

Research Article

Driving Sustainability in Small and Medium Enterprises Through Artificial Intelligence, Blockchain, and Internet of Things: Evidence from Northern Province, Sri Lanka.

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Abstract

Digital transformation has become a strategic pathway for small and medium enterprises to improve sustainability and green value creation. This study examines how the adoption of artificial intelligence, blockchain technology, and the internet of things influences green entrepreneurial practices and sustainability outcomes among small and medium enterprises in Sri Lanka's Northern Province. Using a quantitative research design, primary data were collected from 100 entrepreneurs operating in the Northern province, Sri Lanka through a cluster sampling technique. The study applied confirmatory factor analysis to validate measurement constructs, followed by multiple regression analysis to test the relationships between digital technology adoption and green value creation dimensions. The findings reveal that artificial intelligence and the internet of things significantly contribute to green entrepreneurial practices by improving operational efficiency, innovation capability, and strategic advancement, while blockchain adoption demonstrates a comparatively weaker influence within the sampled enterprises. Further analysis indicates that operational efficiency and strategic advancement act as the most influential drivers of sustainability-oriented performance among green small and medium enterprises. The study also identifies key barriers and enablers shaping technology diffusion, including limited technical expertise, cost-related constraints, and organizational readiness. This research contributes empirical evidence from an underexplored regional context and provides practical implications for entrepreneurs and policymakers seeking to accelerate sustainable digital adoption.

Keywords: Artificial intelligence, Blockchain technology, Digital transformation, Green entrepreneurship, Internet of things, Small and medium scale enterprises

1. Introduction

Digital transformation has increasingly become a key determinant of entrepreneurial competitiveness and long-term business sustainability. In Sri Lanka, a growing number of employers and digital entrepreneurs have gained substantial experience in technology-driven business environments (Mudalige *et al.*, 2023). However, despite early



growth potential, many enterprises experience failure within the first year of operation, reflecting persistent challenges related to limited strategic capability, weak market positioning, and inadequate technology integration. Prior evidence suggests that successful digital commercialization is strongly supported by competencies in digital business strategy, integration of information technology with business processes, and the ability to develop effective stakeholder relationships. In this regard, digital transformation provides entrepreneurs with improved access to industry entry points, reduces operational risks, and enables wider engagement through online marketing platforms and digital financing opportunities. Furthermore, digital literacy and the ability to utilize emerging technologies enhance both operational efficiency and strategic development, thereby strengthening enterprise innovation and performance (Amoah *et al.*, 2023).

The increasing diffusion of advanced technologies has also intensified the role of sustainability in entrepreneurial development. Globally, the adoption of artificial intelligence-based applications has expanded rapidly, with evidence suggesting that more than 77% of small and medium enterprises have implemented some form of artificial intelligence usage, particularly in developed economies where technological infrastructure and expertise are more accessible (Ministry of Technology, Sri Lanka, 2024). As an emerging economy, Sri Lanka is increasingly focusing on digital technology adoption to improve productivity, business excellence, and value creation. Small and medium enterprises play a critical role in this process, as they contribute significantly to employment generation and economic growth.

Nevertheless, enterprise sustainability remains a challenge, as a relatively low proportion of small and medium enterprises remain operational beyond five years. These concerns emphasize the need to strengthen entrepreneurial resilience through both technological advancement and sustainable business strategies.

In parallel, global attention toward environmental sustainability has created pressure for enterprises to adopt green entrepreneurial practices that support eco-friendly operations and responsible value creation. This challenge is particularly relevant for small and medium enterprises in Sri Lanka's Northern Province, where regional development constraints and post-conflict economic restructuring continue to shape entrepreneurial conditions. Emerging digital technologies such as artificial intelligence, blockchain technology, and the internet of things offer strong potential to support green entrepreneurship and sustainability-oriented business performance. Artificial intelligence can support predictive analytics and resource optimization, thereby reduce waste and improve operational efficiency. Blockchain technology can enhance transparency and traceability across supply chains, improving accountability and trust in sustainable business activities. Similarly, the internet of things enables real-time monitoring of environmental indicators, supporting effective energy management and emission reduction initiatives. Collectively, these technologies provide opportunities for

small and medium enterprises to strengthen sustainability outcomes while improving business competitiveness.

Despite the increasing relevance of digital transformation and sustainability, empirical evidence remains limited regarding how small and medium enterprises in Sri Lanka adopt and integrate artificial intelligence, blockchain technology, and the internet of things to promote green entrepreneurial practices and sustainability performance. This limitation is more evident in the Northern Province, where infrastructure gaps and regional disparities may influence technology diffusion and the effectiveness of sustainability initiatives. Therefore, understanding the role of these emerging technologies in shaping green entrepreneurial outcomes is essential for developing evidence-based recommendations for entrepreneurs, policymakers, and development institutions.

Accordingly, this study investigates the role of artificial intelligence, blockchain technology, and the internet of things in driving green entrepreneurial practices and sustainability outcomes among small and medium enterprises in Sri Lanka's Northern Province. Specifically, the study aims to: (i) assess the level and nature of adoption of artificial intelligence, blockchain technology, and the internet of things among small and medium enterprises; (ii) examine the influence of these technologies on green entrepreneurial practices; (iii) evaluate their contribution to sustainability performance across economic, environmental, and social dimensions; and (iv) identify key challenges that limit effective integration of these technologies into sustainable business practices. By addressing these objectives, the study contributes empirical evidence to the growing literature on digital transformation and green entrepreneurship, particularly within an underexplored regional context in an emerging economy.

2. Review of the Literature

An integrated theoretical foundation is essential for understanding how digital technologies influence sustainable business practices in small and medium enterprises (SMEs). This study draws upon four complementary perspectives: the Triple Bottom Line (TBL) framework, the Resource-Based View (RBV), the Diffusion of Innovation (DoI) theory, and the Technology Acceptance Model (TAM). Collectively, these frameworks provide insights into how artificial intelligence (AI), blockchain technology, and the Internet of Things (IoT) can promote green entrepreneurial practices and enhance sustainability performance in SMEs.

The Technology Acceptance Model emphasizes the roles of perceived usefulness and perceived ease of use in technology adoption decisions (Rogers, 2003). Empirical studies in Sri Lanka indicate that managerial attitudes and organizational readiness significantly influence the adoption of digital technologies in SMEs. For instance, Keelson and Padi (2024) demonstrate that AI adoption moderates the relationship between e-commerce integration and business performance, highlighting the critical role of managerial perceptions in technology adoption. Complementing this perspective, Rogers' Diffusion

of Innovations (DoI) theory identifies five factors relative advantage, compatibility, complexity, trialability, and observability that affect adoption behavior (Barney, 1991). Evidence from Sri Lankan SMEs indicates that these factors significantly determine technology uptake, including e-commerce, AI, and IoT adoption (Govinnage and Sachitra 2019).

The Resource-Based View posits that firms gain competitive advantage by leveraging unique resources and capabilities (Barney, 1991). In the SME context, the adoption of AI, blockchain, and IoT enhances operational capacity, resource utilization, and organizational efficiency, which in turn contributes to improved sustainability outcomes (Kumar *et al.*, 2019). Similarly, the Triple Bottom Line (TBL) framework evaluates performance across economic, social, and environmental dimensions (Elkington, 1997). Digital technologies facilitate SMEs in achieving TBL goals by supporting operational efficiency, environmental responsibility, and social accountability (Fong *et al.*, 2023; Ha *et al.*, 2021).

Entrepreneurial competence and experience are also critical determinants of successful technology integration in green SMEs. Studies suggest that environmental awareness, ethical perception, and technology-enabled capabilities underpin the transformation from conventional to green entrepreneurship (Vial, 2023; Susitha, 2021). Entrepreneurial literacy, prior education, and exposure to digital tools reduce business risk and support sustained performance (Jayathilaka and Wijayanayake, 2024). In addition, early life experiences and guidance from mentors influence the development of digital and entrepreneurial capabilities, further affecting green innovation outcomes (Mudalige *et al.*, 2023).

Emerging digital technologies offer specific mechanisms to promote sustainability. AI facilitates predictive analytics, process automation, and resource optimization, improving operational efficiency and market competitiveness. Blockchain ensures transparency, accountability, and traceability in supply chains, thereby supporting responsible environmental practices. IoT enables real-time monitoring of ecological indicators, helping SMEs optimize energy use, reduce waste, and improve environmental performance (Abbasy and Quesada, 2017). Despite these benefits, adoption rates among SMEs in emerging economies remain limited, particularly in post-conflict regions such as Northern Sri Lanka. Most existing research focuses on individual technologies rather than examining their combined influence on sustainability and green entrepreneurial practices.

To address these research gaps, the current study investigates how AI, blockchain, and IoT adoption collectively influences green entrepreneurial practices and sustainability performance among SMEs in Northern Sri Lanka.

The study identifies independent variables as AI adoption, blockchain adoption, and IoT adoption; dependent variables as green entrepreneurial practices and sustainability outcomes; and considers organizational readiness, managerial competence, and

environmental awareness as key mediating and moderating factors. This approach provides a robust hypothesis development framework for analyzing the digital-sustainability nexus and lays the foundation for hypothesis testing in subsequent sections.

Table 1: Development of hypotheses

Sequence	Hypotheses
H1	Adoption of Artificial Intelligence has a significant positive effect on green entrepreneurial practices and sustainability performance of SMEs in Northern Sri Lanka.
H2	Adoption of blockchain technology positively influences green entrepreneurial practices and sustainability performance of SMEs in Northern province, Sri Lanka.
H3	Adoption of the Internet of Things (IoT) positively influences green entrepreneurial practices and sustainability performance of SMEs in Northern province Sri Lanka
H4	Green entrepreneurship practices have a significant positive effect on economic sustainability performance of SMEs in Northern Sri Lanka.
H5	Green entrepreneurship practices have a significant positive effect on environment sustainability performance of SMEs in Northern province Sri Lanka
H6	Green entrepreneurship practices have a significant positive effect on social sustainability performance of SMEs in Northern province Sri Lanka

(Sources: Developed by author)

3. Methods

This study employs a quantitative research approach grounded in a deductive paradigm to examine the influence of digital technology adoption on green entrepreneurial practices and sustainability performance among SMEs in Northern Sri Lanka. The research integrates theoretical perspectives from the Resource-Based View (RBV), Technology Acceptance Model (TAM), Diffusion of Innovation (DoI) theory, and the Triple Bottom Line (TBL) framework to guide hypothesis development and model testing (Acemoglu and Restrepo, 2018).

The target population comprises SMEs that have operated continuously for at least five years across the Northern Province, including the divisional secretariats of Jaffna, Kilinochchi, Mannar, Mullaitivu, and Vavuniya. Given the geographic dispersion and diversity of SMEs in the region, a cluster-purposive sampling strategy was applied to ensure representativeness and minimize potential bias. A total of 100 SMEs were selected based on digital engagement and sustainability orientation. To enhance participation and accessibility, a mixed-mode survey (online and paper-based) was used, while ethical considerations including informed consent, confidentiality, and voluntary participation were strictly observed.

The conceptual framework (Figure 1) examines the relationships among the independent variables (adoption of Artificial Intelligence [AI], Blockchain, and Internet of Things [IoT]), the mediator (green entrepreneurial practices), the dependent variable (sustainability performance measured across economic, environmental, and social dimensions), and moderators (organizational readiness, managerial competence, and environmental awareness). This framework ensures that the developed hypotheses (H1–H5) can be empirically tested in alignment with established theory and prior empirical evidence (Gruber-Risak and Obrecht, 2024).

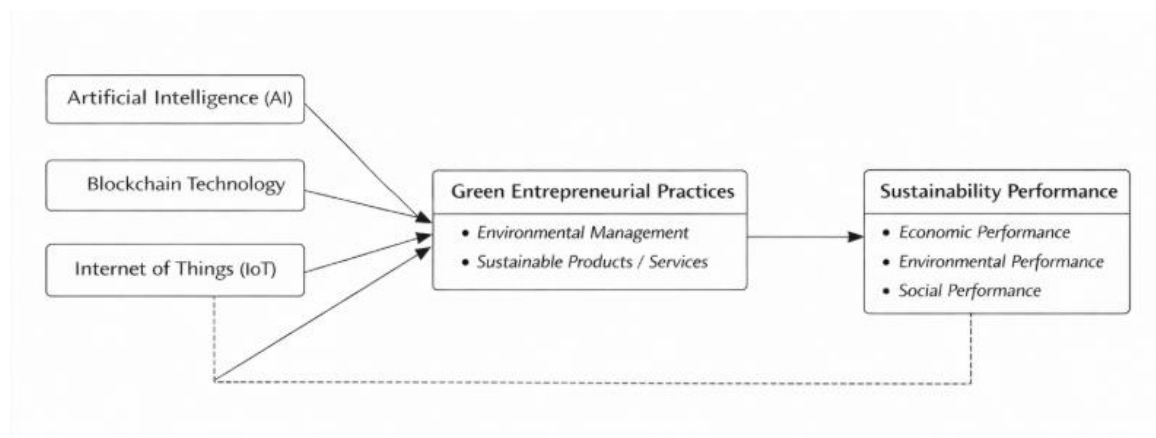


Figure 1. Conceptual framework of the study

Primary data were collected using a structured questionnaire consisting of demographic questions and 51 statements measuring digital technology adoption, green entrepreneurial practices, sustainability outcomes, and organizational and managerial factors. All items were measured on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). This is exhibited in Table 2.

Table 2. Construct and measurement scale

Construct	Dimension	Indicators / items	Measurement scale
Digital Technology Adoption	AI Adoption	1. AI used for customer insights and behavior 2. AI applied in financial decision-making 3. AI supports production process optimization 4. AI helps in predictive maintenance 5. AI used in inventory management 6. AI supports marketing strategy and targeting 7. AI used for risk assessment and forecasting	5-point Likert (1 = Strongly Disagree, 5 = Strongly Agree)
	Blockchain Adoption	1. Blockchain used for supply chain transparency 2. Blockchain ensures secure financial transactions 3. Blockchain used for traceability of products 4. Blockchain supports contracts 5. Blockchain helps prevent fraud in transactions	5-point Likert

		6. Blockchain integrated with record and reporting 7. Blockchain improves data integrity and security	
		1. IoT used to monitor production processes 2. IoT helps track inventory in real time 3. IoT monitors energy consumption 4. IoT supports predictive maintenance 5. IoT devices help track environmental conditions 6. IoT integrated with supply chain management 7. IoT improves operational efficiency & automation	
	IoT Adoption		5-point Likert
	Environmental Management	1. Waste reduction initiatives 2. Energy-efficient practices 3. Use of renewable resources 4. Water conservation 5. Eco-friendly sourcing 6. Environment compliances	5-point Likert
		1. Production of eco-friendly products 2. Sustainable packaging 3. Marketing sustainable services 4. Product life cycle 5. Service Innovation 6. Eco-awareness	
	Sustainable Products/Services		5-point Likert
Green Entrepreneurial Practices	Economic Sustainability	1. Profit growth over time 2. Market competitiveness 3. Cost reduction due to green practices 4. Revenue and green product 5. Green finance 6. Resource utilization	5-point Likert
		1. Reduction in carbon footprint 2. Reduction in waste and emissions 3. Compliance with environmental regulations 4. Recycle & reuse 5. Green certification 6. Energy efficiency	
	Environmental Sustainability		5-point Likert
	Social Sustainability	1. Contribution to community development 2. Employee well-being initiatives 3. Social responsibility engagement 4. Stakeholder engagement 5. Employee training 6. Ethical business practices	5-point Likert

(Source: Operationalized by author)

Data analysis followed a multi-step quantitative procedure. Initially, data were screened and cleaned for missing values and outliers. Descriptive statistics were used to summarize respondent profiles and construct distributions. The reliability and validity of constructs were assessed using Cronbach's alpha, exploratory factor analysis (EFA), and confirmatory factor analysis (CFA). Hypotheses were tested using correlation and regression analyses, including mediation analysis for green entrepreneurial practices and moderation analysis for organizational and managerial factors. These steps ensure

robust, valid, and reliable inference regarding the influence of digital technology adoption on green entrepreneurship and sustainability performance in SMEs.

4. Results and Discussion

The study surveyed 100 entrepreneurs in the Northern Province of Sri Lanka. According to the sample profile most respondents were male (65%), aged between 31–40 years (40%), with the majority holding a bachelor's degree (40%). Entrepreneurs represented manufacturing (35%), services (40%), and retail/trading sectors (25%), with 45% reporting 6–10 years of business experience.

The survey instrument demonstrated excellent reliability, with an overall Cronbach's alpha of 0.93 across constructs, ranging from 0.84 to 0.91. Convergent validity, assessed via Average Variance Extracted (AVE), ranged from 0.55 to 0.62, while discriminant validity, evaluated using the HTMT and Fornell-Larcker criteria, was satisfactory, indicating that the constructs were empirically distinct. This nature has been shown in Table 3.

Table 3. Reliability and validity summary

Construct	Items	Cronbach's α	AVE	Interpretation
AI Adoption	7	0.91	0.61	satisfactory reliability, acceptable convergent validity
Blockchain Adoption	7	0.89	0.59	Good reliability, acceptable convergent validity
IoT Adoption	7	0.90	0.62	Excellent reliability, good convergent validity
Environmental Management	6	0.87	0.57	Good reliability, acceptable convergent validity
Sustainable Products/Services	6	0.85	0.56	Good reliability, acceptable convergent validity
Economic Sustainability	6	0.88	0.60	Good reliability, good convergent validity
Environmental Sustainability	6	0.86	0.58	Good reliability, acceptable convergent validity
Social Sustainability	6	0.84	0.55	Good reliability, acceptable convergent validity

The confirmatory factor analysis (CFA) indicated a good model fit. The Chi-square value (1.85) was below the cutoff of 3.0, while TLI (0.92), CFI (0.93), RMSEA (0.06), and SRMR (0.05) all met recommended thresholds (Table 4). These results suggest that the proposed measurement model aligns well with the observed data.

Table 4: Summary of Confirmatory Factor Analysis (CFA)

Fit Index	Recommended Value	Value (Result)	Interpretation
Chi-Square	≤ 3	1.85	Good model fit
CFI (Comparative Fit Index)	≥ 0.90	0.93	Acceptable to good fit
TLI (Tucker-Lewis Index)	≥ 0.90	0.92	Good fit
RMSEA (Root Mean Square Error of Approximation)	≤ 0.08	0.06	Good fit
SRMR (Standardized Root Mean Square Residual)	≤ 0.08	0.05	Good fit

Correlation analysis (Table 5) revealed positive and significant associations ($p < 0.01$) among all constructs. Adoption of AI, Blockchain, and IoT was moderately to strongly correlated with green entrepreneurial practices ($r = 0.55\text{--}0.60$), which, in turn, were strongly correlated with social, environmental, and economic sustainability outcomes ($r = 0.57\text{--}0.62$). These results highlight that enhanced green practices are associated with improved sustainability across all dimensions.

Table 5. Summary of correlation test

Construct	AI	Blockchain	IoT	Green Practices	Economic Sustainability	Environmental Sustainability	Social Sustainability
AI	1	0.52**	0.54**	0.60**	0.50**	0.48**	0.45**
Blockchain		1	0.50**	0.55**	0.48**	0.46**	0.43**
IoT			1	0.58**	0.49**	0.47**	0.44**
Green Practices				1	0.62**	0.60**	0.57**
Economic Sustainability					1	0.65**	0.60**
Environmental Sustainability						1	0.58**
Social Sustainability							1

Hypothesis testing confirmed all proposed associations (Table 6). Adoption of AI ($\beta = 0.35$), Blockchain ($\beta = 0.28$), and IoT ($\beta = 0.30$) significantly enhanced green entrepreneurship practices ($p < 0.01$). Green entrepreneurship practices, in turn, positively influenced sustainability outcomes across economic ($\beta = 0.40$), environmental ($\beta = 0.42$), and social ($\beta = 0.38$) dimensions. These findings support the conceptual

framework by demonstrating that digital technologies indirectly foster SME sustainability by promoting green practices.

Table 6. Summary of hypothetical test

Hypothesis	Relationship Tested	β (Standardized)	t-value	p-value	Decision
H1	AI → Green Practices	0.35	4.12	<0.001	Supported
H2	Blockchain → Green Practices	0.28	3.45	0.001	Supported
H3	IoT → Green Practices	0.30	3.78	<0.001	Supported
H4	Green Practices → Economic Sustainability	0.40	4.50	<0.001	Supported
H5	Green Practices → Environmental Sustainability	0.42	4.65	<0.001	Supported
H6	Green Practices → Social Sustainability	0.38	4.20	<0.001	Supported

These findings indicate that digitalization and green knowledge perception are critical enablers for SMEs' sustainability performance. Entrepreneurs recognize the potential of IoT for real-time monitoring, resource management, and process optimization, while AI contributes to market competitiveness, operational efficiency, and data-driven decision-making (De Silva, 2025; Vaikunthavasan, 2025). For instance, 60% of green entrepreneurs in service-based sectors employ analytics tools such as Google Cloud to gain competitive insights (Makumbura *et al.*, 2025; Haq and Huo, 2023), while 35% of SMEs in FMCG utilize blockchain platforms like Polygon and Adobe Cloud for operational efficiency. Retail and agricultural export SMEs increasingly integrate IoT platforms such as Thing Speak to meet standardization requirements effectively.

The study highlights that digital technologies enhance green value creation, supporting both economic competitiveness and environmental sustainability. AI facilitates data-driven decision-making, reducing resource wastage, optimizing labor costs, and enabling eco-innovative outputs. Blockchain enhances transparency and legitimacy in eco-friendly operations, while IoT supports lean production and Total Quality Management (Costa Melo *et al.*, 2023; World Economic Forum, 2023). Nevertheless, SMEs in Sri Lanka's Northern Province face contextual challenges in technology adoption. Limited digital infrastructure, constrained access to green finance, and modest IT literacy can slow implementation, although these barriers are not absolute limitations. Focused interventions, capacity-building programs, and supportive policies can enhance digital readiness, enabling SMEs to leverage AI, Blockchain, and IoT to achieve sustainability and competitiveness simultaneously (Siriwardena *et al.*, 2024; Rasool and Dissanayake, 2019).

Overall, the findings affirm the synergistic role of digital technologies and green entrepreneurial practices in promoting sustainability. SMEs adopting these tools are better equipped to navigate emerging market dynamics, innovate responsibly, and create

long-term social, environmental, and economic value, reinforcing the relevance of digitalization as a strategic capability in the post-crisis Northern Province context.

5. Conclusion

This study examined how SMEs in Sri Lanka's Northern Province leverage AI, Blockchain, and IoT to enhance green entrepreneurship practices and achieve economic, environmental, and social sustainability. The findings indicate that digital technologies positively influence green practices, which in turn drive sustainability outcomes, highlighting their role as strategic enablers for eco-innovation and data-driven decision-making. In summary, AI, Blockchain, and IoT serve as critical enablers for SMEs to enhance operational efficiency, foster innovation, and create economic, social, and environmental value, supporting sustainable growth in post-crisis Sri Lankan contexts. The study contributes theoretically by integrating TAM, DoI, RBV, and TBL frameworks to show how organizational capabilities, managerial perceptions, and technology adoption collectively support sustainable entrepreneurship. Practically, the results suggest that policymakers and business support organizations can promote digital adoption and green practices through capacity-building programs, access to green finance, and improved digital infrastructure. A key limitation is the regional focus on the Northern Province, which may affect generalizability to other regions or countries. Future research could explore SMEs in other provinces or emerging economies and adopt longitudinal or qualitative designs to examine the long-term impacts of digital technologies on sustainability.

Author Contributions

Conceptualization, R.S.; methodology, R.S.; software, R.S.; validation, R.S.; formal analysis, R.S.; investigation, R.S.; resources, R.S.; data curation, R.S.; writing—original draft preparation, R.S.; writing—review and editing, R.S.; visualization, R.S.; supervision, R.S.; project administration, R.S.; funding acquisition, R.S. The author has read and agreed to the published version of the manuscript.

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