

AI as a Catalyst for Sustainable SME Growth: Integrating Economic Efficiency with Environmental Goals in Emerging Economies

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Abstract: *In emerging economies such as India, small and medium enterprises (SMEs) act as the foundation for economic growth, contributing significantly to employment and the country's GDP. Yet SMEs face dual challenges: attaining economic efficiency through digital transformation and attaining sustainability targets amidst growing environmental concerns. Artificial Intelligence (AI) has transformative potential, but its adoption in SMEs has been examined mostly from the perspective of cost-cutting and automation with limited consideration for sustainability. The existing research looks at AI adoption for efficiency or sustainability purposes separately, while the integration of AI in delivering sustainability advantage for SMEs receives little attention. Thus, there exists a vital research gap in their integration for a firm's long-term competitiveness. To close this gap, this research proposes SME-AIGEN, a conceptual framework mapping AI adoption levels (Aware → Piloting → Integrated) against green maturity stages (Ad-hoc → Systematic → Certified). The framework identifies four strategic archetypes—Efficiency Seekers, Eco-Improvers, Digital Optimizers, and Sustainable Innovators—and suggests upgrade trajectories with targeted interventions. An integrative literature review methodology is used in this paper. Academic work and policy documents on application of AI in SMEs (predictive analysis, process optimization, and energy management), green practices, and Industry 4.0-driven sustainability in emerging economies have been studied. The findings emphasize the strategic role that AI plays in helping SMEs not merely to survive but prosper in a market that is competitive and driven by sustainability. This pioneering conceptual framework can form the foundation of future empirical studies and policy actions to encourage AI-enabled green transformation in the SME sector.*

Keywords: Artificial Intelligence, Sustainability, SMEs, Emerging Economies, Digital Transformation

I. INTRODUCTION

In emerging economies such as India, SMEs' contributions in generating subsistence, innovation and GDP growth are substantial for development of an economy. Nearly 30% of nation's GDP and over 45% of exports are made up by SMEs according to recent reports, which highlights their central role in economic activity. Also, SMEs provide living to millions in semi-urban and rural areas, thus ensuring an inclusive development. But SMEs are struggling with the twin demand of maintaining their competitiveness in highly globalized and sustainability driven marketplace of today. They are subjected to pressure of improving their efficiency and productivity through digitalization, while adhering to the sustainability directives associated with climate change, energy efficiency, and responsible resource use. So, this dual challenge defines a critical dilemma which SMEs face in developing economies.

AI has emerged with a transformative potential of reshaping business processes, decision-making, and customer engagement. AI applications such as predictive analytics for demand forecasting, computer vision for automated quality control, and route optimization for logistics have proven quantifiable efficiency gains for SMEs (Jadhav, 2021; Ingalagi et al., 2021). In the context of India, studies have brought out that adoption of AI improves productivity and reduces operational costs. Still adoption remains highly uneven. The detriments to AI's uneven adoption are high implementation costs, lack of skilled personnel, and limited digital infrastructure (AI Adoption in SMEs, 2020;



Artificial Intelligence Adaptation Determinants, 2021). Therefore, AI is predominantly pursued as a tool for automation and cost reduction, rather than as a driver of sustainability or long-term competitiveness of SMEs.

SMEs are grappling with the escalating expectations to conform to the sustainability objectives. The expectations are basically driven by climate change, rising energy costs, regulatory compliance, and global supply chain standards. Common practices are energy audits, green procurement policies, waste minimization, and adoption of circular economy principles (Review of Digitalization of SMEs toward Sustainability, 2021; From Digital Transformation to Sustainability in SMEs, 2022). Digital MSME Scheme, the National Action Plan on Climate Change, and Bureau of Energy Efficiency (BEE) programs are initiatives by India which underline the significance of resource efficiency and sustainable production. However, notwithstanding the pressures and opportunities the adoption of green practices among SMEs remains fragmented due to financial constraints, lack of awareness, and insufficient institutional support. The focus of majority of literature written on sustainability in SMEs is the compliance and environmental responsibility, with limited thought to how digitalization, particularly adoption of AI, could accelerate sustainability outcomes.

A fragmented scenario surfaces from the critical analysis of the existing literature. Studies based in AI adoption in SMEs focus on efficiency, meanwhile the sustainability focused studies emphasize on environmental responsibility. Only a small body of work attempts to bridge the gap between these two domains, often in regional contexts outside India. For instance, recent research on SMEs in Africa investigates adoption of AI to support energy management and sustainable logistics. Concurrently, global studies emphasize on Industry 4.0 tools for facilitating net-zero transitions. Yet there remains a huge research gap in the context of the Indian and broader emerging economies, and the pathways to integration of AI adoption with sustainability remain unexplored. Both academic literature and practical policymaking lack a clear unified framework to guide SMEs in leveraging AI for sustainability advantage along with cost efficiency.

To address this research gap, we developed the SME-AIGEN (SME-AI-Green Nexus), which conceptualizes AI as a catalyst for sustainable SME growth in emerging economies. It's a dual-axis model which organizes SMEs along two dimensions: their level of AI adoption (ranging from Aware to Integrated) and their progress in green maturity (ranging from Ad-hoc practices to formally certified). By correlating these axes, the framework puts forth four archetypes. The first group, Efficiency seekers, who lag in both digitalization and adoption of green practices. Next, there are Eco-Improvers, firms which prioritize sustainability but lag in AI adoption. Contrastingly, there are Digital Optimizers, who deploy AI for efficiency but tend to neglect its integration with sustainability. Finally, the sustainable innovators successfully combine AI-driven efficiency with certified green practices. The framework also outlines upgrade paths, showing how SMEs can evolve toward higher competitiveness and sustainability. It's not a rigid, prescriptive model, but a conceptual guide to help scholars and leaders better understand the intersection of AI and sustainability.

Methodologically, the research is based on an integrative literature review. It includes insights from academic research, policy reports, and industry analyses on AI in SMEs, green business practices, and Industry 4.0-driven sustainability. AI applications in predictive analytics, process optimization, and energy management, as well as SME experiences with digitalization and environmental responsibility constitute the key focus areas. Three critical findings come in the limelight: (i) AI can cater to both the needs of delivering cost efficiency and environmental performance through targeted applications, (ii) adoption of both AI and green practices are uneven, particularly in resource-constrained SMEs, and (iii) SME-specific pathways to integrate digital and sustainable transformation are absent from policy frameworks.

This work looks at AI not merely as an automation tool but as a catalyst of environmentally profitable growth. Thus, it serves two purposes. First, it is focused on integration of two largely separate academic domains, that is, adoption of AI and sustainable practices in SMEs and is presenting it as a consolidated conceptual framework suited to the context of emerging economies. Second, it develops pragmatic managerial and strategic implications. These implications help in elevating the course to speed up AI-driven transformation of SMEs towards sustainability. In this way, it complies by policy priorities set by Indian government under the Digital MSME initiative and the Sustainable Development Goals (SDGs) and simultaneously provides broader insights relatable across emerging economies.



The rest of the paper is structured as follows. A systematic review of existing literature focusing on AI in SMEs and sustainability practices is compiled in section 2 of this paper. Section 3 introduces the proposed framework - SME-AIGEN, presenting the strategic archetypes and propositions. The next section then covers managerial and policy implications of our findings. The last section finally concludes the paper with its contributions, limitations and directions for future work.

II. LITERATURE REVIEW

2.1 AI Adoption in SMEs: Efficiency and Competitiveness

All over the globe, SMEs are coming forward to adopt AI and digital tools for optimizing their operations, streamlining processes, and enhance competitiveness. Research highlights the role of AI tools, such as predictive analytics for demand forecasting, computer vision for quality assurance, and chatbots for customer engagement in raising productivity and cutting transaction costs (Adoption of AI Technologies in SMEs Sector, 2020; AI Chatbot Adoption in SMEs, 2022). The findings of empirical research in India reveal that the influence of AI adoption on supply-chain visibility and innovation capability is positive and consequently, it improves sustainable performance outcomes (Ingalagi et al., 2021). In like manner, bibliometric analyses point to the growing momentum of research on AI in SMEs post 2018 but this research remain largely confined to themes like automation and digital efficiency instead of broader sustainability goals. (Bibliometric Analysis, 2023).

However, there is inconsistent adoption even with these advances. SME's need to overcome certain barriers like limited financial resources, lack of skilled human capital, digital infrastructure gaps, and risk aversion (Artificial Intelligence Adaptation Determinants, 2021). AI can be used as a transformative juggernaut in SMEs for maintaining long lasting competitive edge, rather than just as a cost cutting mechanism. This narrow view limits AI's potential of unlocking the path to broader developmental and environmental issues.

2.2 Sustainability Directives for SMEs

Even with all the digital transformations taking place, SMEs face the escalating pressure to meet sustainability targets. These targets are set because of the effects of climate change, the need to achieve net zero globally, increase in energy prices, and the customers' awareness and willingness to buy green products. Research throws light on the view that practices such as energy efficiency, waste reduction, policies for green procurement, and circular economy activities can bring in substantial economic benefits for SMEs and help sustain the environment as well (Review of Digitalization of SMEs toward Sustainability, 2021; Corporate Sustainability in SMEs, 2022).

Within the Indian context, the country's SMEs are affected by the National Action Plan on Climate Change, Bureau of Energy Efficiency programs, and Digital MSME schemes (MSME Annual Report, 2024) along with other policies. The adoption of sustainable green manufacturing practices is gaining ground yet remains highly fragmented because of the absence of measurement frameworks, financial constraints, and widespread ignorance (Sustainable Green Manufacturing in India, 2021). Sustainability is often viewed by SMEs as a compliance burden and a cost of doing business that is easier to forego instead of a business opportunity.

2.3 Linking Digitalization and Sustainability in SMEs

Some attempts are made in latest research work to link these two domains of digitalization and sustainability. Studies reveal the support of AI and other Industry 4.0 tools (IoT, blockchain, big data analytics) in sustainability as it enables energy optimization, predictive maintenance, waste minimization, and carbon tracking (Towards a Greener Tomorrow, 2022; Digital Transformation & Sustainability in Developing Economies, 2023). Research based in Africa demonstrates how AI powered tools improve energy management and logistics which leads to significant cuts in costs and emissions (AI Adoption & Sustainability in African SMEs, 2021).

Even so, much of this research is exploratory or specifically based on a particular context. Although it shows AI's potential to support sustainability in SME sector, but there is only limited integration between the two streams. To give an example, reviewing digitalization in SMEs in a systematic manner underlines that digital adaptation, leadership, and organizational culture are crucial for efficient sustainability outcomes (Review of Digitalization, 2021), however it does



not explicitly develops a theory that how AI corresponds to specific stages of sustainability. In the same manner, studies focused on sustainability tend to press on green practices and discuss barriers without taking digital solutions into account (Corporate Sustainability in SMEs, 2022).

2.4 Barriers and Enablers: A Dual Perspective

Roadblocks and enablers Of AI and sustainability adoption is a recurring motif throughout the reviewed literature. Crucial roadblocks include:

- Financial constraints: Deploying advanced AI systems or sustainability technologies need a significant investment which SMEs often lack (Green Growth for MSMEs, 2023).
- Skill gaps: Often shortages of technical expertise and lack of managerial awareness limit the adoption (Artificial Intelligence Adaptation Determinants, 2021).
- Infrastructure and data readiness: No digital infrastructural support to AI-driven sustainability initiatives for many SMEs in developing economies (Digital Transformation & Sustainability in Developing Economies, 2023).
- Policy fragmentation: Persistent gap between policies programs and their needful implementation support leads to limited adoption.

There are simultaneous enablers that help in adoption, mentioned below:

- Policy incentives like grants, subsidies, tax benefits for adopting digital and green practices.
- Coordination of resources and technical and managerial training through collaborative platforms for SMEs.
- Certification and measurement systems (e.g., ISO 14001) to align environmental performance with market benefits.
- Leadership and entrepreneurial orientation as cultural drivers of change (Adoption of Digital Technologies by SMEs for Sustainability, 2020).

2.5 Identified Research Gap

As the potential of AI for efficiency and sustainability in SMEs is clearly presented in the reviewed studies, there is no concept for their intersection as a means for leveraging strategic edge to SMEs. Some partial evidence are presented through sector-specific or regional studies (e.g., in Africa), but there is lack of conceptual frameworks positioning AI as a propellant of sustainability in SMEs, especially in India and other emerging economies. Additionally, designing targeted interventions become difficult because of obscure of maturity status in the existing literature.

2.6 Positioning SME-AIGEN

Introduced SME-AIGEN frameworks connects the two streams and closes the integration gap. It maps the AI adoption levels in SMEs (Aware → Piloting → Integrated) contrasting to their sustainability maturity status (Ad-hoc → Systematic → Certified), providing a structural path to guide SMEs throughout their evolving digital and green journeys. Hence, the proposed framework amalgamates disconnected research streams as well as defines an empirical testing and development of policies for SMEs in developing economies.

III. PROPOSED CONCEPTUAL FRAMEWORK: SME-AIGEN

3.1 Rationale for the Framework

As the literature review has demonstrated that even though AI adoption enhances efficiency of operations and sustainability practices improve environmental outcomes, their consolidation within SMEs is given a little attention. These domains are treated separately in the existing literature, overlooking the need for understanding how SMEs can gain a foothold at consolidating digitalization and sustainability. To fill this gap, an attempt is made by the proposed SME-AIGEN model through a structured lens to assess the interdependent evolution of AI adoption and green practice maturity in SMEs.



3.2 Framework Dimensions

The SME-AIGEN framework is based on two-dimensional system, with key axes for X and Y:

- **AI Adoption Levels**
 - Aware: SMEs are aware of AI concepts and its efficiency benefits but lack pragmatic implementation.
 - Piloting: AI is applied on a limited, small scale (e.g., predictive analytics in inventory, energy monitoring systems).
 - Integrated: AI tools are used for various operations, for decision making and long-term strategies.
- **Green Maturity Stages**
 - Ad-hoc: SMEs adopt only minimal sustainable practices as reaction to environmental policy and regulatory compliances. Examples of such practices are waste segregation and basic energy saving.
 - Systematic: adopt organized sustainability-driven measures such as audits, eco-procurement, and structured recycling systems.
 - Certified: SMEs go for acquiring certifications (ISO 14001, BEE ratings) and adopt institutionalized practices, embedding them in their corporate strategy.

Figure 1 and Table 1 visually represent the strategic archetypes produced in the framework.

3.3 Strategic Archetypes

1. **Efficiency Seekers (Low AI × Low Green)**
 - a. Cutting costs and daily operational survival is the focus.
 - b. Limited knowledge about AI and sustainability.
 - c. Require basic digital tools and training to efficiently operate the tools along with awareness campaigns to encourage SMEs to opt for digitalization.
2. **Eco-Improvers (Low AI × Higher Green)**
 - a. Eco-friendly practices (waste reduction, energy efficiency) are adopted but lag in digitalization.
 - b. Harnessing AI can lead to substantial efficiency benefits in sustainability efforts.
3. **Digital Optimizers (Higher AI × Low Green)**
 - a. SMEs use AI for operational efficiency (automation, forecasting, customer analytics).
 - b. Neglect sustainability, but there exists potential to integrate eco-KPIs into AI systems.
4. **Sustainable Innovators (High AI × High Green)**
 - a. SMEs fully integrate AI and sustainability in strategy.
 - b. Can access the green supply chains and gain competitive edge, can attract consumers who are conscious about green producer practices, and secure green finance.

Figure 1. SME-AIGEN Framework: AI Adoption × Green Maturity

AI Adoption Levels/ Green Maturity Levels	Low Sustainability Maturity	High Sustainability Maturity
Low AI	Efficiency Seekers	Eco-Improvers
High AI	Digital Optimisers	Sustainable Innovatore



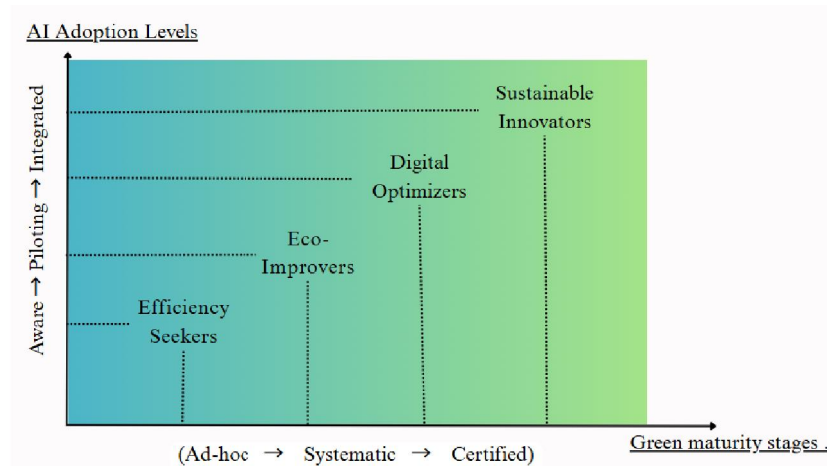


Table 1. SME-AIGEN Archetypes, Features, Needs, and Upgrade Pathways

Archetype	Features	Needs	Upgrade Path
Efficiency Seekers	Low AI adoption- Low sustainability maturity: Focus on survival and cost control	Basic digital literacy; Awareness of sustainability benefits	Move toward Eco-Improvers or Digital Optimizers through training and awareness
Eco-Improvers	Low AI adoption- Higher sustainability maturity: Committed to eco-practices but lack digital tools	AI tools for energy management and waste optimization	Adopt AI pilots in green areas to transition toward Sustainable Innovators
Digital Optimizers	High AI adoption- Low sustainability maturity: Focus on efficiency without green integration	Incorporation of eco-KPIs into AI applications	Integrate sustainability metrics to evolve into Sustainable Innovators
Sustainable Innovators	High AI adoption- High sustainability maturity: AI and sustainability integrated in strategy	Support for scaling, green finance access, and certifications	Maintain leadership, innovate green business models, access global green supply chains

3.4 Upgrade Pathways and Propositions

Potential pathways towards progression are laid out by the framework for SMEs:

- *Efficiency Seekers* → *Eco-Improvers* → *Sustainable Innovators* (via sustainability-focused AI pilots).
- *Efficiency Seekers* → *Digital Optimizers* → *Sustainable Innovators* (via operational AI adoption, later integrating ecological metrics).

The following propositions surface from the above stated transitions for validation based on empirical data in the future:

- P1: Dual benefits of reduced costs and emissions are achieved through adoption of AI-enabled energy management system.
- P2: Using computer vision for quality control in SMEs reduces defects and material waste, thereby enhancing both, efficiency and sustainability.
- P3: Optimizing logistics through AI-powered tool curbs fuel consumption and at the same time improves delivery reliability.



- P4: SMEs' integration of AI analytics with institutional sustainability certifications strengthens their competitiveness in globalised markets.

3.5 Implications of the Framework

The SME-AIGEN framework contributes to theory and practice as it:

- Provides a systematic method for classifying SMEs based on their transformation in both streams (digital + green).
- Offers pathways to refurbish (e.g., Efficiency Seekers → Eco-Improvers → Sustainable Innovators).
- Guides policymakers to formulate targeted policy supports for SMEs according to their archetype.
- Informs managers about where they stand and how to advance along the AI-sustainability spectrum deliberately.

IV. POLICY AND MANAGERIAL IMPLICATIONS

4.1 Managerial Implications

SME-AIGEN framework suggests that SMEs begin their dual transformation journeys from different starting points. Therefore, the managers must take their specific starting points into account and tailor their strategies according to their archetype:

- **Efficiency Seekers:** Should first tackle develop basic digital capabilities and awareness of sustainability benefits. Digitalization of record-keeping, adopting energy metering measures, and training of staff in eco-literacy can be the first practical steps.
- **Eco-Improvers:** Such enterprises are already committed to environmental practices. These firms should now explore AI-enabled energy optimization and waste analytics. For example, introducing AI-based dashboards can measure CO₂ savings and cost metrics side by side.
- **Digital Optimizers:** These firms need to adopt sustainability KPIs together with their existing AI systems. Modifications in routing algorithms to track fuel used in each delivery and carbon footprint left per delivery is an example.
- **Sustainable Innovators:** Firms should pursue green certificates (ISO 14001, BEE ratings), use AI for product innovation, and market their products and services as environment friendly and sustainable. In this way they can set them apart from competitors, strengthening their brand value.

Overall, the framework advice managers to map out in such a way where the valuation of AI investments is made in terms of productivity and environmental impact, abiding by a dual lens strategy.

4.2 Policy Implications

The SME-AIGEN framework lays down pathway for designing targeted actions for governments and development agencies:

- **Segmented Support Programs:** Policies should be specifically focused on one archetype to offer customized incentives and training. So, instead of a general approach for digitalization, policies and programs should differentiate between Efficiency Seekers, Eco-Improvers, and Digital Optimizers.
- **Green Finance Mechanisms:** SMEs opting for AI in sustainability projects should be given priority in credit guarantee schemes, concessional loans, or ESG-linked financing.
- **Digital Public Goods:** Provisions of shared AI infrastructure, cloud credits, and open-source sustainability tools should be made by Governments. This will lower down the cost barriers for SMEs.
- **Capacity-Building:** AI-for-sustainability training programs should be offered through public-private partnerships with technology vendors and universities to overcome the skill gaps.



- Policy Coherence: Current initiatives such as Digital MSME, Atmanirbhar Bharat, and National Action Plan on Climate Change should be aligned with SMEs operating at different stages. Also, policies can have explicit provisions for AI-enabled sustainability pathways for SMEs in India.

4.3 Ecosystem-Level Implications

In addition to the firm-level and policy-level strategies, ecosystem are also crucial because SMEs require more than just managerial and policy changes with their sustainability efforts. A broader network and cooperation of organizations is essential for fostering this revolutionary cause of integrating AI and sustainability. Platforms for knowledge sharing and allowing showcasing of AI-sustainability pilots of SMEs can be created by industry associations and chambers of commerce, playing their part. Bigger firms can give incentives to SMEs which are meeting green standards to encourage them to adopt green practices and go for institutional certifications. Global companies like donors and multilateral enterprises should promote cross-country learning, as lack of knowledge and awareness is one of the common challenges faced by SMEs in emerging economies.

4.4 Summary

To summarize, the SME-AIGEN framework provides actionable roadmaps for various stakeholders to follow. As managerial implications, it urges to customize the strategies for different stages of evolution of SMEs like from basic efficiency-seeking to full-fledged sustainable innovation. It guides policymakers to design support systems targeting specific needs of SMEs at their different transformational stages. For the wider ecosystem, it stresses collaboration, knowledge diffusion, and global partnerships. These implications show how SMEs can enhance competitiveness but also contribute meaningfully to the sustainable development goals in developing economies.

V. CONCLUSION

Small and medium-sized enterprises (SMEs) play a vital role in the social and economic fabric of developing nations like India, but they must simultaneously meet growing sustainability standards and increase efficiency through digital transformation. The literature shows that while adopting AI can result in significant efficiency gains, this has only been considered from the perspective of cost reduction and automation. Like this, SMEs' sustainability initiatives are frequently dispersed and driven by compliance. To investigate how AI can be a catalyst for sustainable SME growth, generating both economic and environmental value, very little research combines these two aspects.

This paper suggested the SME-AIGEN framework, a conceptual model that creates four strategic archetypes—Efficiency Seekers, Eco-Improvers, Digital Optimizers, and Sustainable Innovators—by mapping AI adoption levels against green maturity stages. In addition to offering a diagnostic tool for determining SMEs' current state, the framework makes recommendations for upgrade paths and focused interventions that can direct their development. The framework emphasizes how AI applications—like predictive analytics, computer vision-based quality control, and logistics optimization—can concurrently improve cost effectiveness and environmental performance by utilizing insights from an integrative review of sixteen scholarly articles, policy documents, and government reports.

This study has ramifications for several stakeholders. The framework provides SME managers with a road map for integrating sustainability and AI into their strategy. It gives policymakers advice on how to adjust financing schemes, capacity-building projects, and support programs to the various needs of SMEs. It highlights the importance of cooperation, information exchange, and integration into international sustainable supply chains for the larger ecosystem.

This paper's primary limitation is that it primarily contributes conceptually. The developed hypotheses remain theoretical in the absence of empirical testing and need to be validated through surveys, case studies, or sector-specific analyses. The SME-AIGEN framework should be applied to a variety of industries and contexts in future studies, looking at how various archetypes change in response to shifting market and policy conditions.



In summary, this study presents AI as a transformative enabler of sustainable development in SMEs rather than just a tool for automation. SMEs in emerging economies can boost their competitiveness and support national and international sustainability agendas by coordinating digital adoption with environmental objectives.

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