direct replacement interpretation, however, is insufficient for understanding

contemporary AI. A job is normally a bundle of tasks, and the technological capacity to perform one task does not mean that the whole occupation becomes redundant. AI can automate selected activities, support employees in other activities, increase productivity, alter job design, create new responsibilities and increase demand for particular skills.

The ILO's 2025 refined global assessment provides an important basis for this task-oriented interpretation. It estimates that one in four workers globally are in occupations with some exposure to GenAI, but it also emphasizes that transformation is more likely than complete replacement because occupations generally contain tasks that continue to require human input (Gmyrek et al., 2025).

The OECD likewise reports that AI can bring significant workplace benefits while creating risks associated with work intensity, data collection and use, inequality and automation. In its 2024 workplace evidence, four in five surveyed workers said AI improved their performance and three in five said it increased their enjoyment of work, while the OECD cautioned that benefits depend on addressing associated risks (OECD, 2024).

Against this background, the present paper uses secondary data to examine AI and the future of employment. It focuses on five linked questions: the extent of occupational exposure; evidence of productivity and augmentation; the possibility of job transformation and displacement; the changing skills landscape; and the institutional measures required for a responsible transition.

Problem Statement:

The public debate on AI and employment often reduces a complex process to the question of whether AI will destroy jobs. Such a framing can overlook the difference between exposure, adoption, task automation, job transformation and actual employment outcomes. It can also overlook the unequal distribution of AI opportunities and risks across occupations, income groups, genders and countries.

A second problem is that technology adoption is not determined by technical capability alone. Infrastructure, cost, organizational readiness, worker skills, regulation, data governance and the consequences of errors all influence whether and how AI is used. The ILO notes that infrastructure constraints, insufficient digital skills, cost and operational difficulties can limit full adoption, meaning that estimates of potential exposure should not be treated as observed job losses. cite turn0search10

A third problem concerns skills. If AI changes the task composition of occupations, education and training systems must adapt. Workers may need to combine technological literacy with analytical thinking, creativity, communication, domain expertise and the ability to evaluate AI outputs. The WEF's 2025 analysis identifies AI and big data, networks and cybersecurity, technological literacy, creative thinking, resilience, flexibility and lifelong learning among skills expected to rise in importance.

Objectives of the Study:

1. To examine the impact of Artificial Intelligence and Generative AI on employment through secondary evidence.
2. To review evidence on occupational exposure to Generative AI.
3. To examine the role of AI in automation, augmentation, productivity and job transformation.
4. To identify major employment-related risks, including displacement, work intensity, inequality, privacy and data-related concerns.

5. To examine changes in skill requirements and the importance of reskilling and upskilling.
6. To understand the role of education, organizations and labour-market institutions in managing AI-driven change.
7. To suggest measures for responsible AI adoption and human-AI collaboration.

Research Questions:

- What does recent secondary evidence indicate about occupational exposure to Generative AI?
- Does the evidence suggest replacement of occupations or transformation of tasks?
- What productivity and workplace benefits have been documented?
- What employment-related risks accompany AI adoption?
- Which skills are becoming more important in AI-enabled workplaces?
- What measures can educational institutions, employers and policymakers adopt to support workers?

Review of Literature:

The literature reviewed for this paper covers task-based theories of technological change, empirical evidence on AI exposure, productivity experiments, workplace surveys and global assessments of future skills. The studies collectively suggest that AI has multiple employment effects rather than a single universal outcome.

Autor (2015) argued that technology changes the composition of tasks and can complement human labour. Acemoglu and Restrepo (2019) similarly developed a framework in which automation may displace tasks while productivity effects and the creation of new tasks can offset some labour-demand effects. These approaches provide the conceptual basis for examining AI at the task level.

Webb (2020) and Felten, Raj and Seamans (2021) examined occupational exposure to AI and showed that exposure varies substantially according to the tasks associated with occupations. Eloundou et al. (2023) extended this line of inquiry to large language models and identified broad potential exposure in language-intensive work.

Noy and Zhang (2023) provided experimental evidence that Generative AI can increase the speed and quality of selected writing tasks. Their results are important for the augmentation perspective because they show that AI can improve worker performance under controlled conditions rather than simply substituting for the worker.

Brynjolfsson, Li and Raymond (2025) supplied field evidence from customer support, reporting an average 15% increase in issues resolved per hour among 5,172 agents using an AI assistant. The study illustrates how AI can increase worker productivity, while also highlighting the need to consider differences across worker experience and workplace context.

The ILO's 2023 and 2025 assessments provide a global task-based view. The 2023 analysis concluded that augmentation was likely to be the dominant effect for many occupations, while the 2025 refined index found that about one quarter of global employment is in occupations with some GenAI exposure and that transformation is more likely than full replacement.

OECD research highlights both benefits and risks. Its 2024 workplace paper reports positive performance experiences among surveyed workers but also identifies concerns about automation, work intensity, data use and inequality. Lane (2024) further examines differences among groups and emphasizes the

importance of access to AI-related opportunities and productivity-enhancing tools.

The WEF's Future of Jobs Report 2025 draws on more than 1,000 employers representing over 14 million workers across 55 economies. It identifies technological change, economic conditions, demographic change and other forces as drivers of labour-market transformation through 2030.

Study/Source	Year	Evidence or Focus	Implication for Employment
Autor	2015	Task composition and complementarity	Technology can alter tasks without eliminating all work.
Acemoglu & Restrepo	2019	Automation and new tasks	Displacement and productivity/new-task effects can coexist.
Webb	2020	Occupational AI exposure	Exposure differs according to occupational tasks.
Felten, Raj & Seamans	2021	AI exposure index	Exposure varies across occupations and industries.
Noy & Zhang	2023	Generative AI experiment	Productivity and quality improved in selected writing tasks.
Eloundou et al.	2023	LLM exposure	Language-intensive tasks have broad potential exposure.
OECD	2024	Workplace survey/policy evidence	Benefits coexist with work-intensity, data and inequality risks.
ILO	2025	Global occupational exposure	One in four workers are in occupations with some GenAI exposure; transformation is emphasized.
Brynjolfsson et al.	2025	Customer-support field study	AI assistance increased issues resolved per hour by 15% on average.
WEF	2025	Employer survey	Major job and skill changes are expected through 2030.

Research Methodology:

1. Research Design:

This paper adopts a descriptive, analytical and review-based research design. It is a secondary-data study and does not involve primary fieldwork. The method is appropriate because the objective is to synthesize established evidence from authoritative international reports and academic studies concerning AI, work and employment.

2. Sources of Data:

The main secondary sources are publications of the International Labour Organization (ILO), OECD, World Economic Forum (WEF), World Bank and peer-reviewed academic research. Particular emphasis is placed on the ILO's 2025 refined global index, OECD's 2024 workplace analysis, WEF's 2025 Future of Jobs Report and established academic studies on AI exposure and productivity.

3. Data Analysis:

The study uses thematic synthesis and descriptive comparison. Evidence is organized under five themes: (1) occupational exposure, (2) productivity and augmentation, (3) job transformation and displacement, (4) skills and reskilling, and (5) risks and governance. Numerical estimates reported by the original sources are reproduced as secondary evidence and are not presented as original survey findings.

4. Reliability and Validity:

Priority is given to primary institutional reports, peer-reviewed research and established research organizations. Findings are interpreted

within the methodological limitations stated by the original sources. In particular, potential exposure is distinguished from actual employment effects, and employer expectations are distinguished from observed labour-market outcomes.

5. Ethical Considerations:

Because the paper uses publicly available secondary sources and does not collect personal information, no respondent-level ethical procedure is required. All major empirical claims are attributed to their original sources.

Secondary Data Findings and Analysis:

1. Global Exposure to Generative AI:

The ILO's 2025 refined global index is one of the most important sources for assessing potential occupational exposure to GenAI. The analysis covers nearly 30,000 tasks and uses task-level assessment, expert input and AI-assisted scoring. It estimates that approximately one in four workers globally are in an occupation with some degree of GenAI exposure. About 3.3% of global employment falls into the highest exposure category. Exposure is higher in high-income economies, where the ILO estimates 34% of employment is in the four exposure gradients, compared with 11% in low-income countries.

The same evidence shows that clerical occupations remain particularly exposed. At the same time, exposure has increased in some highly digitized professional and technical roles as Generative AI capabilities have expanded. This demonstrates that AI exposure is not restricted to routine clerical work; it increasingly includes specialized digital activities.

The significance of these figures should be interpreted carefully. The ILO describes them as potential exposure rather than observed job losses. The estimates represent an upper threshold under conditions of full implementation and do not account fully for infrastructure, cost, skills and operational barriers.

Indicator	Secondary Evidence	Interpretation
Global employment in occupations with some GenAI exposure	About 25%	A substantial share of employment may experience task-level effects.
Highest exposure category	3.3% of global employment	A smaller share has very high potential exposure.
High-income countries	34% of employment in exposure gradients	Exposure is higher where digital and clerical employment is more prevalent.
Low-income countries	11% of employment in exposure gradients	Lower exposure partly reflects employment structure and digital access.
Most exposed occupational area	Clerical work	Routine and information-processing tasks have high potential exposure.
Most likely overall outcome	Job transformation	Human input remains important across most occupations.

2. Automation versus Augmentation:

The secondary evidence does not support a simple conclusion that AI will automatically eliminate occupations. The ILO's task-based analysis explicitly distinguishes potential automation from the broader transformation of jobs. Most occupations combine tasks with different degrees of AI exposure, and many tasks still require human judgment, interaction or physical execution.

This distinction is reinforced by productivity studies. Noy and Zhang (2023) found

that Generative AI improved performance in selected writing tasks. Brynjolfsson et al. (2025) found a 15% average increase in issues resolved per hour among 5,172 customer-support agents using an AI assistant. These studies provide evidence that AI can complement workers and raise productivity in particular settings.

Augmentation does not mean that employment effects are always positive. If organizations can produce the same output with fewer workers, some tasks or positions may be reduced even when remaining workers become more productive. Therefore, productivity gains should be examined together with job quality, work intensity, employment transitions and distributional effects.

3. Workplace Benefits:

OECD evidence provides a broader workplace perspective. In its surveys of employers and workers, four in five workers reported that AI improved their performance at work, while three in five reported increased enjoyment of work. At the same time, the OECD identifies risks relating to increased work intensity, collection and use of data, inequality and automation.

The coexistence of benefits and risks suggests that the outcome of AI adoption depends partly on how technology is introduced. AI can reduce time spent on repetitive tasks, support information processing and improve access to assistance. However, poorly designed systems can increase monitoring, intensify workloads or create new risks when outputs are inaccurate or decisions are insufficiently supervised.

4. Changing Skills:

AI changes not only the number of tasks performed by workers but also the capabilities required to perform those tasks effectively. The WEF's 2025 employer survey identifies AI and big data as among the fastest-growing skill areas, alongside networks and cybersecurity and technological literacy. It also identifies creative thinking, resilience, flexibility, agility, curiosity and lifelong learning as important skills expected to rise.

An important implication is that technical skills alone are insufficient. Workers need the ability to formulate problems, evaluate AI outputs, identify errors, apply domain knowledge and make responsible decisions. In education, this means that AI literacy should be combined with communication, critical thinking, analytical reasoning and professional knowledge.

5. Unequal Effects across Workers and Economies:

The secondary evidence indicates that AI exposure is uneven. The ILO reports higher overall exposure in high-income countries and identifies substantial differences between female and male employment in the highest exposure categories. cite turn0search0 OECD research similarly emphasizes that different socio-demographic groups may experience different opportunities and risks, including differences in access to AI-related employment opportunities and productivity-enhancing tools.

These differences matter for policy because a transition to AI-enabled work may widen existing inequalities if access to digital infrastructure, education, training and AI tools is uneven. Conversely, targeted investment in skills and access can help more workers participate in productivity gains.

6. Future Labour-Market Change:

The WEF Future of Jobs Report 2025 uses employer expectations to examine labour-market change through 2030. It reports that 22% of jobs are expected by surveyed employers to be disrupted by 2030, with 170 million roles projected to be created and 92 million displaced, implying a net increase of 78 million in the survey's aggregate employer projections. These

are employer expectations, not observed outcomes or a forecast guaranteed to occur.

The importance of the WEF evidence is therefore not the precise numerical projection alone but the indication that employers anticipate significant occupational and skill restructuring. The findings reinforce the need for education systems and organizations to prepare for changing task requirements rather than waiting for disruption to occur.

Discussion:

The combined secondary evidence suggests that AI is best understood as a general-purpose technology capable of altering the organization of work. The central change is likely to occur through tasks. Some tasks can be automated, some can be augmented, and new tasks can emerge around supervising, evaluating, integrating and governing AI systems.

The ILO evidence provides the strongest support for distinguishing exposure from replacement. One quarter of global workers being in occupations with some exposure is significant, but it does not mean that one quarter of jobs will disappear. The occupational exposure measure identifies potential for task change, while the actual outcome depends on adoption, work organization and the continuing need for human input.

Productivity evidence adds another dimension. When AI allows workers to complete selected tasks faster or with better quality, organizations may use the resulting capacity in different ways. They may increase output, reduce costs, improve service quality, redesign roles or reduce labour demand for particular tasks. The distribution of productivity gains therefore becomes an important employment issue.

Skills emerge as a central connecting factor. Workers who can use AI effectively may benefit from augmentation, while workers without access to training may find it more difficult to adapt. The WEF evidence on rapidly rising technology and human skills, together with OECD concerns about unequal access, suggests that reskilling should be treated as a continuing institutional responsibility rather than a one-time intervention.

For India, the issue is particularly relevant because employment spans highly digitized services as well as manufacturing, commerce, agriculture, public services and a large informal sector. The effects of AI are therefore unlikely to be uniform. Access to infrastructure, language resources, digital skills, organizational readiness and sector-specific applications will influence the pace and form of AI adoption. A useful Indian research agenda should consequently examine sectoral and regional differences rather than assuming a single national effect.

Major Findings:

- AI has substantial potential exposure across global employment, but exposure is not equivalent to actual job loss.
- Approximately one in four workers globally are in occupations with some degree of GenAI exposure according to the ILO's 2025 refined index.
- Clerical occupations remain among the most exposed, while exposure is also increasing in some highly digitized professional and technical activities.
- Job transformation and augmentation are important mechanisms through which AI may affect employment.
- Experimental and workplace evidence demonstrates productivity improvements in selected tasks and settings.
- AI adoption can generate benefits while also creating risks relating to work intensity, data use, privacy, inequality and automation.

- AI and big data, cybersecurity and technological literacy are among the skills expected to increase in importance, alongside creative thinking, resilience and lifelong learning.
- AI-related opportunities and risks are unevenly distributed across countries, occupations and worker groups.
- Employer projections indicate substantial job and skill restructuring through 2030, but projections should not be treated as guaranteed outcomes.
- Education, reskilling, organizational preparedness and responsible governance are central to managing the employment transition.

Suggestions:

1. For Educational Institutions:

- Introduce AI literacy across disciplines rather than restricting AI education to computer science.
- Teach students how to formulate effective tasks for AI systems and how to verify AI-generated outputs.
- Strengthen critical thinking, analytical reasoning, creativity, communication and problem-solving.
- Integrate cybersecurity, privacy, ethics and responsible AI use into curricula.
- Develop practical projects that combine AI tools with domain-specific knowledge.
- Provide continuous faculty development so teachers can adapt curricula to changing AI capabilities.

2. For Students and Workers:

- Develop continuous learning and reskilling habits.
- Acquire practical knowledge of AI tools relevant to the profession.
- Combine AI literacy with strong domain expertise rather than relying on AI output alone.
- Develop the ability to verify sources, detect errors and evaluate AI-generated content.
- Strengthen human skills such as communication, creativity, teamwork, resilience and critical thinking.

3. For Organizations:

- Identify which tasks should be automated, augmented or retained under human leadership.
- Provide role-specific AI training and reskilling opportunities.
- Develop clear internal policies for privacy, security, accountability and acceptable AI use.
- Maintain meaningful human oversight for high-impact decisions.
- Measure AI adoption not only through productivity but also through job quality, workload, employee experience and skill development.

4. For Policymakers:

- Expand digital infrastructure and access to affordable AI-enabled technologies.
- Support large-scale reskilling and upskilling programmes.
- Strengthen frameworks for privacy, cybersecurity, accountability and responsible AI.
- Promote research on AI and employment using Indian sectoral and regional data.
- Encourage social dialogue among employers, workers, educators and government agencies concerning technological transition.

Limitations of the Study:

- The study is based entirely on secondary sources and does not include original respondent-level field data.

- Different sources use different definitions and methodologies for AI exposure, adoption and employment effects.
- AI capabilities and adoption are changing rapidly, so findings may evolve as technology develops.
- Potential occupational exposure should not be interpreted as observed job displacement.
- Employer expectations and projections, including those in the WEF report, are not equivalent to realized labour-market outcomes.
- International evidence may not fully represent the employment structure and institutional conditions of India.
- Some productivity studies focus on particular tasks or workplaces and therefore cannot automatically be generalized to all occupations.

Scope for Future Research:

Future research can extend this secondary-data study through India-focused sectoral analysis. Important areas include IT and IT-enabled services, education, banking, healthcare, manufacturing, retail, business-process operations and small enterprises. Studies can compare urban and rural settings, formal and informal employment, different educational groups and different levels of digital access.

Longitudinal research would be particularly valuable because employment effects may emerge gradually. Future studies can combine labour-force data, enterprise surveys, job-posting data, productivity indicators and qualitative interviews. Such evidence would allow researchers to distinguish potential exposure from actual adoption and employment transitions.

At the institutional level, research can examine which forms of AI training produce measurable improvements in worker productivity, job quality and career mobility. Studies can also investigate how AI changes teaching and learning in higher education and what curriculum reforms are required to prepare students for AI-enabled employment.

Conclusion:

Artificial Intelligence is changing employment through a combination of automation, augmentation, productivity improvement and job redesign. The secondary evidence reviewed in this paper does not support treating AI exposure as synonymous with universal job replacement. The ILO's 2025 refined global index shows that approximately one in four workers are in occupations with some GenAI exposure, but it also indicates that transformation is more likely than complete redundancy because human input remains necessary in many occupational tasks.

Workplace evidence indicates that AI can improve performance and productivity in selected contexts, while OECD research shows that these benefits coexist with concerns about work intensity, data use, inequality and automation. The WEF evidence further indicates that employers anticipate major changes in jobs and skills through 2030, with AI and big data among the fastest-growing skill areas.

The central implication is that the future of employment will depend not only on technological capability but also on the capacity of people and institutions to adapt. Education systems must strengthen AI literacy, critical thinking and domain expertise. Employers must invest in reskilling and responsible implementation. Policymakers must address unequal access, privacy, cybersecurity and labour-market transition. Workers must develop the capacity to collaborate with AI while retaining the human judgment required for complex decisions.

For India, this transition should be approached through sector-specific and inclusive strategies. AI can contribute to productivity and new forms of work, but the benefits will depend on access to skills, infrastructure, organizational capacity and responsible governance. A human-centred approach to AI can therefore help ensure that technological progress contributes to productive, adaptable and sustainable employment.

References:

1. Acemoglu, D., & Restrepo, P. (2019). Artificial intelligence, automation, and work. In A. Agrawal, J. Gans, & A. Goldfarb (Eds.), The Economics of Artificial Intelligence. University of Chicago Press.
2. Autor, D. H. (2015). Why are there still so many jobs? The history and future of workplace automation. Journal of Economic Perspectives, 29(3), 3–30.
3. Brynjolfsson, E., Li, D., & Raymond, L. R. (2025). Generative AI at work. Quarterly Journal of Economics, 140(2), 889–942.
4. Eloundou, T., Manning, S., Mishkin, P., & Rock, D. (2023). GPTs are GPTs: An early look at the labor market impact potential of large language models. arXiv preprint arXiv:2303.10130.
5. Felten, E. W., Raj, M., & Seamans, R. (2021). Occupational, industry, and geographic exposure to artificial intelligence. Strategic Management Journal, 42(12), 2197–2214.
6. Gmyrek, P., Berg, J., Kamiński, K., Konopczyński, F., Ładna, A., Nafradi, B., Rosłaniec, K., & Troszyński, M. (2025). Generative AI and jobs: A refined global index of occupational exposure. ILO Working Paper 140. International Labour Organization. https://doi.org/10.54394/HETP0387
7. International Labour Organization. (2025). Generative AI and jobs: A 2025 update. International Labour Organization.
8. Lane, M. (2024). Who will be the workers most affected by AI? A closer look at the impact of AI on women, low-skilled workers and other groups. OECD Artificial Intelligence Papers, No. 26.
9. Noy, S., & Zhang, W. (2023). Experimental evidence on the productivity effects of generative artificial intelligence. Science, 381(6654), 187–192.
10. OECD. (2024). Using AI in the workplace: Opportunities, risks and policy responses. OECD Artificial Intelligence Papers, No. 11. https://doi.org/10.1787/73d417f9-en
11. Webb, M. (2020). The impact of artificial intelligence on the labor market. Working Paper.
12. World Economic Forum. (2025). The Future of Jobs Report 2025. World Economic Forum.
13. World Bank. (2023). Digital Progress and Trends Report 2023: Strengthening AI Foundations. World Bank.

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