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The Role of Digital Transformation in Enhancing Supply Chain Efficiency and Resilience

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Abstract

The adoption of new technological systems offers a revolutionary opportunity for the sustainable economic empowerment of India, especially in improving supply chain efficiency, development of MSMEs, and inclusive development. This research paper recommends the Technology-Driven Model of Sustainable Economic Empowerment, which will utilize AI, cloud computing, digital twins, IoT, and blockchain to improve efficiency and sustainability while encouraging financial inclusion and job creation. According to empirical findings by PwC, NITI Aayog and other relevant sources. AI can add USD 135-150 billion of value to MSMEs' manufacturing production by 2035. At the same time, it can help achieve the value of USD 3.13 – 3.21 trillion for the entire economy if MSMEs account for 50% of manufacturing gross value-added. Digitalization has already helped achieve over 100 billion UPI transactions, saving the country's INR 3.48 trillion through Direct Benefit Transfers.

This paper employs literature review, secondary research and case studies to bring out the advantages associated with cost saving between 15% and 25% sustainability indicators, and resilience following disruptions. Obstacles in the form of digital divide, cybersecurity issues, skill gaps and expensive MSME adoption are explored in detail. The policy suggestions include partnership between government and private firms, scaling up of India AI Mission, edge AI deployment and greener computing. In this framework, technology emerging as the enabler of growth with economic empowerment and environmental conservation in India, which is aiming for a \$30 - \$35 trillion economy.

Keywords: Technology-Driven Economic Empowerment, Digital Transformation in India, Sustainable Supply Chain, AI and Digital Twins, MSME Empowerment, SDG 9, Cloud Computing, Agentic AI.

Introduction

Supply Chain Management (SCM) and wider economic ecosystems in India are undergoing a transformative digital shift, and these serve as important levers for sustainable economic empowerment. Considering that the country has more than 7.5 crore MSMEs contributing approximately 31.1%, 35.4% and 48.6% to its GDP, manufacturing and export respectively, it is crucial to integrate technology to remain competitive, inclusive and resilient (Economic Survey 2025-26; PIB, 2026). The country's digital landscape has seen significant improvements. With the number of internet users jumping from 250 million to 970 million, initiatives such as Digital India, Aadhaar, UPI and ONDC have brought about democracy in access, lower transaction cost, and Direct Benefits Transfer (DBT) that not only helped save up to INR 3.48 trillion but also empowered millions (NITI Aayog, 2026). The Viksit Bharat@2047 mission aims at reaching a \$ 30 trillion economy, with technology services expected to contribute around 7-8% of GDP (\$750-850 billion by 2035).

Digitalization in SCM will help optimize the flow of goods, information and finance. Through technologies such as AI, cloud computing, Internet of Things (IoT), blockchain and digital twins, real-time visibility, predictive analysis and automation are facilitated. In India, this will translate to efficient processes in sectors like agriculture, manufacturing and logistics, which are critical for rural job generation and poverty eradication.

Cloud computing facilitates scalability and centralization of platforms that can store data and perform analytical functions. Digital twins facilitate scenario simulations, predictive maintenance and bottleneck detection, resulting in saving and reduced downtime. Today, agentic AI systems perform activities independently in areas like procurement, logistics and risk management. The recent pandemic and the subsequently geopolitical events exposed vulnerabilities within traditional supply chains, leading to an accelerated pace of adoption. To counter these vulnerabilities, India introduced various strategies such as nearshoring, PLIs, and the IndiaAI Mission. Budget 2026 focused on AI, semiconductor manufacturing and green hydrogen production.

Economic empowerment sustainably involves growth, social inclusiveness and environmental preservation-Triple Bottom Line by Elkington, J. (1997). In the context of resource constrained MSMEs, edge AI and cloud computing reduce barriers to entry. According to PwC & ORF (2026), AI can contribute 19.2% of the future manufacturing growth until 2035, offering tremendous potential for MSMEs through productivity improvements, market connectivity and GVC linkages. Some challenges remain: the digital divide, cybersecurity risks, skill shortages and high initial investments. Issues related to the environment, such as greenhouse gas emissions from data centers, pose another challenge that needs to be addressed through green computing technologies. However, the benefits are immense-drones with blockchain for stock control, GenAI for forecasting and DPI for financial inclusion. The proposed model is called Technology-Driven Model and draws from relevant literature on cloud and digital twin technology, including some India-specific cases like MSME clusters, agricultural value chain, and circular economy.

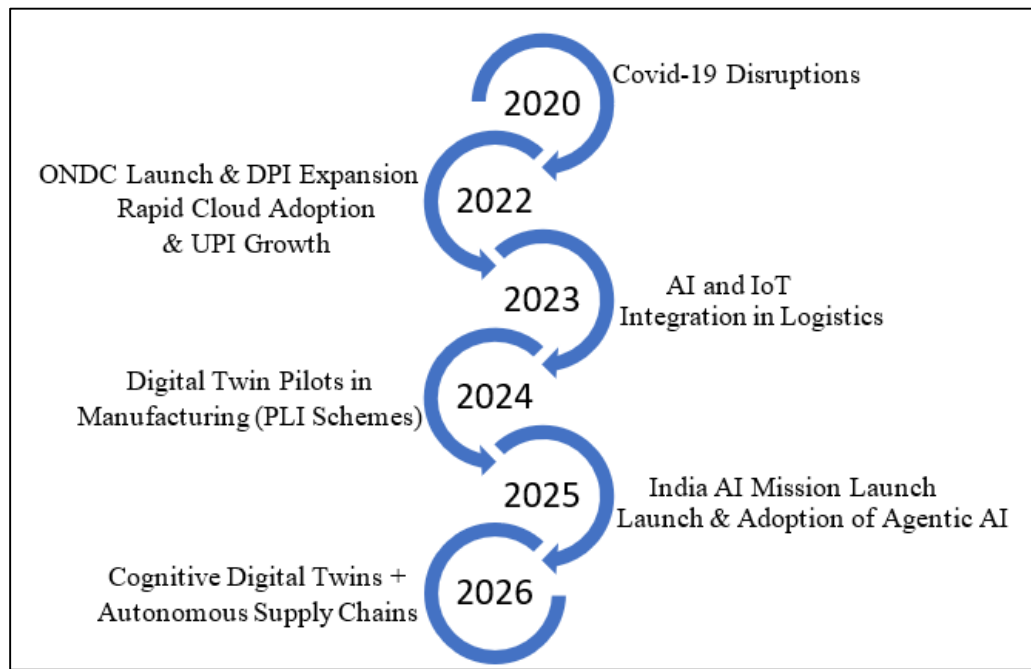


Figure 1: Evolution in Indian Supply Chain Management between 2020-2026

Source: Author's own compilation

Recent trends (2025-2026) indicate promising development like 5G developing, CNPN for industrial networks and the success of the Atal Innovation Mission to promote entrepreneurship. Better results achieved through the SDG India Index in terms of SDG 9 (improvement from 41 in 2018 to 61 in 2023-24) are indicative of improvements in roads, telecommunication infrastructure and innovations. The paper adds value through its efforts to blend global best practices with local situations. It highlights issues relating to the utilization of technology to promote holistic development such as quality employment, equality and climate resilience.

Literature Review

Literature relating to the concept of digital transformation, artificial intelligence (AI) and sustainable supply chain management is a sound starting point towards gaining insights into the role of technology in sustainable economic empowerment of India. Four themes emerge from the thematic analysis conducted based on PRISMA protocol by integrating recent literature (2021-2026) within the following areas:

1. Digital Technologies in Supply Chain Optimization

Cloud computing and AI are two enabling technological factors behind effective and efficient Supply Chains. According to Yenugula et al. (2023), cloud computing technologies play an important role in real-time data analysis and collaboration, solving important SCM problems, such as lack of visibility and responsiveness. In turn, Toorajipour et al. (2021) conducted a systematic review of AI usage in SCM, findings that such AI techniques as machine learning, neural networks and optimization help increase the effectiveness of demand forecasting, logistics and risk management activities. New developments may result in creating agentic AI systems, capable of making autonomous decisions.

Digital twins complement the discussed technologies. In their study, Zaidi et al. (2024) analyze 129 works and suggest adopting a three-layer approach for integration of both internal links (procurement, manufacturing) and external ones (suppliers, distributors) in order to achieve real-time integration and effective crisis management. At the same time, Sharma and Gupta (2024) analyze the potential use of cognitive digital twins in Industry 5.0 by discussing their ability to optimize processes, aligning them strategically to SDG 9 (Industry, Innovation and Infrastructure), using the TOE-HOT framework. These technologies assist Indian MSME clusters in PLI initiative, decreasing downtime (Roman et al., 2025).

2. Green Supply Chain Management and Sustainability

In relation to sustainability, many studies have examined the use of digital tools in Green Supply Chain Management (GSCM). According to Samad et al. (2021), GSCM initiatives help achieve better environmental, operational and economic performance, with collaboration playing an essential role in moderating environmental and economic impacts. Additionally, Chauhan et al. (2022) explained how emerging technologies such as Industry 4.0 comprising IoT, blockchain, cloud computing, AI and digital twins can enhance transparency, minimize wastage and embrace circular economy approaches. The importance of emerging tools for sustainable sourcing and distribution is reiterated by Hariyani et al. (2024).

Green entrepreneurship and digitalization in achieving circular economy objectives in Indian MSMEs was discussed in Mondal et al. (2023), in which top management commitment and technology infrastructure are identified as key enablers. The positive effect of artificial intelligence (AI) and green technology innovation (GTI) in promoting sustained green growth in India was shown by Behera et al. (2025), with AI being moderating variables between renewable energy generation, GTI and SDGs. Lastly, Manigandan et al. (2024) emphasized that green innovations and environmental policies are important for sustainable economic growth, whereas excessive consumption of natural resources exerts negative pressure.

3. Inclusive Empowerment and Socio-Economic Impact

Empowerment studies using technology are becoming increasingly common, Hussain (2024) empirically showed that technology-based start-ups empower the youth through employment opportunities, learning skills, entrepreneurship and technology adoption. Indradevi et al. (2025) used UTAUT2 to prove that Digital India policies have led to the empowerment of rural women due to increased performance expectancy, effort expectancy and facilitating conditions. Venkateshwarlu and Veeramalla (2025) and Suparman et al. (2025) focused on how digital technologies play an important role in empowering farmers with respect to improved yield, income generation and sustainable environment.

The literature on financial inclusion demonstrates the importance of digitalization. Nagoji (2026) showed how digital economy measures (UPI, PMJDY, and Aadhaar) contribute to sustainable development and the Viksit Bharat agenda. Pradhan et al. (2021) made a casual link between ICT infrastructure, financial inclusion and economic growth in Indian states. Nevertheless, Mukherjee (2025) and Adi Syahid et al. (2025) stressed how the digital divide persists to affect benefits unequally.

4. Policy Framework and Viksit Bharat@2047

Technology adoption and policy studies have been correlated with each other because of the national aspirations of the country concerned. For instance, Pulicherla et al. (2022) pointed out that green manufacturing policies would help in achieving “Make in India” and “Atmanirbhar Bharat” aims of the country. Similarly, Mishra et al. (2026) underscored the need to integrate smart technologies and human resource development for inclusive growth till 2050. Rajamoorthi (2025) and Gupta and Ahmed (2026) focused on technology adoption and digital innovation as enablers of sustainable MSME growth. Goyal et al. (2025) noted raising basic digital adoption among MSMEs but slower uptake of advanced tools like AI and digital twins.

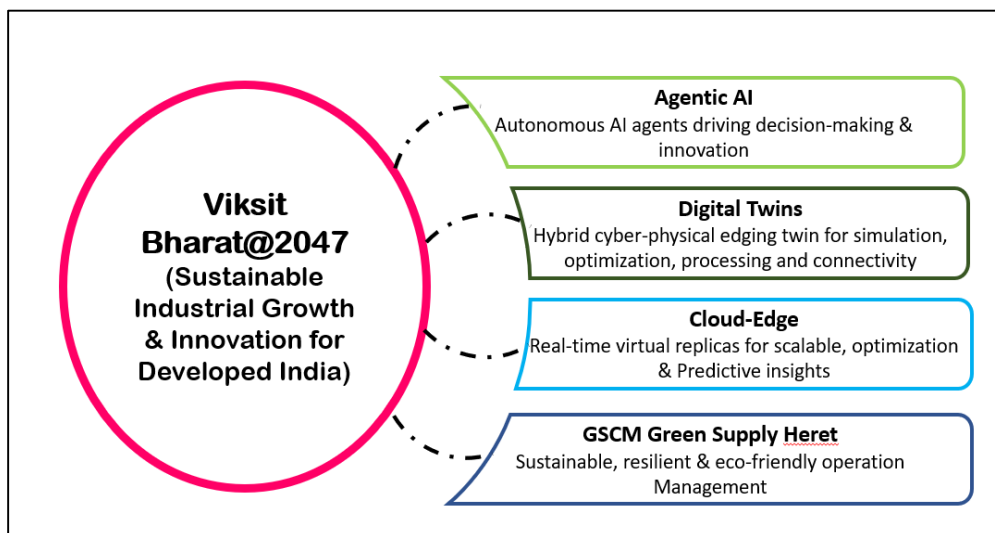


Figure 2: Technological and Strategic pillars for Viksit Bharat@2047

Source: Author's own compilation after review of 72 literatures

However, various gaps can be identified. The first one concerns the lack of empirical validation in India in respect to the integration model combining agentic AI, cognitive digital twin technologies, cloud-edge computing infrastructure and blockchain technologies for the benefit of MSMEs. Moreover, the existing literature either addresses efficiency concerns related to technology use or social issues related to inclusive growth, while the connection between the four pillars mentioned above within the framework of Viksit Bharat or SDG 9 goals remains unexplored. Another gap concerns the lack of empirical evidence on the role of collaborative capabilities and policy-making initiatives aimed at addressing the digital divide problem in relation to rural, tribal and women-owned businesses. Finally, it is important to note that no attention is paid to cybersecurity issues concerning the use of increasingly autonomous digital technologies in GSCM. At the same time, the environmental impact of digital infrastructure development needs to be considered.

The proposed research will bridge these gaps by developing the Technology-Driven Model for Sustainable Economic Empowerment, using the results of systematic review analysis of 72 sources.

Methodology

This study complied with the PRISMA 2020 framework (Page et al., 2021) for conducting systematic reviews. An extensive search was done across, Google Scholar, ScienceDirect and government websites like NITI Aayog, PIB and reports from PwC for articles with keywords related to digital transformation of supply chain in India, AI and MSME empowerment, cloud computing sustainability, agentic AI, digital twin technology and Viksit Bharat technology published between January 2020 to May 2026. Inclusion criteria comprise English language, peer-reviewed articles, reports and case studies emphasizing technology adoption, economic empowerment and sustainability in India or similar settings. Exclusion criteria involve opinions prior to 2020.

Following the removal of duplicates, a total of 478 records were screened based on their titles and abstract. Out of which those, 166 articles were assessed in detail. Finally, 72 studies were included in this review. A data extraction from helped extract thematic information about methodology, findings and limitations of each study. A thematic analysis revealed enabling factors, impacts, challenges and model elements. A flow diagram showing this process can be seen in figure 1. A meta-analysis could not be done because of the heterogeneity in findings.

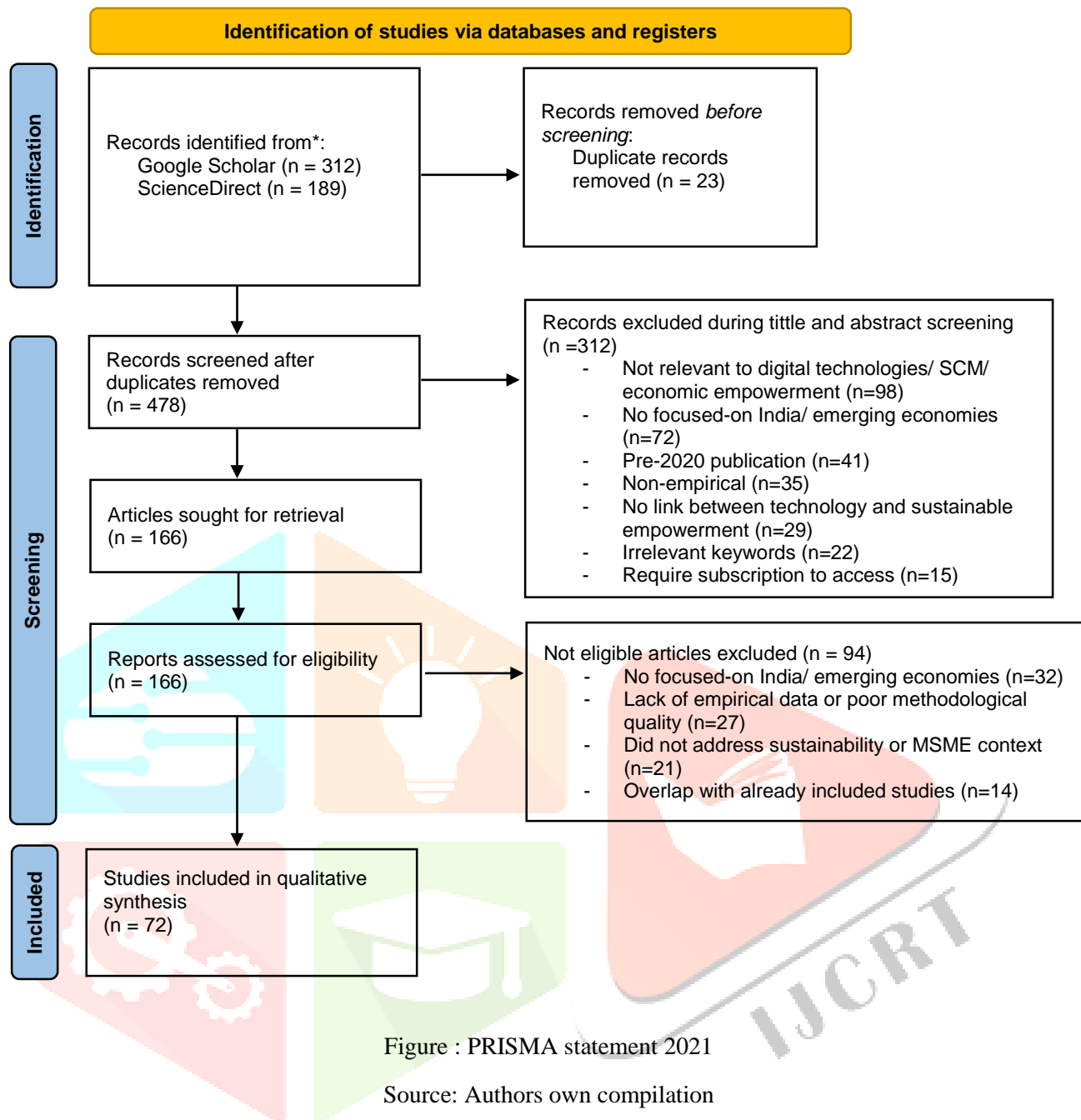


Figure : PRISMA statement 2021

Source: Authors own compilation

Findings and Discussion

PRISMA-informed systematic literature review of 72 studies from Google Scholar and ScienceDirect shows that there is robust evidence that a technology-based approach is very effective in ensuring sustainable economic empowerment in India. Cloud computing and hybrid cloud-edge technologies can be extremely efficient in improving supply chain visibility and collaboration. Efficiency improvements of up to 20-30% have been observed in several studies, thanks to real-time data sharing and scalable infrastructures (Yenugula et al., 2023; Fraihat et al., 2024).

Another impactful technology that holds tremendous potential for predictive maintenance, scenario simulation and resiliency is digital twin (DT). According to the latest projections for the India digital twin market, it will grow from USD 2.305 billion in 2025 to USD 63.41 billion by 2035 at a CAGR of 39.3%. The implementation of this technology in PLI-supported clusters could result in up to 50% downtime reduction and better supply chain resiliency (Roman et al., 2025; Singh, 2024).

In this regard, agentic and generative AI becomes indispensable for autonomous orchestration. According to the renowned report by PwC India & ORF (2026), which is frequently cited in the reviewed sources, AI cloud

bring USD 135.6-149.9 billion to manufacturing MSMEs if the contribution of MSMEs to manufacturing MSMEs if the contribution of MSMEs to manufacturing Gross Value Added (GVA) would increase to 50% till 2035. General AI potential for major sectors could be valued from USD 550 billion to 607 billion until 2035 to achieve Viksit Bharat@2047 objectives (PwC India & ORF, 2026; NITI Aayog, 2026).

Examples of AI-based solutions for India confirm the empowerment opportunities. ONDC, along with UPI provided equal access to markets for MSMEs, whereas DPI projects have already created enormous financial benefits through DBTs (Economic Survey 2025-26). Large-scale study conducted by a group of scholars of MSMEs' adoption of AI, cloud ERP, SCM systems, e-commerce and social media technologies for 7,835 enterprises showed a significant use of digital means but a low adoption rate of advanced technologies by micro-enterprises (India SME Forum, 2025; RIS, 2026).

Integration into Sustainability: IoT, blockchain and Digital Twins contribute to GSCM through fostering circular economy approaches, traceability and reducing emissions. Literature review emphasizes both issues of increasing efficiency and high energy requirements of data centers, highlighting the need for green computing and renewable energy (Samuels, 2025). Technology-Driven Framework Proposed: The following is a framework synthesized based on the reviewed 72 sources consisting of four key pillars:

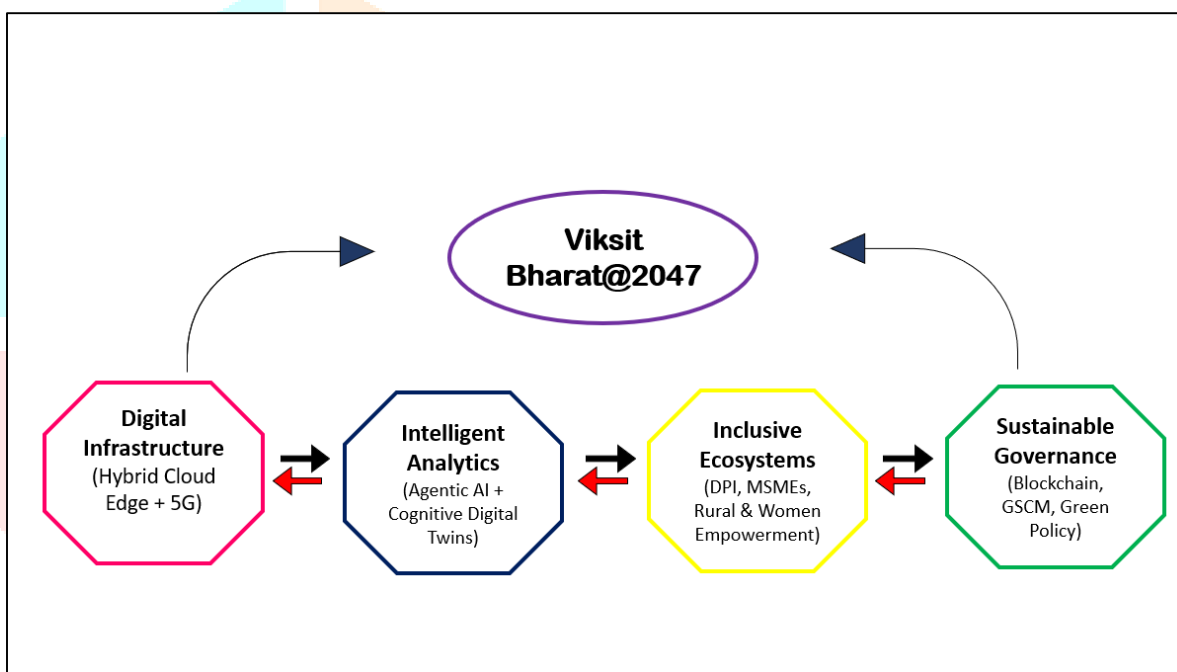


Figure 3: Proposed Technology-Driven Framework

Source: Author's own compilation

Digital Infrastructure (a hybrid model combining cloud and edge computing, 5G and CNPN to reduce latency)

Intelligent Analytics (agentic artificial intelligence + digital twins for predictive autonomy)

Inclusive Ecosystems (DPI platforms focusing on MSMEs, rural MSMEs and women entrepreneurs)

Sustainable Governance (traceability via blockchain technology and ESG-aligned policies)

The above-mentioned model is expected to reduce operational cost by 15-25%, improve order fulfillment efficiency and build greater resilience (BCG, 2024; PwC India & ORF, 2026).

Challenges: The digital divide (rural, micro-MSMEs), cybersecurity threats, skill shortages and implementation costs remain constant challenges (PwC India & ORF, 2026; India SME Forum, 2025).

However, the IndiaAI Mission (INR 10,372 crore) provides a vital path forward; fast and focused diffusion of technology is imperative.

Case studies on ONDC, financial services using UPI and the development of new digital twin systems in logistics and manufacturing demonstrate how technology leverages employment creation, GVC participation and climate resilience; see SDG 9 & Viksit Bharat@2047 (NITI Aayog, 2026).

Conclusion

The PRISMA-conformable review of 72 articles published on Google Scholar and ScienceDirect proves that the implementation of the Technology-Driven Model for Sustainable Economic Empowerment in India holds significant transformational prospects. Utilizing cloud computing, digital twins, agentic artificial intelligence, IoT and blockchain can enable optimization of the supply chain process, support 7.6+ crore MSMEs, fulfill the objectives of SDG 9 and aid progress towards the goal of creating a \$30-\$35 trillion economy by 2047 (Viksit Bharat@2047' economy), as projected by PwC India and ORF (2026) and Roman et al. (2025).

In the first place, the four pillars of the model are a realistic framework, as it has proved effective at ensuring 15-25% efficiency, adding AI-generated value worth USD 135- USD150 billion to the manufacturing MSMEs by 2035 and improving the sustainability performance (Market Research Future, 2026; PwC India & ORF, 2026). Examples of success in UPI, ONDC, DPI and emerging digital twin applications validate scalability across key sectors.

Policy Implications: Focus on MSME-centric execution of IndiaAI Mission, increase public-private collaboration in green digital infrastructure, promote digital skills development programs (Tier-2/3 and rural locations) and build regulatory sandboxes for agentic AI and blockchain technology. Robust cybersecurity protocols and congruence with net-zero commitments in essential (NITI Aayog, 2026; Economic Survey 2025-26).

Limitations: Bias could arise from reliance on secondary literature in English. The scope of research provided by Google Scholar added depth on India-specific issues but needed strict quality control criteria due to heterogeneity. Meta-analysis was not feasible due to heterogeneity.

Further Research: Primary longitudinal studies and sectoral pilot projects (agr-processing, textiles) would confirm the effectiveness of the model. Investigate complementarities with quantum computing, 6G and long-term implications for social equity through SDG India Index scores (PwC India & ORF, 2026).

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