APTISI Transactions on Management (ATM)
Vol. 9, No. 3, 2025, pp. 290∼301
E-ISSN: 2622-6804 P-ISSN: 2622-6812, DOI:10.33050

Framework for Implementing Green Supply Chain Practices in Indonesian Small and Medium Enterprises

Qurotul Aini[1], Marviola Hardini[2], Ihsan Nuril Hikam[3], Thomas Green[4*]
[1]Department of Information, Satya Wacana Christian University, Indonesia
[2]Faculty of Economics and Business, University of Raharja, Indonesia
[3]Faculty of Information Technology, University of Raharja, Indonesia
[4]Faculty of Economics and Business, Eesp Incorporation, British Indian Ocean Territory
[1]982022016@student.uksw.edu, [2]marviola@raharja.info, [3]ihsan.nuril@raharja.info, [4]thom.green@eesp.io
***Corresponding Author**

Article Info

Article history:

Received August 8, 2025
Revised October 15, 2025
Accepted October 18, 2025

Keywords:

Green Supply Chain Management
SMEs
Sustainability
Indonesia
SDGs

ABSTRACT

The urgent need to address climate change, environmental degradation, and resource depletion has driven the adoption of sustainable business practices globally. For Small and Medium Enterprises (SMEs), particularly in developing countries such as Indonesia, transitioning toward sustainability presents both challenges and opportunities. Green Supply Chain Management (GSCM) offers a **comprehensive approach to integrating environmental considerations** into every stage of the supply chain, from sourcing raw materials to end-of-life product management. **This study develops** a practical GSCM framework tailored for Indonesian SMEs, using a **qualitative multiple-case study method** across three sectors: food, handicrafts, and logistics. Data collection methods included semi-structured interviews, on-site observations, and document analysis, followed by thematic coding and cross-case synthesis. **The resulting framework** identifies five interrelated components: supplier collaboration, eco-friendly material selection, waste reduction strategies, energy efficiency optimization, and sustainability performance monitoring. The framework is validated through triangulation of data sources and feedback from SME stakeholders. By aligning with the United Nations Sustainable Development Goals (SDGs), particularly Goals 12 and 13, **this study provides** actionable insights for policymakers, SME owners, and practitioners seeking to enhance sustainability while maintaining operational efficiency.

Corresponding Author:

DOI: https://doi.org/10.33050/atm.v9i3.2521

1. INTRODUCTION

Sustainability has evolved from a corporate social responsibility initiative into a fundamental business requirement in the 21st century [1]. Accelerating environmental crises, including global warming, biodiversity loss, and pollution, necessitate systemic change in how goods and services are produced, distributed, and consumed [2]. Businesses are now expected to integrate environmental and social considerations into their operational strategies, with supply chains representing a critical leverage point for achieving sustainability outcomes [3, 4]. In this context, GSCM has emerged as a viable strategic framework for embedding sustainability

into procurement, production, distribution, and end-of-life processes [5, 6]. While GSCM adoption is growing globally [7], SMEs face unique barriers such as limited capital [8], inadequate technological capabilities, and lack of access to sustainability expertise [9, 10]. For many SMEs, especially in emerging economies, these constraints hinder the full-scale adoption of GSCM practices [11].

Indonesia presents a compelling context for studying GSCM in SMEs due to its economic structure [12, 13]. SMEs contribute more than 60% to the nation's GDP and employ over 97% of its workforce [14, 15]. However, despite their economic significance, many Indonesian SMEs operate with resource limitations, informal management structures, and short-term business horizons, all of which pose challenges to implementing sustainable supply chain practices [16].

The Indonesian government has introduced several policies and incentives to promote sustainability, including regulations on waste management [12], renewable energy adoption [17], and eco-labeling standards [18, 19]. While these policies create a favorable environment for green initiatives, SMEs often struggle with policy compliance due to bureaucratic complexity and limited regulatory awareness [20–22]. This gap underscores the need for frameworks that translate policy requirements into practical, context-sensitive actions for SMEs [23, 24].

Globally, research on GSCM has documented benefits such as improved operational efficiency [25], enhanced brand image, and reduced environmental impact [26, 27]. Case studies in countries like China, India, and Vietnam demonstrate that SMEs adopting GSCM can access new market opportunities, reduce production costs, and improve customer loyalty [28]. However, the majority of these studies are quantitative in nature [29], focusing on statistical relationships rather than the process of implementation [30, 31].

In Indonesia, existing GSCM studies tend to focus on large corporations, leaving a gap in practical, field-based research for SMEs [32, 33]. A few qualitative studies have explored sustainability in specific sectors, such as tourism or food processing, but a comprehensive, multi-sector framework grounded in empirical SME data is still lacking [34]. Addressing this gap is crucial for scaling sustainability across the broader economy [35, 36].

Furthermore, GSCM adoption aligns closely with global development priorities [37, 38]. The United Nations Sustainable Development Goals (SDGs) explicitly highlight the role of sustainable production and consumption (Goal 12) and climate action (Goal 13) in creating resilient economies [39, 40]. SMEs, as the backbone of national economies, play a pivotal role in achieving these goals through efficient resource use, waste minimization, and low-carbon operations [41, 42].

This study responds to the identified gap by developing a GSCM framework tailored to Indonesian SMEs [43], based on multiple case studies across three diverse sectors. By focusing on real-world implementation, the research aims to provide actionable guidance for SME owners, industry associations, and policymakers seeking to integrate sustainability into business operations. The framework's emphasis on adaptability ensures its applicability across different industries, while its alignment with the SDGs underscores its relevance to global sustainability efforts.

Unlike frameworks developed in Vietnam and India, which emphasize regulatory enforcement and large-scale industrial clusters, this framework highlights barriers unique to Indonesian SMEs, such as informal structures and limited infrastructure. This distinction underscores the novelty of the proposed model. SMEs account for more than 60% of industrial waste and 52% of energy consumption in Indonesia (Ministry of Industry, 2023).

2. RESEARCH METHODOLOGY

2.1. Research Approach

This research adopts a qualitative multiple-case study approach to capture the complexity of GSCM implementation within SMEs. A qualitative method was chosen because it allows for in depth exploration of operational realities, decision making processes, and contextual challenges that are often overlooked in quantitative surveys. The multiple-case design enables comparative analysis across different sectors, enhancing the generalizability of findings while maintaining contextual richness.

2.2. Case Selection Criteria

Three SMEs were purposively selected from the food, handicrafts, and logistics sectors to represent diverse operational contexts. Selection criteria included: (1) active involvement in supply chain activities, (2) existing or emerging sustainability initiatives, and (3) willingness to provide access to operational data,

facilities, and personnel for interviews and observations. The chosen sectors were strategically selected to reflect different levels of environmental impact and operational complexity [44].

2.3. Research Sites and Context

The food SME operates in urban Yogyakarta, the handicraft SME is based in rural Bali, and the logistics SME is located in the industrial zone of Surabaya. These locations were chosen to capture variations in regulatory environments, infrastructure availability, and market access. Each site also provided insights into how local culture, customer expectations, and supply chain networks influence GSCM adoption.

2.4. Data Collection Techniques

Data collection was conducted between January and April 2025 and included three primary methods:

1. Semi-structured interviews with owners, managers, and operational staff to capture personal perspectives on sustainability practices and challenges.

2. On-site observations to document operational processes, facility layouts, and waste management practices.

3. Document review including procurement records, waste logs, energy bills, and relevant company policies.

2.5. Sampling, Data Recording, and Management

A total of 12 participants were interviewed across the three SMEs, with roles ranging from owners to production supervisors and procurement officers, ensuring both strategic and operational perspectives were represented. This purposive sampling approach was selected to capture diverse views on the adoption and challenges of GSCM within each SME.

All interviews were audio-recorded with the consent of participants and transcribed verbatim to ensure accurate data collection. The interview transcripts were securely stored in password-protected digital folders to maintain confidentiality and safeguard against unauthorized access. Furthermore, observation notes from field visits were digitized immediately after each session to minimize recall bias and preserve the integrity of the data. This data management strategy ensured that the collected information remained organized, secure, and accessible for subsequent analysis.

2.6. Data Analysis, Triangulation, and Framework Development

The data analysis was conducted using thematic analysis, following Braun and Clarke's six-step framework. This approach allowed for a structured yet flexible process to identify, analyze, and report patterns (themes) within the qualitative data. The six steps included: (1) familiarization with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the final report. This iterative process ensured that the findings were both comprehensive and reflective of the underlying patterns in the data, while also allowing for inductive theme emergence and deductive verification against existing literature on GSCM practices.

To enhance the validity of the findings, data triangulation was applied. This involved cross-referencing the data from interviews, observations, and document reviews to ensure consistency and reliability across different sources of information. Investigator triangulation was also employed, with two independent researchers reviewing the coding process to minimize researcher bias and enhance the credibility of the analysis [45, 46]. By integrating these strategies, the study aimed to minimize biases and strengthen the overall validity of the findings.

Based on the findings from the data analysis, a preliminary GSCM framework was developed. This framework synthesized key themes identified from the case studies and was presented to the participating SMEs for validation. This iterative validation process ensured that the framework was both practically relevant and contextually accurate, reflecting the real-world operational challenges and sustainability priorities of Indonesian SMEs [47, 48]. The final GSCM framework consists of five interrelated components: supplier collaboration, eco-friendly material selection, waste reduction strategies, energy efficiency optimization, and sustainability performance monitoring.

2.7. Ethical Considerations, Limitations, and Justification for Qualitative Approach

Ethical approval for this study was obtained from the [University Ethics Committee Name]. Participants were informed of the study's objectives and provided written consent prior to data collection, ensuring transparency and respecting their autonomy in the research process. Confidentiality was maintained throughout the study by anonymizing company names and participant identifiers. This approach safeguarded the privacy of the SMEs involved and adhered to ethical research standards [49].

While qualitative case studies offer rich and contextually detailed insights, they inherently limit statistical generalizability. The findings from this study may not be directly applicable to all SMEs, particularly those outside of the specific sectors or geographical locations studied. However, the multi-sector approach, involving SMEs from the food, handicrafts, and logistics sectors, enhances the robustness and transferability of the findings. By demonstrating the applicability of the GSCM framework across different industries and operational contexts, this study offers valuable insights that can guide similar efforts in other regions or sectors, albeit with contextual adaptations [50].

A qualitative research approach was deemed most appropriate for this study, given the exploratory nature of the research question, the absence of detailed frameworks for Indonesian SMEs, and the need to capture the nuanced operational realities that are often overlooked in quantitative studies. The qualitative approach allowed for an in-depth exploration of the challenges and opportunities faced by SMEs in adopting GSCM practices, providing a holistic view that is essential for developing a practical and contextually relevant framework [50].

2.8. Summary of Methodological Design

The methodological approach ensured that findings were grounded in empirical realities while retaining theoretical relevance. The combination of purposive sampling, multiple data collection methods, and iterative validation strengthened the credibility and applicability of the resulting framework. In addition, by triangulating interviews, observations, and document reviews, the study was able to capture not only the stated practices of SMEs but also the actual operational behaviors that reflect day-to-day sustainability challenges. This holistic approach reduced the risk of bias and enhanced the reliability of the conclusions, while the iterative validation with SME stakeholders ensured that the framework was both academically rigorous and practically implementable. Consequently, the methodology balances depth and breadth, offering insights that are robust enough for scholarly discourse yet directly useful for SME practitioners and policymakers.

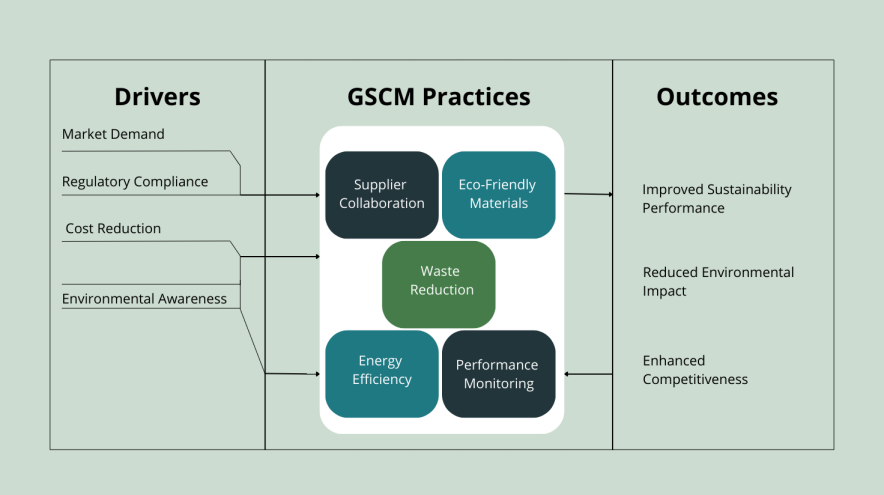

Figure 1. Conceptual Framework for GSCM in SMEs

Figure 1 illustrates the conceptual framework for GSCM adoption in small and medium-sized enterprises (SMEs), beginning with four key drivers: market demand, regulatory compliance, cost reduction, and environmental awareness, which collectively influence the adoption of sustainable practices. These drivers encourage SMEs to integrate sustainability into their operations by implementing five core GSCM practices: supplier collaboration, eco-friendly materials, waste reduction, energy efficiency, and performance monitoring. The implementation of these practices creates a systematic process that not only addresses environmental

challenges but also enhances business resilience and long-term growth. The application of these practices is expected to generate positive outcomes, including improved sustainability performance, reduced environmental impact, and enhanced competitiveness in increasingly eco-conscious markets. For instance, the food SME successfully reduced packaging costs by 12% through waste minimization strategies such as optimizing packaging design and materials, while the logistics SME achieved fuel savings of up to 15% through vehicle replacement and advanced route optimization techniques. These quantified results provide clear evidence of the tangible value and operational benefits of adopting GSCM practices, emphasizing their role in driving both environmental and financial performance improvements.

Table 1. Characteristics of Case Study SMEs

SME Code	Sector	Location	Key GSCM Drivers	Main Barriers
SME A	Food	Yogyakarta	Customer cooperation	High implementation cost
SME B	Handicrafts	Bali	Eco-design, green sourcing	Weak enforcement of regulations
SME C	Logistics	Surabaya	Internal environmental mgmt	Limited infrastructure

Table 1 presents the characteristics of the case study SMEs, highlighting their sector, location, key GSCM drivers, and main barriers. The food SME in Yogyakarta was mainly driven by customer cooperation but faced high implementation costs, the handicraft SME in Bali emphasized eco-design and green sourcing while struggling with weak enforcement of regulations, and the logistics SME in Surabaya focused on internal environmental management but encountered limited infrastructure. These characteristics illustrate how contextual factors such as sectoral priorities, geographical settings, and resource availability shape both the opportunities and challenges of GSCM adoption in Indonesian SMEs.

3. RESULTS AND DISCUSSION

3.1. Overview of GSCM Adoption and Sectoral Practices

Analysis of the three case studies revealed a common pattern in GSCM adoption among Indonesian SMEs. All participating SMEs demonstrated varying levels of sustainability awareness and efforts toward adopting GSCM practices. However, the scope and depth of implementation differed significantly by sector. The food SME prioritized waste reduction as a means of addressing both cost and regulatory pressures, illustrating how small investments in waste management, such as composting organic waste and optimizing packaging sizes, can result in immediate cost savings while enhancing compliance with regulatory standards. On the other hand, the handicraft SME placed a strong emphasis on eco-friendly materials, such as sustainably harvested wood and natural dyes, to differentiate itself in a competitive market and appeal to environmentally conscious consumers. The logistics SME, meanwhile, concentrated on improving energy efficiency, notably through the adoption of fuel-efficient delivery vehicles and route optimization software, aimed at reducing fuel costs and minimizing their carbon footprint. These sector-specific approaches highlight the diverse ways SMEs are integrating sustainability into their operations while also addressing the challenges and opportunities unique to their industries.

Additionally, supplier collaboration emerged as a key component for effective GSCM implementation. SMEs that actively engaged their suppliers in sustainability discussions were better able to source environmentally friendly materials and negotiate sustainable procurement terms. This collaborative approach not only ensured the integration of green practices into the supply chain but also fostered stronger supplier relationships, which are crucial for long-term sustainability goals. However, significant challenges arose when suppliers lacked their own environmental policies or certifications, especially in fragmented supply networks. This issue highlights the need for further industry-wide standardization and the development of transparent, green supply chains. The handicraft SME, in particular, demonstrated the strongest commitment to eco-friendly sourcing, using materials like sustainably harvested wood and natural dyes. Despite the clear environmental benefits, they faced barriers such as higher material costs and inconsistent supply availability, which forced the company to adopt hybrid sourcing strategies balancing eco-friendly materials with conventional ones to ensure

product availability and market competitiveness.

3.2. Sustainability Strategies and Cross-Sector Variations

Waste reduction strategies were particularly impactful in the food SME. By implementing measures such as composting organic waste and optimizing packaging sizes, the food SME was able to reduce operational costs while improving regulatory compliance. This low-cost, high-impact strategy served as an accessible entry point for SMEs new to GSCM, offering an easy way to start integrating sustainable practices with minimal capital investment. These early waste reduction practices not only facilitated better compliance with local environmental regulations but also helped improve the company's image as a sustainable brand, appealing to an increasingly eco-conscious consumer base.

The logistics SME, by focusing on energy efficiency, was able to achieve substantial fuel cost savings by replacing older delivery vehicles with newer, more fuel-efficient models and by adopting route optimization software. These energy-saving measures, though initially expensive, resulted in payback periods of less than three years, demonstrating the financial viability of energy efficiency measures, even for resource-constrained SMEs. Furthermore, the logistics SME was able to significantly reduce its carbon emissions, contributing positively to both environmental sustainability and operational efficiency. However, it is important to note that only one of the SMEs in this study maintained formal sustainability metrics, tracking key performance indicators like energy consumption, waste volumes, and recycling ratios. This lack of formal performance monitoring is a critical gap in GSCM implementation, as it prevents SMEs from accurately quantifying progress or effectively communicating their sustainability achievements to stakeholders.

The cross-sector analysis highlighted both similarities and differences across the SMEs. While each sector implemented GSCM practices tailored to their specific needs and challenges, all faced common barriers: limited access to green technology, insufficient regulatory incentives, and a lack of skilled human resources. Despite these shared obstacles, the drivers of GSCM adoption varied across sectors. For the handicraft sector, market demand for eco-friendly products was the primary driver, as consumers increasingly prioritized sustainability in their purchasing decisions. For the food sector, regulatory compliance particularly related to waste management was the most significant motivator. In contrast, for the logistics sector, the primary driver was cost savings, as SMEs sought to reduce fuel consumption and operational expenses. These sectoral differences underline the importance of context when implementing GSCM practices, as each industry must navigate unique challenges and drivers to successfully integrate sustainability into their supply chains.

3.3. Alignment with Literature and SDGs

The findings of this study align with existing literature on GSCM in SMEs from countries like Pakistan, Saudi Arabia, and ASEAN nations, emphasizing supplier collaboration and cost-saving opportunities as key drivers for GSCM adoption. Indonesian SMEs in this study also engaged suppliers in sustainability discussions and implemented cost-effective practices such as energy-efficient operations and waste reduction. A unique contribution of this study is its advocacy for a phased adoption approach, tailored to the resource constraints faced by SMEs in developing economies, in contrast to the one-size-fits-all models often applied in developed economies.

Additionally, the GSCM practices identified in this study contribute to SDG 12 (Responsible Consumption and Production) by promoting efficient resource use, waste minimization, and sustainable sourcing. These practices help reduce the environmental footprint while improving operational efficiency and support SDG 13 (Climate Action) through energy efficiency and optimized logistics. By incorporating SDGs into their strategies, SMEs not only contribute to global sustainability goals but also enhance their market positioning, particularly among environmentally conscious consumers, opening up new market opportunities and strengthening their brand image.

3.4. Summary of Key Results

The five-component framework offers a structured yet flexible approach to GSCM adoption in SMEs, providing a clear roadmap for businesses to transition toward sustainable practices. By starting with low-cost, high-impact initiatives such as waste reduction and basic energy efficiency measures, SMEs can gain early wins that build confidence and demonstrate tangible benefits. As these foundational practices become established, businesses can gradually progress toward more advanced and resource-intensive initiatives, including supplier collaboration and the use of eco-friendly materials. This incremental process allows SMEs to build

sustainability capacity step by step without jeopardizing financial stability or overwhelming existing operational systems. Moreover, the framework encourages continuous learning and adaptation, enabling SMEs to respond effectively to evolving market demands, regulatory changes, and technological advancements. By fostering a culture of gradual improvement and innovation, SMEs can not only achieve environmental and social goals but also enhance long-term competitiveness and resilience in an increasingly sustainability-driven global economy.

Table 2. Summary of GSCM Components and Outcomes in SMEs

Component	Description	Sector Example	Key Outcomes
Supplier Collaboration	Engaging suppliers on sustainability	Handicrafts, Food	Access to eco- materials, stronger branding
Eco- friendly Materials	Sourcing low- impact inputs	Handicrafts	Market differentiation, customer loyalty
Waste Reduction	Minimizing and recycling waste	Food	Cost savings, regulatory compliance
Energy Efficiency	Reducing energy/fuel consumption	Logistics	Reduced operational costs, lower emissions
Performance Monitoring	Tracking sustainability metrics	Logistics	Data- driven decision making

Table 2 summarizes the core GSCM components identified in the study along with their descriptions, sector-specific examples, and key outcomes. Supplier collaboration was found to be crucial in both food and handicraft SMEs for gaining access to eco-friendly materials and enhancing branding. Eco-friendly material selection, particularly in the handicraft sector, created market differentiation and strengthened customer loyalty. Waste reduction, demonstrated by the food SME, led to immediate cost savings and better compliance with regulations. Energy efficiency, applied in logistics operations, reduced operational costs and emissions, while performance monitoring enabled data-driven decision making. Together, these components demonstrate the multi-dimensional benefits of GSCM adoption for SMEs across different industries.

4. MANAGERIAL IMPLICATIONS

The findings from this study offer several important managerial implications for small and medium-sized enterprises (SMEs) seeking to implement GSCM practices. These implications are particularly valuable for managers, business owners, and policymakers in Indonesia and similar emerging economies, where SMEs face unique challenges and opportunities related to sustainability.

4.1. Phased Adoption of GSCM Practices

One of the key contributions of this study is the emphasis on a phased adoption approach to GSCM. Managers should understand that implementing GSCM practices does not require an immediate, large-scale overhaul of business operations. Instead, SMEs should begin by adopting low-cost, high-impact measures, such as waste reduction and energy efficiency optimization, which provide immediate cost savings and compliance with environmental regulations. These initial efforts create a foundation for more advanced sustainability practices, such as supplier collaboration and eco-friendly material selection, which require greater investment and long-term commitment. This incremental approach allows businesses to manage risks and costs effectively, making sustainability more achievable even for resource-constrained SMEs.

4.2. Supplier Collaboration and Green Sourcing

Supplier collaboration emerged as a critical component for the successful implementation of GSCM. Managers should focus on building strong relationships with suppliers, particularly by engaging them in discussions about sustainability and encouraging them to adopt environmentally friendly practices. While establishing such relationships may be challenging especially when suppliers lack environmental certifications SMEs can start by identifying suppliers who share similar sustainability goals and work together to improve material sourcing, reduce waste, and enhance supply chain transparency. By fostering these relationships, SMEs can se-

cure a reliable supply of sustainable materials while differentiating themselves in the market as environmentally responsible businesses.

It is also important for SMEs to consider the cost-benefit trade-offs associated with green sourcing. While eco-friendly materials may come at a premium, the long-term benefits, such as improved brand reputation, access to environmentally conscious consumers, and potential for export market expansion, often outweigh the higher costs. Managers should assess these factors carefully to determine the optimal balance between sustainability and profitability.

4.3. Energy Efficiency and Cost Savings

Energy efficiency optimization emerged as a major driver of cost savings, particularly for the logistics SME. Managers should prioritize energy-efficient measures, such as upgrading to fuel-efficient vehicles and adopting route optimization software, which can result in significant reductions in fuel consumption and operational costs. Although the upfront investment may be high, SMEs can benefit from short payback periods (e.g., less than three years), making these investments financially viable in the long run. These energy-efficient practices not only contribute to cost savings but also align with global sustainability goals by reducing the SME's carbon footprint.

In addition to energy efficiency, managers should also explore the integration of renewable energy sources, such as solar power, into their operations. This will further reduce dependence on fossil fuels, lower energy costs, and enhance the business's environmental credentials, positioning it as a forward-thinking company committed to sustainable practices.

4.4. Waste Reduction and Compliance

For SMEs in sectors like food production, waste reduction strategies provide a significant opportunity for improving both operational efficiency and regulatory compliance. Managers should begin by implementing simple, cost-effective waste management practices, such as composting organic waste and optimizing packaging sizes. These strategies can lead to immediate cost savings and reduce the environmental impact of operations, making them ideal starting points for SMEs new to GSCM. Moreover, waste reduction initiatives often lead to improved regulatory compliance, especially in countries with strict environmental regulations. Managers should actively monitor regulatory trends to ensure that their practices align with local and international sustainability standards.

Adopting waste reduction practices not only supports environmental goals but can also enhance an SME's brand image. Consumers are increasingly attracted to businesses that demonstrate a commitment to environmental stewardship, and SMEs that effectively manage waste and reduce packaging materials may gain a competitive edge in the market.

4.5. Formal Sustainability Performance Monitoring

One of the key gaps identified in the study was the lack of formal sustainability performance monitoring in most SMEs. Managers should consider implementing simple, cost-effective sustainability metrics that track key indicators such as energy consumption, waste volumes, and recycling ratios. These metrics will allow businesses to quantify their sustainability efforts, track progress over time, and make informed decisions about further investments in green practices.

In addition, performance monitoring is crucial for communicating sustainability achievements to stakeholders, including customers, investors, and regulators. Transparent reporting of sustainability performance can enhance the SME's credibility and demonstrate its commitment to meeting both environmental and social goals. Managers can leverage digital tools and software to streamline performance tracking and ensure that sustainability goals are met efficiently.

4.6. Policy Implications and Government Support

Policymakers can play a crucial role in supporting the adoption of GSCM practices among SMEs. While government regulations and incentives for sustainability exist, many SMEs face challenges in navigating the complex regulatory landscape. Policymakers should aim to simplify the regulatory framework and provide clear guidelines for SMEs to follow. In particular, incentives such as tax breaks, subsidies for green technologies, and training programs can encourage SMEs to adopt GSCM practices.

Governments can also help SMEs by providing access to financial support for initial investments in green technologies, such as energy-efficient equipment or sustainable material sourcing. By fostering a

supportive policy environment, governments can facilitate the widespread adoption of GSCM, which not only benefits individual SMEs but also contributes to broader national sustainability goals, such as those outlined in the United Nations Sustainable Development Goals (SDGs).

4.7. Final Thoughts

The implementation of GSCM practices in SMEs offers numerous benefits, including cost savings, improved regulatory compliance, and enhanced brand reputation. However, for SMEs, the journey toward sustainability requires careful planning and strategic action. Managers should take an incremental, phased approach to GSCM adoption, focusing on low-cost, high-impact measures to build momentum before scaling up more advanced practices. By fostering strong supplier collaborations, investing in energy-efficient technologies, reducing waste, and implementing performance monitoring tools, SMEs can significantly improve their sustainability practices while maintaining operational efficiency. With the right support from policymakers and industry stakeholders, SMEs can play a key role in advancing sustainability efforts within Indonesia and globally.

5. CONCLUSION

This study developed a practical, five- component framework for GSCM adoption in Indonesian SMEs, derived from multiple case studies across the food, handicrafts, and logistics sectors. The framework's core components supplier collaboration, eco- friendly materials selection, waste reduction strategies, energy efficiency optimization, and sustainability performance monitoring were found to be both relevant and adaptable to diverse SME contexts.

The findings indicate that incremental, phased adoption of GSCM practices offers a realistic pathway for SMEs to enhance sustainability without compromising financial viability. Low- cost measures, such as waste reduction and energy efficiency improvements, can serve as effective entry points, building momentum for more complex initiatives like supplier collaboration and formal sustainability monitoring.

By aligning with the United Nations Sustainable Development Goals, particularly SDG 12 and SDG 13, the framework not only addresses environmental priorities but also strengthens market competitiveness. Integrating IoT for real-time monitoring and Blockchain for supply chain transparency could further enhance the robustness of the framework. Future research could explore integrating digital technologies such as IoT and blockchain into SME GSCM frameworks to enhance traceability, efficiency, and reporting accuracy. Beyond environmental benefits, GSCM adoption among SMEs can stimulate green job creation, enhance competitiveness in ASEAN markets, and support national policy goals such as the Low Carbon Development Initiative.

6. DECLARATIONS

6.1. About Authors

Qurotul Aini (QA) https://orcid.org/0000-0002-7546-5721
Marviola Hardini (MH) https://orcid.org/0000-0003-3336-2131
Ihsan Nuril Hikam (IN) https://orcid.org/0009-0000-0345-9763
Thomas Green (TG) https://orcid.org/0009-0001-7048-2231

6.2. Author Contributions

Conceptualization: QA; Methodology: MH; Software: QA; Validation: QA and MH; Formal Analysis: QA; Investigation: QA; Resources: QA; Data Curation: MH; Writing Original Draft Preparation: QA; Writing Review and Editing: QA and MH; Visualization: MH; All authors, QA, MH, IN, and TG, have read and agreed to the published version of the manuscript.

6.3. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

6.4. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

6.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

REFERENCES

[1] V. Kandpal, A. Jaswal, E. D. Santibanez Gonzalez, and N. Agarwal, "Corporate social responsibility (csr) and esg reporting: redefining business in the twenty-first century," in *Sustainable energy transition: Circular economy and sustainable financing for environmental, social and governance (ESG) practices*. Springer, 2024, pp. 239–272.

[2] S. R. Hoque and S. R. Sultana, "Addressing global environmental problems: Challenges, solutions, and opportunities," *The Social Science Review: A Multidisciplinary Journal*, vol. 2, no. 2, pp. 124–130, 2024.

[3] D. S. S. Wuisan, R. A. Sunardjo, Q. Aini, N. A. Yusuf, and U. Rahardja, "Integrating artificial intelligence in human resource management: A smartpls approach for entrepreneurial success," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 5, no. 3, pp. 334–345, 2023.

[4] O. Esan, F. A. Ajayi, and O. Olawale, "Supply chain integrating sustainability and ethics: Strategies for modern supply chain management," *World Journal of Advanced Research and Reviews*, vol. 22, no. 1, pp. 1930–1953, 2024.

[5] R. K. Singh, "Exploring the impact of green supply chain strategies and sustainable practices on circular supply chains," *Benchmarking: An International Journal*, vol. 32, no. 4, pp. 1387–1409, 2025.

[6] R. Aprianto, A. Famalika, I. Idayati, I. N. Hikam *et al.*, "Examining influencers role in tiktok shop's promotional strategies and consumer purchases," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 6, no. 1, pp. 13–28, 2024.

[7] E. Ernawati, D. R. Fauziana, and E. N. Yunus, "An integrated green supply chain model for indonesian msmes: Internal-external drivers, practices, and performance," *Business Review and Case Studies*, vol. 6, no. 1, pp. 49–49, 2025.

[8] I. Muda, R. Sivaraman, S. I. S. Al-Hawary, U. Rahardja, R. S. Bader, D. Kadarsyah, K. S. Mohsen, A. H. Jabbar, and P. Chaudhary, "Hub location-allocation in computer-based networks under disruption using whale optimization algorithm," *Industrial Engineering & Management Systems*, vol. 21, no. 3, pp. 503–515, 2022.

[9] V. A. Mankar, V. Katare, L. Lodhi, and T. K. Kaushik, "A study of drivers and barriers of green supply chain management practices in the context of developing framework for smes," in *Leveraging AI for Innovative Sustainable Energy: Solar, Wind and Green Hydrogen*. IGI Global Scientific Publishing, 2025, pp. 1–14.

[10] Z. Zaharuddin, S. Wahyuningsih, A. Sutarman, and I. N. Hikam, "Understanding purposeful leadership in entrepreneurial contexts: A bibliometric analysis," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 6, no. 2, pp. 213–230, 2024.

[11] P. Kanwal, A. K. Yadav, and N. J. Dewasiri, "Entrepreneurial orientation and green supply chain management (gscm)," in *Impacts of Entrepreneurial Orientation on Supply Chain Management*. IGI Global, 2025, pp. 197–236.

[12] A. Nabilla, S. Widiyanesti, and G. Anggadwita, "The role of green supply chain management and environmental management practices in enhancing enviropreneurship performance based on evidence from indonesian tourism smes," *Discover Sustainability*, vol. 6, no. 1, p. 737, 2025.

[13] J. Jones, E. Harris, Y. Febriansah, A. Adiwijaya, and I. N. Hikam, "Ai for sustainable development: Applications in natural resource management, agriculture, and waste management," *International Transactions on Artificial Intelligence*, vol. 2, no. 2, pp. 143–149, 2024.

[14] Y. Prananda and A. Amalia, "The effect of sharia people's business credit (kur) financing on the development of micro, small, and medium enterprises (msmes): A case study of pt. pawnshop cps ar hakim medan," *Indonesian Interdisciplinary Journal of Sharia Economics (IIJSE)*, vol. 8, no. 3, pp. 7807–7818, 2025.

[15] Q. Aini, D. Manongga, U. Rahardja, I. Sembiring, and Y.-M. Li, "Understanding behavioral intention to use of air quality monitoring solutions with emphasis on technology readiness," *International Journal of Human–Computer Interaction*, vol. 41, no. 8, pp. 5079–5099, 2025.

[16] A. Siri, "Green leadership and sustainable business performance: Evidence from southeast asian smes,"

INTERNATIONAL JOURNAL OF ECONOMIC LITERATURE, vol. 2, no. 10, pp. 1061–1077, 2025.

[17] A. S. Amin and S. Nursyamsiah, "Integrating sustainable supply chain practices and risk management: Strategies to enhance msmes performance in indonesia," *Indonesian Interdisciplinary Journal of Sharia Economics (IIJSE)*, vol. 8, no. 2, pp. 5818–5836, 2025.

[18] P. Rashi, M. C. Lohani, N. Luftiani, T. Hermansyah, and I. N. Hikam, "New personalized social approach based on flexible integration of web services," *International Transactions on Artificial Intelligence*, vol. 1, no. 1, pp. 1–17, 2022.

[19] A. Ghufroni, F. Silaswaty, and D. Yudanto, "Legal gaps in waste management regulation of indonesia's fashion industry," *Jurnal Ilmu Hukum Kyadiren*, vol. 7, no. 1, pp. 325–340, 2025.

[20] S. Liu, K. I. Okere, and O. B. Muoneke, "Energizing small and medium-sized enterprises for environmental sustainability in poor europe: Do green finance and bureaucratic quality matter?" in *Natural Resources Forum*, vol. 49, no. 1. Wiley Online Library, 2025, pp. 116–137.

[21] S. Pranata, K. Hadi, M. H. R. Chakim, Y. Shino, and I. N. Hikam, "Business relationship in business process management and management with the literature review method," *ADI Journal on Recent Innovation*, vol. 5, no. 1Sp, pp. 45–53, 2023.

[22] Kemendikdasmen, "Dwp kemendikdasmen gelar bazar hardiknas 2025 dorong kemandirian," https://www.kemendikdasmen.go.id/berita/12797-dwp-kemendikdasmen-gelar-bazar-hardiknas-2025-dorong-kemandi, 2025, accessed: 2025-09-18.

[23] E. Sánchez, R. Calderón, and F. Herrera, "Artificial intelligence adoption in smes: Survey based on toe–doi framework, primary methodology and challenges," *Applied Sciences*, vol. 15, no. 12, p. 6465, 2025.

[24] J. Siswanto, V. A. Goeltom, I. N. Hikam, E. A. Lisangan, and A. Fitriani, "Market trend analysis and data-based decision making in increasing business competitiveness," *Sundara Advanced Research on Artificial Intelligence*, vol. 1, no. 1, pp. 1–8, 2025.

[25] A. Ruangkanjanases, A. Khan, O. Sivarak, U. Rahardja, and S.-C. Chen, "Modeling the consumers' flow experience in e-commerce: The integration of ecm and tam with the antecedents of flow experience," *Sage Open*, vol. 14, no. 2, p. 21582440241258595, 2024.

[26] R. A. Rupa and A. N. M. Saif, "Impact of green supply chain management (gscm) on business performance and environmental sustainability: case of a developing country," *Business Perspectives and Research*, vol. 10, no. 1, pp. 140–163, 2022.

[27] E. P. Harahap, E. Sediyono, Z. A. Hasibuan, U. Rahardja, and I. N. Hikam, "Artificial intelligence in tourism environments: A systematic literature review," *2022 IEEE Creative Communication and Innovative Technology (ICCIT)*, pp. 1–7, 2022.

[28] X. H. Nguyen, T. A. Duong, V. A. Nguyen, K. L. Nguyen, N. T. Dinh, and D. H. Mai, "The impact of corporate social responsibility, green supply chain management on the performance of small and medium enterprises in vietnam: a systematic literature review and directions for future research," *International Journal of Research and Review*, vol. 9, no. 5, 2022.

[29] D. A. Putro *et al.*, "Green supply chain management innovation in promoting sustainability in indonesia's palm oil industry," *Jurnal Penelitian Pendidikan IPA*, vol. 11, no. 5, pp. 925–934, 2025.

[30] X. Fang, J. Li, Q. Ma, R. Zhou, and S. Du, "A quantitative review of nature-based solutions for urban sustainability (2016–2022): From science to implementation," *Science of the Total Environment*, vol. 927, p. 172219, 2024.

[31] M. I. Sanni, R. D. Pramudya, D. A. Jamaludin, S. V. Sihotang, I. N. Hikam *et al.*, "Integrating technology and environmental policy for effective air quality monitoring in indonesia," in *2024 3rd International Conference on Creative Communication and Innovative Technology (ICCIT)*. IEEE, 2024, pp. 1–6.

[32] T. Feng, M. Qamruzzaman, S. S. Sharmin, and S. Karim, "Bridging environmental sustainability and organizational performance: The role of green supply chain management in the manufacturing industry," *Sustainability*, vol. 16, no. 14, p. 5918, 2024.

[33] P. Hendriyati, F. Agustin, U. Rahardja, and T. Ramadhan, "Management information systems on integrated student and lecturer data," *Aptisi Transactions on Management (ATM)*, vol. 6, no. 1, pp. 1–9, 2022.

[34] A. A. Lincoln and B. Diamond, "A multi-sector assessment of sustainability and socially responsible practices of international businesses in nigeria," in *Sustainability in Global Companies: Theory and Practice*. Springer, 2025, pp. 229–259.

[35] R. Raman, S. Ray, D. Das, and P. Nedungadi, "Innovations and barriers in sustainable and green finance

for advancing sustainable development goals," *Frontiers in Environmental Science*, vol. 12, p. 1513204, 2025.

[36] I. Amsyar, E. Cristhopher, U. Rahardja, N. Lutfiani, and A. Rizky, "Application of building workers services in facing industrial revolution 4.0," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 3, no. 1, pp. 32–41, 2021.

[37] P. Yu, Z. Chen, R. Neu, J. Pan, S. Lu, and K. Guo, "From an entrepreneurial perspective: innovation and collaboration in green supply chain management (gscm)," in *The Synergy of Sustainable Entrepreneurship*. IGI Global Scientific Publishing, 2025, pp. 1–30.

[38] E. N. Fuad, Y. E. Mohammad, M. Aminnudin, and M. S. Rhomadhon, "Enhancing sustainability in indonesian smes through green hrm and supply chains," *Problems and Perspectives in Management*, vol. 23, no. 2, p. 384, 2025.

[39] D. Firoiu, G. H. Ionescu, C. M. Cismaș, M. P. Costin, L. M. Cismaș, and C. F. Ciobanu, "Sustainable production and consumption in eu member states: Achieving the 2030 sustainable development goals (sdg 12)," *Sustainability*, vol. 17, no. 4, p. 1537, 2025.

[40] M. Muafi and Y. Liestyana, "Creating the business processes performance and msme performance: Adoption of green supply chain practices," in *Sustainable Advanced Manufacturing and Logistics in ASEAN*. IGI Global Scientific Publishing, 2025, pp. 157–168.

[41] A. Rizky, N. Lutfiani, W. S. Mariyati, A. A. Sari, and K. R. Febrianto, "Decentralization of information using blockchain technology on mobile apps e-journal," *Blockchain Frontier Technology*, vol. 1, no. 2, pp. 1–10, 2022.

[42] T. W. Rafiuddin, N. Lutfiani, A. Rizky, G. P. Cesna *et al.*, "Evaluating the effectiveness of gamification in mobile banking to increase savings rates," in *2024 2nd International Conference on Technology Innovation and Its Applications (ICTIIA)*. IEEE, 2024, pp. 1–6.

[43] F. L. Wong and W. Santosa, "The effect of the implementation of internal green supply chain management on operational flexibility, delivery, product quality and production costs in convection sme in bogor city, indonesia," *Golden Ratio of Data in Summary*, vol. 5, no. 1, pp. 78–85, 2025.

[44] Kemendikbudristek, "Dukung transformasi umkm masa depan kemendikbudristek berpartisipasi," https://www.kemendikdasmen.go.id/berita/4325-dukung-transformasi-umkm-masa-depan-kemendikbudristek-berpar, 2025, accessed: 2025-09-18.

[45] M. Yusuf, M. Yusup, R. D. Pramudya, A. Y. Fauzi, and A. Rizky, "Enhancing user login efficiency via single sign-on integration in internal quality assurance system (espmi)," *International Transactions on Artificial Intelligence*, vol. 2, no. 2, pp. 164–172, 2024.

[46] A. Rizky, S. Kurniawan, R. D. Gumelar, V. Andriyan, and M. B. Prakoso, "Use of blockchain technology in implementing information system security on education," *BEST Journal (Biology Education, Sains and Technology)*, vol. 4, no. 1, pp. 62–70, 2021.

[47] R. Supriati, N. Lutfiani, D. Apriani, A. Rizky *et al.*, "Utilizing the potential of blockchain technology for leading education 4.0," in *2022 International Conference on Science and Technology (ICOSTECH)*. IEEE, 2022, pp. 01–08.

[48] A. Rizky, S. Silen, and D. A. Putra, "The role of blockchain technology in facing revolution education 4.0," *BEST Journal (Biology Education, Sains and Technology)*, vol. 4, no. 1, pp. 77–85, 2021.

[49] A. Rizky, R. W. Nugroho, W. Sejati, O. Sy *et al.*, "Optimizing blockchain digital signature security in driving innovation and sustainable infrastructure," *Blockchain Frontier Technology*, vol. 4, no. 2, pp. 183–192, 2025.

[50] A. Rizky, M. Z. Firli, N. A. Lindzani, S. Audiah, and L. Pasha, "Advanced cyber threat detection: Big data-driven ai solutions in complex networks," *Journal of Computer Science and Technology Application*, vol. 1, no. 2, pp. 136–143, 2024.