DIGITAL INTELLIGENCE AND SUSTAINABLE INNOVATION IN AGRI AND E-COMMERCE SMES

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ABSTRACT

Small and Medium Enterprises (SMEs) play a critical role in economic development, employment generation, and innovation, particularly in the agriculture and e-commerce sectors. With rapid digital transformation, *digital intelligence*—the strategic use of data analytics, artificial intelligence (AI), Internet of Things (IoT), and digital platforms—has emerged as a key driver of *sustainable innovation*. This article explores how digital intelligence enables sustainable innovation in agri-based and e-commerce SMEs by enhancing productivity, reducing environmental impact, improving supply chain efficiency, and fostering inclusive growth. Understanding gender-based perceptions is important for designing inclusive and effective policies that address diverse needs and expectations. Differences in viewpoints may influence the adoption and utilization of digital tools, participation in innovation programs, and responsiveness to sustainability-oriented interventions. Examining whether such differences exist helps policymakers and institutional stakeholders ensure equitable access to resources and balanced representation in digital transformation initiatives. Accordingly, this study examines gender-based differences in perceptions of key policy and institutional support factors relevant to digital intelligence and sustainable innovation in agri and e-commerce SMEs. By exploring these perceptions, the research contributes to a better understanding of inclusivity in digital policy frameworks and supports the development of targeted strategies that foster sustainable and inclusive SME growth.Drawing on contemporary literature and real-world practices, the paper examines opportunities, challenges, and policy implications, emphasizing the need for capability building, digital infrastructure, and supportive ecosystems to ensure long-term sustainability.

Keywords: Digital Intelligence, Sustainable Innovation, SMEs, Agriculture, E-Commerce and Digital Transformation

INTRODUCTION

The global economy is witnessing a paradigm shift driven by digital technologies and sustainability imperatives. Small and Medium Enterprises (SMEs), which constitute over 90% of businesses worldwide, are increasingly expected to balance economic growth with environmental and social responsibility. In agriculture and e-commerce—two sectors central to food security, livelihoods, and consumption—this challenge is particularly acute. Digital intelligence refers to the ability of organizations to collect, analyze, and apply digital data for informed decision-making and innovation. When strategically integrated, digital intelligence acts as a catalyst for sustainable innovation, enabling SMEs to optimize resource use, minimize waste, and create resilient business models. For agri and e-commerce SMEs, digital intelligence offers tools to respond to climate variability, market volatility, and changing consumer preferences. This article examines the intersection of digital intelligence and sustainable innovation in agri and e-commerce SMEs, highlighting how digital tools are reshaping value creation while advancing sustainability goals.

CONCEPTUAL FRAMEWORK

1. Data Analytics and Big Data: Data analytics and big data enable SMEs to collect, process, and interpret large volumes of structured and unstructured data generated from digital interactions, supply chains, and operational activities. By transforming raw data into actionable insights, these tools support informed decision-making, demand forecasting, and performance optimization. In agri and e-commerce SMEs, data analytics helps identify consumer trends, optimize resource use, and reduce waste. Big data-driven insights also enhance strategic planning and support sustainable innovation by enabling enterprises to measure economic, environmental, and social performance effectively.

2. Artificial Intelligence and Machine Learning: Artificial intelligence and machine learning empower SMEs to automate processes, identify patterns, and make predictive decisions with minimal human intervention. These technologies analyze complex datasets to improve accuracy in forecasting, pricing, inventory management, and customer personalization. In agriculture, AI supports precision farming and climate risk assessment, while in e-commerce it enhances recommendation systems and logistics optimization. By improving efficiency and reducing resource consumption, AI and machine learning contribute significantly to sustainable innovation and long-term competitiveness.

3. Internet of Things (IoT) : The Internet of Things (IoT) connects physical devices such as sensors, machinery, and equipment to digital networks, enabling real-time data collection and monitoring. In agri-SMEs, IoT devices support precision irrigation, soil monitoring, and crop health management, reducing water and input waste. In e-commerce and logistics, IoT enhances inventory tracking and cold-chain management. By providing real-time visibility and control, IoT improves operational efficiency and supports environmentally sustainable practices.

4. Cloud Computing: Cloud computing provides SMEs with scalable, cost-effective access to computing resources, data storage, and software applications through internet-based platforms. It eliminates the need for heavy upfront investment in IT infrastructure, making advanced digital tools accessible to small enterprises. In agri and e-commerce SMEs, cloud-based systems support data analytics, collaboration, and supply chain integration. Cloud computing enhances flexibility, resilience, and innovation capacity while supporting sustainable operations through efficient resource utilization.

5. Digital Platforms and Ecosystems: Digital platforms and ecosystems connect multiple stakeholders, including producers, consumers, service providers, and institutions, within integrated digital environments. These platforms facilitate market access, information exchange, and collaboration among agri and e-commerce SMEs. By reducing transaction costs and intermediaries, digital ecosystems improve efficiency and transparency. They also enable scalable innovation, support circular economy practices, and promote inclusive participation, making them essential for sustainable digital transformation.

Figure: 1
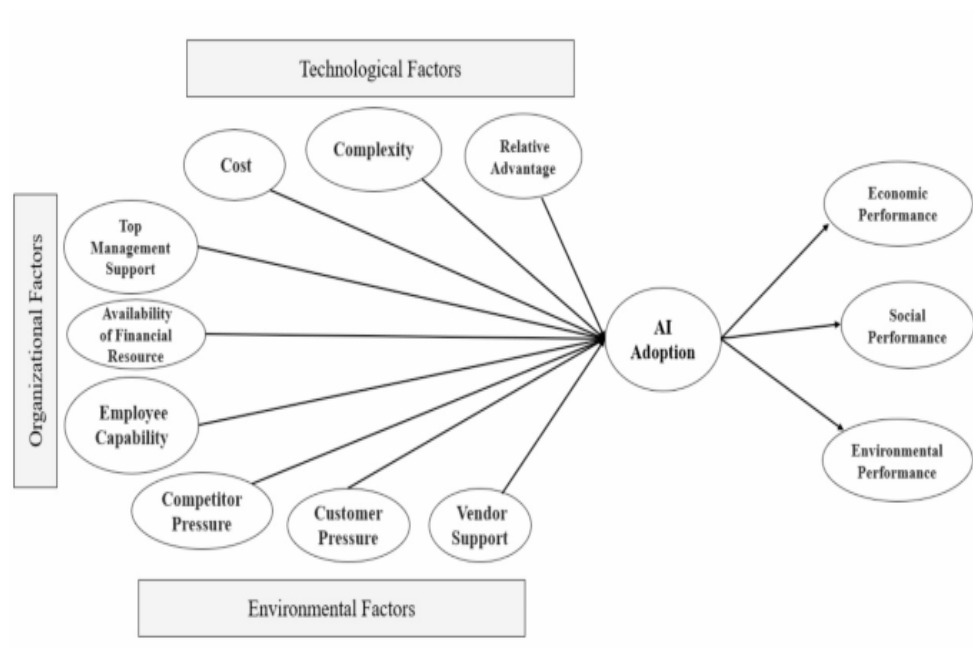
SUSTAINABLE INNOVATION; AN OVERVIEW

Economic Sustainability: Economic sustainability refers to the ability of enterprises to generate long-term economic value while maintaining financial stability and competitiveness. For agri and e-commerce SMEs, it involves efficient resource utilization, cost optimization, and continuous innovation to ensure profitability over time. Digital intelligence supports economic sustainability by improving productivity, enhancing market access, and enabling data-driven decision-making. By adopting sustainable business models, SMEs can reduce operational risks, respond effectively to market changes, and create resilient value chains that contribute to inclusive economic growth and long-term business viability.

Environmental Sustainability: Environmental sustainability focuses on minimizing negative environmental impacts while conserving natural resources for future generations. In agri and e-commerce SMEs, this includes reducing carbon emissions, managing waste, conserving water and energy, and promoting eco-friendly practices. Digital technologies such as IoT, data analytics, and smart logistics enable efficient monitoring and optimization of resource use. By integrating environmental sustainability into operations, SMEs can comply with regulations, reduce ecological footprints, and contribute to climate resilience and sustainable development goals.

Social Sustainability: Social sustainability emphasizes equity, inclusiveness, and the well-being of individuals and communities involved in business activities. For agri and e-commerce SMEs, it includes fair labor practices, ethical sourcing, community engagement, and consumer trust. Digital platforms enhance transparency, improve access to markets, and support financial inclusion for small producers and marginalized groups. By prioritizing social sustainability, SMEs can strengthen stakeholder relationships, enhance brand credibility, and promote inclusive growth that benefits society alongside economic and environmental objectives.

ROLE OF SMES IN AGRI AND E-COMMERCE

Agri-SMEs

Agri-based Small and Medium Enterprises (Agri-SMEs) play a vital role in ensuring food security, rural employment, and sustainable economic development. These enterprises operate across the agricultural value chain, including input supply, farming services, processing, and storage, transportation, and agri-technology solutions. However, Agri-SMEs face persistent challenges such as climate variability, fragmented markets, low productivity, post-harvest losses, and limited access to finance and technology. Digital intelligence offers transformative potential by enabling data-driven decision-making and sustainable innovation in agricultural practices. Through technologies such as precision farming tools, IoT sensors, satellite imagery, and AI-based analytics, Agri-SMEs can optimize resource utilization, reduce input waste, and enhance crop yields. Digital platforms further facilitate market access by connecting farmers directly with buyers, improving price transparency and income stability. In addition, digital traceability systems enhance food safety and promote sustainable and ethical farming practices. By integrating digital intelligence with sustainability objectives, Agri-SMEs can strengthen resilience, reduce environmental impact, and contribute to inclusive rural development while remaining competitive in evolving agri-food ecosystems.

E-Commerce SMEs

E-commerce Small and Medium Enterprises (E-Commerce SMEs) are central to the digital economy, driving innovation in online retail, logistics, and digital service delivery. These enterprises enable market access for small producers, expand consumer choice, and promote entrepreneurial activity. However, E-commerce SMEs also face sustainability challenges, including high return rates, packaging waste, carbon emissions from logistics, and intense market competition. Digital intelligence plays a crucial role in addressing these challenges by enabling efficient, data-driven business operations. Advanced data analytics and artificial intelligence help E-commerce SMEs forecast demand accurately, manage inventory efficiently, and personalize consumer experiences, thereby reducing waste and operational inefficiencies. Digital supply chain tools improve logistics planning and route optimization, leading to lower transportation costs and reduced environmental impact. Furthermore, digital platforms support transparency in sourcing and enable the adoption of circular economy practices such as resale, recycling, and reverse logistics. By leveraging digital intelligence, E-commerce SMEs can align profitability with sustainability goals, enhance customer trust, and build resilient, responsible business models in an increasingly competitive digital marketplace.

DIGITAL INTELLIGENCE IN E-COMMERCE SMES

1. Data-Driven Consumer Insights

Data-driven consumer insights play a pivotal role in enabling sustainable innovation among agri and e-commerce SMEs. Through the use of digital intelligence tools such as big data analytics, artificial intelligence, and customer relationship management systems, SMEs can collect and analyze vast amounts of consumer data related to preferences, purchasing behavior, and sustainability awareness. These insights help firms understand shifting consumer demand toward environmentally friendly, ethically sourced, and socially responsible products. By aligning product offerings with these preferences, SMEs can reduce unsold inventory, minimize waste, and improve overall resource efficiency.

Moreover, real-time consumer data allows SMEs to personalize marketing strategies and promote sustainable consumption patterns. For example, targeted recommendations for eco-friendly products and transparent sustainability messaging enhance consumer engagement and loyalty. In agri-based SMEs, data-driven insights also help forecast demand more accurately, reducing post-harvest losses and ensuring better price realization for producers. Overall, data-driven consumer insights enable SMEs to make informed decisions that balance profitability with environmental and social objectives. By embedding sustainability into data-driven strategies, SMEs can strengthen competitiveness while contributing to long-term sustainable development.

2. Sustainable Supply Chain Management

Sustainable supply chain management is increasingly supported by digital intelligence in agri and e-commerce SMEs. Advanced technologies such as artificial intelligence, Internet of Things (IoT), and cloud-based analytics enhance supply chain visibility and coordination across multiple stakeholders. Data-driven demand forecasting helps SMEs align production and procurement with actual market needs, thereby reducing overproduction, inventory holding costs, and material waste. In logistics, AI-enabled route optimization and real-time tracking systems minimize fuel consumption and carbon emissions, contributing to environmental sustainability.

Digital intelligence also improves supplier coordination and performance monitoring. SMEs can assess suppliers based on sustainability metrics such as energy use, emissions, and ethical practices, enabling responsible sourcing decisions. In agri supply chains, digital platforms facilitate efficient aggregation, storage, and transportation of perishable goods, reducing spoilage and post-harvest losses. Furthermore, transparency enabled by digital tools enhances accountability and compliance with environmental regulations. Overall, sustainable supply chain management supported by digital intelligence allows SMEs to achieve operational efficiency, cost savings, and reduced environmental impact while building resilient and responsible supply networks.

3. Circular Economy Models

Circular economy models emphasize resource efficiency, waste reduction, and value retention, and digital intelligence serves as a key enabler for their adoption by agri and e-commerce SMEs. Through data analytics and digital platforms, SMEs can track product life cycles, material flows, and customer usage patterns. This information supports strategies such as reuse, recycling, refurbishment, and remanufacturing. In e-commerce SMEs, digital platforms facilitate resale and reverse logistics systems, allowing products to re-enter the value chain instead of becoming waste.

In agri-based SMEs, circular economy practices include converting agricultural waste into value-added products such as biofertilizers, animal feed, or energy inputs. Digital intelligence helps optimize these processes by monitoring resource inputs and outputs, ensuring efficiency and scalability. Additionally, circular models enable SMEs to diversify revenue streams while reducing dependency on virgin resources. By integrating circular economy principles into their business models, SMEs can lower environmental impact, comply with sustainability regulations, and enhance long-term resilience. Digital intelligence thus transforms circular economy concepts into practical, data-driven strategies that support sustainable innovation and competitive advantage.

4. Ethical Sourcing and Transparency

Ethical sourcing and transparency are essential components of sustainable innovation, particularly for agri and e-commerce SMEs operating in complex and fragmented supply chains. Digital intelligence tools such as blockchain, IoT-enabled tracking, and cloud-based data systems enhance traceability and accountability across sourcing networks. These technologies allow SMEs to verify the origin of raw materials, monitor production conditions, and ensure compliance with labor, environmental, and quality standards.

Transparency enabled by digital systems builds trust among consumers, suppliers, and regulators. SMEs can communicate verified information related to fair trade practices, environmental impact, and social responsibility directly to consumers through digital platforms. In agri-SMEs, ethical sourcing supported by digital traceability ensures fair pricing for farmers and promotes sustainable farming practices. For e-commerce SMEs, transparent sourcing enhances brand credibility and meets growing consumer demand for responsible business practices. Overall, ethical sourcing and transparency enabled by digital intelligence not only reduce reputational and operational risks but also strengthen long-term relationships across the value chain, contributing to inclusive and sustainable growth.

CHALLENGES IN ADOPTING DIGITAL INTELLIGENCE

1. Infrastructure Gaps

Infrastructure gaps remain a significant barrier to the adoption of digital intelligence among agri and e-commerce SMEs, particularly in developing and rural economies. Limited access to reliable internet connectivity, inadequate broadband penetration, and unstable power supply restrict the effective use of digital technologies such as cloud computing, IoT devices, and real-time data analytics. In agri-based SMEs, poor digital infrastructure in rural areas hampers the deployment of precision agriculture tools, digital marketplaces, and supply chain tracking systems. As a result, SMEs are unable to fully leverage data-driven decision-making for productivity and sustainability improvements. In addition, insufficient logistics and digital payment infrastructure constrains e-commerce SMEs from expanding into remote regions. The absence of integrated digital platforms further limits interoperability across supply chain actors. These infrastructure gaps widen the digital divide, reducing competitiveness and slowing sustainable innovation. Addressing these challenges requires coordinated investments in digital connectivity, energy infrastructure, and smart logistics systems. Public–private partnerships and government-led digital inclusion initiatives are critical to creating an enabling environment where SMEs can adopt digital intelligence and contribute to sustainable economic development.

2. Skills and Capability Constraints

Skills and capability constraints pose a major challenge to the effective adoption of digital intelligence in agri and e-commerce SMEs. Many SME owners and employees lack digital literacy, data analytics expertise, and technical knowledge required to implement and manage advanced technologies such as artificial intelligence, blockchain, and IoT systems. This skills gap limits the ability of SMEs to interpret data insights, integrate digital tools into business processes, and align digital strategies with sustainability objectives. In agri-SMEs, limited exposure to digital training reduces farmers' and agri-entrepreneurs' willingness to adopt smart farming solutions and digital platforms. Similarly, e-commerce SMEs often struggle to attract skilled professionals due to financial constraints and competition from larger firms. The absence of structured training programs and advisory support further exacerbates these challenges. Capacity-building initiatives, including digital skill development programs, industry–academia collaborations, and targeted SME training, are essential to overcome these

constraints. Enhancing digital capabilities enables SMEs to harness digital intelligence effectively and drive sustainable innovation.

3. Financial Barriers

Financial barriers significantly hinder the adoption of digital intelligence and sustainable innovation among agri and e-commerce SMEs. The high initial costs associated with acquiring digital technologies, such as AI-driven analytics systems, IoT devices, and cybersecurity solutions, often exceed the financial capacity of small enterprises. Additionally, ongoing expenses related to software subscriptions, system maintenance, and skilled personnel further discourage investment in digital transformation. Agri-SMEs face additional challenges due to income uncertainty, seasonal cash flows, and limited access to formal credit. Traditional financial institutions often perceive digital innovation investments as high-risk, making it difficult for SMEs to secure funding. E-commerce SMEs, particularly startups, also encounter difficulties in scaling digital solutions due to limited venture capital and financing options. Addressing these financial barriers requires supportive policy measures such as subsidies, low-interest loans, innovation grants, and digital adoption incentives. Financial inclusion through fintech solutions can further enable SMEs to invest in digital intelligence and pursue sustainable business practices.

4. Data Security and Privacy Concerns

Data security and privacy concerns present critical challenges for agri and e-commerce SMEs adopting digital intelligence. As SMEs increasingly rely on digital platforms, cloud services, and data analytics, they become vulnerable to cyber threats, data breaches, and unauthorized access. Limited awareness of cybersecurity practices and lack of robust security infrastructure expose sensitive business and consumer data to significant risks. In e-commerce SMEs, breaches of customer data can result in loss of consumer trust, legal liabilities, and reputational damage. Agri-SMEs handling farm data, financial information, and supply chain records also face similar risks. Compliance with data protection regulations further complicates digital adoption, particularly for SMEs with limited legal and technical expertise. Strengthening data security requires investments in cybersecurity systems, employee training, and clear data governance frameworks. Support from governments and industry bodies in the form of guidelines, shared security platforms, and awareness programs can help SMEs manage data risks while leveraging digital intelligence for sustainable innovation.

Research Gap

Despite growing interest in digital transformation and sustainability, limited empirical research examines the combined role of digital intelligence in driving sustainable innovation specifically within agri and e-commerce SMEs. Existing studies often focus on large enterprises or analyze digital technologies and sustainability in isolation. Moreover, gender-based perceptions of policy and institutional support mechanisms remain underexplored, particularly in the context of developing economies. The lack of integrated frameworks and sector-specific evidence creates a gap in understanding how digital intelligence, sustainability dimensions, and demographic factors interact to influence SME performance and innovation outcomes.

Importance of the Study

This study is important as it provides insights into how digital intelligence can enable sustainable innovation in agri and e-commerce SMEs, sectors that are critical for economic growth, employment, and food security. By examining key policy and institutional support factors, the research offers practical implications for policymakers, practitioners, and

development agencies. The study also highlights gender-based perspectives, supporting inclusive policy design and targeted capacity-building initiatives. The findings contribute to academic literature by integrating digital intelligence and sustainability concepts, while offering evidence-based guidance to enhance SME competitiveness and long-term resilience.

Statement of the Problem

Agri and e-commerce SMEs face increasing pressure to adopt digital technologies while simultaneously addressing economic, environmental, and social sustainability challenges. However, many SMEs struggle with inadequate infrastructure, limited skills, financial constraints, and insufficient institutional support, hindering effective digital transformation. Furthermore, differences in stakeholder perceptions, including gender-based variations, may influence the adoption and success of digital intelligence initiatives. The absence of clear understanding regarding these challenges and perceptions limits the effectiveness of policy interventions. This study seeks to address this problem by examining key support factors influencing digital intelligence–driven sustainable innovation in agri and e-commerce SMEs.

Objectives of the Study

The primary objective of the study is to examine the role of digital intelligence in promoting sustainable innovation among agri and e-commerce SMEs. Specifically, the study aims to analyze the importance of key policy and institutional support factors such as investment in digital infrastructure, promotion of digital skill development, financial incentives and subsidies, public–private partnerships, and support for agri-tech and e-commerce incubators. Another objective is to assess whether perceptions of these factors differ based on gender. The study also seeks to contribute to a better understanding of how digital intelligence supports economic, environmental, and social sustainability in SMEs. Overall, the research aims to provide evidence-based insights to support inclusive policymaking and strategic decision-making for sustainable SME development.

Methodology

The study adopts a quantitative research design to examine perceptions of policy and institutional support for digital intelligence–driven sustainable innovation in agri and e-commerce SMEs. Primary data were collected using a structured questionnaire designed on a five-point Likert scale. The sample consisted of 300 respondents, including owners, managers, and employees of agri and e-commerce SMEs. A random sampling technique was employed to ensure unbiased representation of the target population. Data were analyzed using descriptive statistics and inferential tools, including one-way ANOVA, to examine differences in perceptions based on gender. The methodology ensures reliability, objectivity, and generalizability of findings within the defined study context.

Analysis and findings

Policy and institutional support play a crucial role in enabling digital intelligence–driven sustainable innovation in agri and e-commerce SMEs. Investments in digital infrastructure, skill development initiatives, financial incentives, public–private partnerships, and innovation incubators create an enabling environment for small and medium enterprises to adopt advanced digital technologies and sustainable business practices. However, perceptions of these support mechanisms may vary across different demographic groups, particularly gender, due to differences in access, experience, roles, and engagement within digital and entrepreneurial ecosystems.

H_0: There is no significant difference between male and female respondents in their perceptions of policy and institutional support factors—namely investing in digital

infrastructure, promoting digital skill development, providing financial incentives and subsidies, encouraging public–private partnerships, and supporting agri-tech and e-commerce incubators—for digital intelligence–driven sustainable innovation.

Table 1

Perceptions of policy and institutional support factor and Gender

Factors		N	Mean	Std. Deviation	F	Sig
Investing in digital infrastructure	Male	150	17.4951	1.25461	4.089	.000
	Female	150	19.1034	2.74311		
	Total	300	17.6800	2.45961		
Promoting digital skill development	Male	150	18.2913	3.49593	7.201	.007
	Female	150	20.4483	3.18014		
	Total	300	18.6320	3.43922		
Providing financial incentives and subsidies	Male	150	23.2330	3.23817	8.065	.005
	Female	150	24.9091	3.01511		
	Total	300	23.5040	3.16132		
Encouraging public–private partnerships	Male	150	18.1602	5.15677	7.020	.003
	Female	150	18.0000	6.26099		
	Total	300	19.1020	5.37115		
Supporting agri-tech and e-commerce incubators	Male	150	21.5583	3.88572	8.022	.011
	Female	150	19.9091	4.08545		
	Total	300	21.9520	3.88844		

The ANOVA results reveal statistically significant gender-based differences across all five factors, as the *p-values (Sig.)* are less than 0.05 in every case.

For investing in digital infrastructure, the obtained F-value (4.089, p = .000) indicates a significant difference between male and female respondents. Female respondents reported a higher mean score (19.1034) compared to males (17.4951), leading to the rejection of H_{01}.

Similarly, for promoting digital skill development, the F-value of 7.201 (p = .007) confirms a significant difference in perceptions. Female respondents again demonstrated stronger agreement (Mean = 20.4483) than male respondents (Mean = 18.2913), resulting in rejection of H_{02}.

In the case of providing financial incentives and subsidies, the F-value (8.065, p = .005) shows a significant difference, with females exhibiting higher mean scores than males. Hence, H_{03} is rejected.

For encouraging public–private partnerships, the ANOVA result (F = 7.020, p = .003) also indicates a statistically significant difference, leading to the rejection of H_{04}.

Finally, supporting agri-tech and e-commerce incubators shows a significant difference (F = 8.022, p = .011). Male respondents reported a higher mean score than females, resulting in rejection of H_{05}.

Overall, the findings suggest that gender significantly influences perceptions of policy and institutional support mechanisms for digital intelligence–driven sustainable innovation.

Policy and Institutional Support for Digital Intelligence–Driven Sustainable Innovation

Investing in digital infrastructure is a foundational requirement for enabling digital intelligence adoption among agri and e-commerce SMEs. Reliable broadband connectivity, cloud infrastructure, digital payment systems, and smart logistics networks are essential for data-driven operations and sustainable innovation. Public investment in rural connectivity and last-mile digital access can significantly reduce the digital divide and enhance SME participation in digital ecosystems.

Promoting digital skill development is equally critical. Targeted training programs in data analytics, artificial intelligence, cybersecurity, and digital platforms can enhance the capabilities of SME owners and employees. Collaboration between educational institutions, industry, and government agencies can ensure that skill development initiatives align with evolving technological and sustainability needs.

Providing financial incentives and subsidies encourages SMEs to invest in digital technologies and sustainable practices. Measures such as tax incentives, low-interest loans, innovation grants, and technology adoption subsidies reduce financial risk and accelerate digital transformation.

Encouraging public–private partnerships (PPPs) fosters knowledge exchange, technology transfer, and resource sharing. PPPs can support pilot projects, shared digital platforms, and scalable sustainability solutions tailored to SME needs.

Supporting agri-tech and e-commerce incubators further strengthens innovation ecosystems. Incubators provide mentorship, funding access, and technological support, enabling SMEs to develop scalable, sustainable, and digitally intelligent business models.

Managerial Implications

For SME owners and managers:

- Digital intelligence should be embedded in strategic planning
- Sustainability metrics must be integrated into performance measurement
- Collaboration with technology providers and platforms is essential
- Incremental adoption of digital tools can reduce risk and cost

Future Research Directions

- Empirical assessment of digital intelligence impact on SME sustainability
- Comparative analysis across regions and sectors
- Role of AI ethics in SME innovation
- Consumer response to digitally enabled sustainable practices

CONCLUSION

Digital intelligence is transforming agri and e-commerce SMEs by enabling sustainable innovation that aligns economic growth with environmental and social responsibility. Through data-driven decision-making, smart technologies, and digital platforms, SMEs can enhance productivity, resilience, and inclusivity. However, realizing this potential requires overcoming infrastructural, financial, and skill-related barriers. With supportive policies, institutional frameworks, and strategic commitment, digital intelligence can serve as a powerful enabler of sustainable development in agri and e-commerce ecosystems. These results demonstrate that male and female respondents differ significantly in their perceptions

of the importance of policy and institutional support mechanisms for fostering digital intelligence and sustainable innovation. Female respondents generally reported higher mean scores for digital infrastructure investment, digital skill development, and financial incentives, indicating stronger agreement regarding their importance. Conversely, male respondents showed relatively higher agreement for supporting agri-tech and e-commerce incubators. Based on these findings, the overall null hypothesis is rejected. The results confirm that gender plays a significant role in shaping perceptions of policy-driven support for digital intelligence and sustainable innovation in agri and e-commerce SMEs.

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