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Implementing Green Logistics in Agricultural MSMEs in Sukabumi, West Java, Indonesia: Its Impact on Operational Efficiency and Environmental Sustainability

Implementasi Logistik Hijau pada Usaha Mikro, Kecil, dan Menengah (UMKM) Pertanian di Sukabumi, Jawa Barat, Indonesia: Dampaknya terhadap Efisiensi Operasional dan Keberlanjutan Lingkungan

Nabila Eprilya Putri[1*], Fitrina Lestari[2], Riyan Mirdan Faris[3]

[1,2,3]Fakultas Bisnis dan Humaniora, Universitas Nusa Putra, Sukabumi, Indonesia

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ABSTRACT

Green Logistics (GL) presents a strategic framework for enhancing operational efficiency and environmental sustainability two key imperatives in modern supply chains. However, its implementation among MSMEs, particularly in agriculture and in developing countries, remains both understudied and underutilized. This study explores the extent to which GL practices influence Operational Efficiency and Environmental Sustainability within agricultural MSMEs in Sukabumi, West Java, Indonesia. Adopting a mixed methods approach, quantitative data were collected from 76 MSME actors and analyzed using SEM PLS, while qualitative insights were gathered through open ended survey questions. Results show that GL significantly impacts Operational Efficiency ($\beta = 0.593$) and Environmental Sustainability ($\beta = 0.485$), with Efficiency acting as a partial mediator ($\beta = 0.406$). The R^2 values of 0.633 and 0.352 suggest strong predictive validity for the structural model. The qualitative data reinforce these findings by highlighting real world constraints limited access to eco-friendly tools, a lack of technical knowledge, and insufficient training. While geographically localized, the study provides transferable insights into the broader barriers and potential of GL adoption among MSMEs in emerging economies. It also affirms the relevance of the NRBV and GSCM frameworks when adapted to rural and resource constrained contexts.

Corresponding Author:
Nabila Eprilya Putri,
Fakultas Bisnis dan Humaniora, Universitas Nusa Putra, Sukabumi, Indonesia
Email: nabila.eprilya_mn22@nusaputra.ac.id

INTRODUCTION

Global climate change, ongoing energy crises, and the growing urgency of sustainability have compelled industries around the world to rethink how they move goods and manage logistics. Amid these challenges, the concept of Green Logistics (GL) has gained traction not merely as a buzzword, but as a strategic approach that integrates energy efficiency, digital transformation, emission reduction, and waste management into a more environmentally responsible logistics system. In developed economies, GL practices have proven effective in enhancing both operational performance and environmental outcomes (Pishdar et al., 2022). However, this momentum has not been equally mirrored in developing countries, especially among micro, small, and medium sized agricultural enterprises (MSMEs), which often lack the capacity to adopt such practices (Anaman et al., 2023).

In Indonesia, MSMEs are crucial to the national economy; however, their capacity to implement green technologies is severely limited. According to the Ministry of Cooperatives and MSMEs, over 90% of these enterprises still depend on fossil fuel based logistics, which are inefficient and contribute significantly to greenhouse gas emissions (Prihastiwi et al., 2023). Logistics costs, which comprise 25–30% of operational expenses, especially hinder their competitiveness (Prihastiwi et al., 2023). An illustrative case is Sukabumi, West Java, a region characterized by a robust agricultural sector and numerous MSMEs; it exemplifies the intersection of GL, efficiency, and environmental sustainability, offering a relevant context for studying these dynamics (Nwaubani et al., 2023).

The selection of Sukabumi as the case study site is justified as it embodies typical characteristics of agricultural MSMEs in developing nations, including limited resources, inadequate infrastructure, and scarce access to green technology (Rezaei et al., 2018). Although geographically localized, the empirical insights drawn from this setting resonate with broader challenges faced by similar enterprises in tropical and emerging regions, thus offering relevance beyond national borders. Existing literature predominantly addresses GL in larger industrial contexts or within developed nations, thereby neglecting agricultural MSMEs in developing contexts this constitutes a significant gap in the academic discourse (Dias et al., 2021).

Theoretically, this research aligns with the Natural Resource Based View (NRBV), which posits that environmental capabilities can act as strategic advantages for firms (Sunargo, 2022). While NRBV provides a strong theoretical foundation, it has been critiqued for its normative assumptions and limited applicability in resource constrained environments such as MSMEs (Hart, 1995). To address this, the study contextualizes NRBV by accounting for external barriers like infrastructure, market readiness, and regulatory gaps. Additionally, concepts from Green Supply Chain Management (GSCM) and eco-efficiency serve as complementary middle range theories, illustrating how practices such as waste management, green procurement, and digital integration can simultaneously enhance environmental and economic performance (Novitasari, 2023; Zhu, 2008).

While most existing studies have relied on descriptive or case study methodologies, this research adopts a more robust quantitative-inferential method using Structural Equation Modeling Partial Least Squares (SEM-PLS) to examine the relationships among key constructs: Green Logistics, Operational Efficiency, and Environmental Sustainability. Two main hypotheses are proposed: Green Logistics positively influences Operational Efficiency among agricultural MSMEs in Sukabumi; and Green Logistics positively affects Environmental Sustainability in the same context. These hypotheses are tested using structured indicators that have been validated for reliability and construct validity.

In parallel, qualitative insights are gathered to explore the drivers and barriers to GL adoption, providing a contextualized understanding beyond what the quantitative model can capture. This dual approach acknowledges the nuanced, real-world constraints faced by MSMEs and enriches the analytical depth of the study (Ahmad, 2024). Ultimately, this research offers a theoretically grounded yet practically relevant contribution to the literature on Green Logistics in MSMEs, while informing policy design aimed at fostering sustainable logistics transitions in rural economies (Hidayat et al., 2024).

Green Logistics and Its Implementation in MSMEs

Green Logistics (GL) represents a forward looking approach to embedding sustainability within logistics operations. It emphasizes the shift toward renewable energy, the adoption of energy saving transportation modes, the use of digital distribution technologies, efficient waste handling, and the cultivation of environmentally aware human capital (Arroyo et al., 2023). This model holds particular promise for Micro, Small, and Medium Enterprises (MSMEs), which despite their inherent structural adaptability frequently struggle to integrate green practices due to resource constraints and institutional limitations (Panghal et al., 2023).

To assess the extent of GL implementation in MSMEs, several core indicators are commonly used: transport efficiency (X1), adoption of renewable energy (X2), waste recycling practices (X3), and integration of digital tools such as IoT (X4) (Le, 2023). In high income countries, the integration of GL has consistently proven to lower logistics costs and improve competitive positioning (Janné & Fredriksson, 2021). In contrast, many MSMEs in Indonesia still depend on conventional logistics systems, which tend to be inefficient and are often disconnected from modern green technologies. This dependence limits their overall performance and adaptability, particularly within the agricultural sector (Wardani et al., 2022).

Moreover, the need for institutional backing and targeted policy support has been underscored in studies from Eastern Europe, reinforcing the notion that challenges in adopting green logistics are not isolated, but part of a broader global issue facing small enterprises (Kwak et al., 2020).

Theoretical Structure: From NRBV to Applied Green Logistics

This study is anchored in the Natural Resource-Based View (NRBV), which posits that firms that manage natural resources effectively can cultivate a lasting competitive advantage (Ahmad, 2024; Hart, 1995). However, critics argue that NRBV is often overly normative, assuming a level playing field where all firms possess equal capacity to develop and exploit environmental capabilities. This assumption becomes especially problematic for Micro, Small, and Medium Enterprises (MSMEs) in emerging markets, which frequently operate under institutional voids and infrastructure limitations that hinder green strategy implementation.

To more critically assess the applicability of NRBV, this study considers insights from entrepreneurial development literature. For example, Hessels & Terjesen, 2010 emphasize that firm level resource limitations common among MSMEs are significantly shaped by broader institutional and market conditions. Their work suggests that access to knowledge networks, financing, and supportive policy ecosystems plays a crucial role in enabling smaller enterprises to pursue sustainability-oriented innovation.

In light of this, the integration of Green Supply Chain Management (GSCM) serves to complement NRBV by illustrating how practical tools such as waste management (X3), eco-friendly material usage (X6), environmental certification (X7), and green human capital development (X8) can translate sustainability ambitions into measurable performance outcomes (Mızrak, 2024; Novitasari, 2023; Shree, 2025; Zhu, 2008).

Green Logistics (GL) is positioned in this study as an applied framework operationalizing both NRBV and GSCM principles within agricultural MSMEs. This integrated perspective allows for a more grounded empirical investigation into how GL practices affect operational efficiency (Y1) and environmental sustainability (Y2), particularly within resource-constrained, rural microenterprise contexts.

2.3 Operational Efficiency as a Strategic Outcome

Operational efficiency in SME logistics is closely tied to faster distribution and reduced logistics costs, captured by indicators Y1_1 and Y1_2. Rahman, 2024 highlight how digitalization and structured GL practices support both net-zero emissions goals and internal efficiency. Furthermore, efficiency and sustainability serve as mutually reinforcing dimensions, particularly within agricultural logistics (Zhou et al., 2023).

2.4 Environmental Sustainability as the Strategic Outcome of GL

Environmental sustainability emerges as a key outcome of effective GL systems. Indicators Y2_1 and Y2_2 in this study assess how GL influences ecosystems and long term business viability. Research has demonstrated that the adoption of green practices, such as harnessing renewable energy and reducing carbon emissions, can enhance customer loyalty and bolster long-term business resilience (Tokarski, 2021). This investigation extends existing knowledge into the relatively underexplored area of agricultural logistics specific to MSMEs.

2.5 Related Studies and Research Gaps

The study of Green Logistics (GL) within agricultural Micro, Small, and Medium Enterprises (MSMEs) in Sukabumi, West Java, underscores several notable gaps in the current body of literature. To begin with, there is a clear empirical gap, as very few studies have zeroed in on GL practices specifically within Indonesia's agricultural MSME landscape. Much of the existing research such as that by Gupta, 2024 and Larina et al., 2021 tends to focus on general logistical systems, often overlooking the distinctive operational realities and constraints of small scale agricultural enterprises in rural settings like Sukabumi. This points to the urgent need for field-based research that examines how GL can be effectively applied in agricultural contexts and what measurable outcomes it produces.

In addition, a theoretical gap persists regarding the application of the Natural Resource-Based View (NRBV) to small scale agricultural sectors. Although Liang et al., 2019 have highlighted how resource optimization can drive competitive advantage, their findings remain largely rooted in broader or non-agricultural industries. As such, the adaptation of NRBV to agricultural MSMEs particularly in Indonesia has yet to be fully developed, leaving a theoretical void in understanding how these enterprises might leverage environmental capabilities strategically.

Lastly, a contextual gap is apparent due to the lack of studies tailored to the specific socio-economic characteristics of Sukabumi. While existing literature does explore GL in various global contexts, much of it emphasizes urban or industrialized areas, offering little insight into the logistical realities of rural agricultural operations ("Impact of Green Logistics on Sustainability of Supply Chain," 2018). Given Sukabumi's strong agricultural base and unique logistical landscape, there is a pressing need for context-aware research that can inform practical and regionally appropriate GL strategies.

METHODS

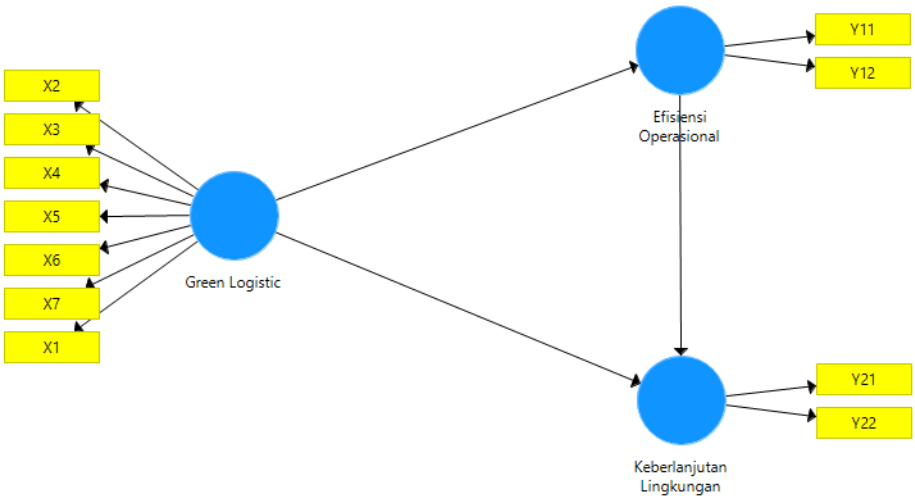
This study is grounded in the Natural Resource-Based View (NRBV), which positions environmental management capabilities as strategic assets that can generate sustained competitive advantage (Hart, 1995). Within this theoretical lens, the adoption of Green Logistics (GL) by Micro, Small, and Medium Enterprises (MSMEs) is expected not only to enhance environmental outcomes but also to improve operational performance.

In the proposed model, GL is treated as an exogenous latent construct composed of seven key indicators: Transportation Efficiency (X1), Renewable Energy Use (X2), Waste Management (X3), Digitalization and IoT (X4), Use of Eco-Friendly Materials (X5), Regulatory Certification (X6), and Human Resource Training (X7). This construct is hypothesized to directly influence two endogenous constructs:

- Operational Efficiency (Y1) – measured through perceptions of cost reduction and improved distribution speed (Y1_1, Y1_2),
- Environmental Sustainability (Y2) – measured by perceived environmental conservation and business sustainability (Y2_1, Y2_2).

The conceptual model (see Figure 1) illustrates the hypothesized causal pathways.

Figure 1. Conceptual Framework



Research Hypotheses:
H1: Green Logistics positively influences Operational Efficiency.
H2: Green Logistics positively influences Environmental Sustainability.

3.1 Research Design and Approach

This study adopts a mixed methods explanatory sequential design (Creswell, 2014), in which quantitative analysis is followed by qualitative exploration. The quantitative phase applies Partial Least Squares Structural Equation Modeling (PLS-SEM) using SmartPLS 4.0, focusing on reflective constructs. The qualitative phase supports interpretation through exploratory insights into implementation barriers and drivers, collected via open-ended responses and field notes.

3.2 Research Site and Respondents

The study was conducted in Sukabumi Regency, West Java, Indonesia, a rural region with a strong agricultural base and an active ecosystem of agricultural logistics MSMEs. According to local statistics (Badan Pusat Statistik Kabupaten Sukabumi, 2025), there are 94 logistics-focused MSMEs operating in agricultural supply chains. A minimum sample of 76 respondents was determined using Slovin's formula at a 5% margin of error. Respondents included MSME owners or senior logistics managers across major subdistricts involved in agricultural distribution.

3.3 Data Collection Techniques

Quantitative data were collected using a structured Likert-scale questionnaire (1–5) based on constructs adapted from previous validated studies (e.g., Novitasari, 2023; Zhu, 2008). The instrument underwent content validation via expert review. Qualitative data were gathered through open-ended questions and field observations, enabling triangulation and enrichment of the statistical findings.

3.4 Variables and Indicators

Table 1. Operationalization of Variables

Variable	Indicator	Code
Green Logistics	Transportation Efficiency, Renewable Energy, Waste Management, Digitization, Environmentally Friendly Materials, Certification, HR Training	X1–X7
Operational Efficiency	Cost Reduction, Distribution Speed Improvement	Y1_1, Y1_2
Environmental Sustainability	Clean Energy Usage, Environmental Impact	Y2_1, Y2_2

3.5 Data Analysis Techniques

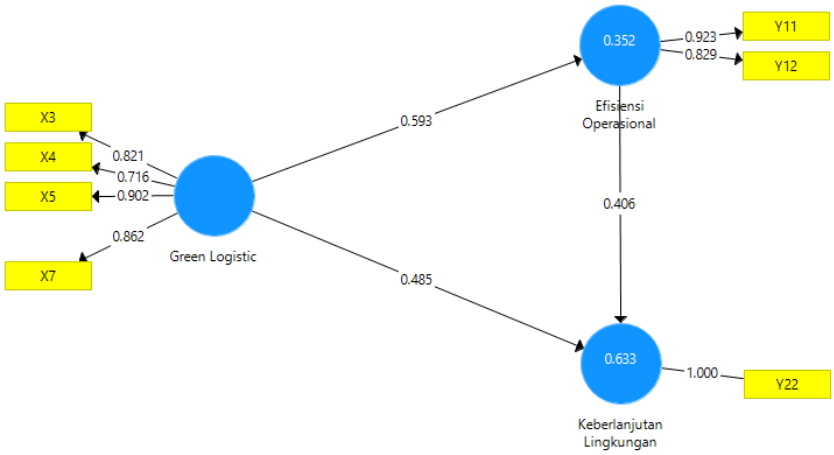
Quantitative data were analyzed through PLS-SEM, following these stages:

- Outer Model Evaluation: Includes tests for convergent validity (outer loadings > 0.7), construct reliability (CR > 0.7), average variance extracted (AVE > 0.5), and discriminant validity using HTMT ratio (< 0.85).
- Inner Model Evaluation: Assesses path coefficients, R^2 values, and the significance of relationships via bootstrapping (5,000 resamples).

3.6 Model Validation and Justification

Outer model testing indicated that certain GL indicators (such as X2 and X3 in specific groups) were removed due to low loadings, in order to improve construct reliability. All constructs achieved AVE and CR values exceeding minimum thresholds. The inner model results show R^2 values of 0.633 for Environmental Sustainability and 0.587 for Operational Efficiency, suggesting moderate to strong predictive power.

Figure 2. Model Validation and Justification



RESULT AND DISCUSSION

The evaluation of the outer model demonstrates that all indicators used in this study exhibit excellent levels of validity and reliability. All outer loading values exceed the recommended threshold of 0.7, while the Average Variance Extracted (AVE) and Composite Reliability (CR) values for all three constructs Green Logistics, Operational Efficiency, and Environmental Sustainability surpass the minimum accepted benchmarks. These results affirm that the measurement model fulfills statistical quality criteria and is suitable for further analysis of structural relationships.

Table 2. Outer Model Evaluation

Construct	Indicator	Outer Loading	Cross Loading			Construct Reliability and Validity			
			Operational Efficiency	Green Logistic	Environmental Sustainability	Cronbach's Alpha	rho_A	Composite Reliability	AVE
Green Logistics	X3	0.821	0.436	0.821	0.544	0.845	0.859	0.897	0.686
	X4	0.716	0.445	0.716	0.560				
	X5	0.902	0.452	0.902	0.555				
	X7	0.862	0.598	0.862	0.709				
Operational Efficiency	Y11	0.923	0.923	0.579	0.722	0.711	0.779	0.870	0.770
	Y12	0.829	0.829	0.446	0.456				
Environmental Sustainability	Y22	1.000	0.693	0.725	1.000	1.000	1.000	1.000	1.000

All latent constructs in the measurement model meet the statistical requirements for convergent and discriminant validity. Each indicator's outer loading exceeds 0.7, indicating strong and consistent representation of its respective construct. The cross loading analysis further confirms that every item loads highest on its designated construct, fulfilling the Fornell-Larcker criterion for discriminant validity.

From a reliability standpoint, all constructs display Cronbach's Alpha and Composite Reliability values above 0.7, reflecting strong internal consistency. Furthermore, AVE values for each construct are greater than 0.5, meaning over 50% of the variance in observed variables is accounted for by the underlying latent construct. These findings confirm that all constructs in the model are both valid and reliable for use in subsequent structural analysis.

Evaluation of the inner model reveals robust predictive validity. Green Logistics has a significant positive effect on both Operational Efficiency and Environmental Sustainability. Moreover, Operational Efficiency partially mediates the relationship between Green Logistics and sustainability outcomes. The model demonstrates a good fit (SRMR = 0.089) and high explanatory power (R^2 for Environmental Sustainability = 0.633), reinforcing the model's robustness and relevance for agricultural logistics MSMEs in Indonesia.

Table 3. Path Coefficients and Effect Sizes

Relationship	Coefficient Value	Interpretation	f^2	Effect Size Interpretation
Green Logistics → Operational Efficiency	0.593	Strong and positive influence	0.543	Large effect
Green Logistics → Environmental Sustainability	0.485	Moderate and positive influence	0.415	Large effect
Operational Efficiency → Environmental Sustainability	0.406	Moderate and positive influence	0.291	Medium effect

All three paths in the structural model exhibit positive coefficients greater than 0.4, confirming the significant contribution of Green Logistics and Operational Efficiency toward achieving sustainability in MSMEs. The substantial effect of Green Logistics on both endogenous constructs underlines its pivotal role in driving efficiency and environmental outcomes.

Table 4. R^2, Discriminant Validity, and Model Fit

Endogenous Construct	R^2	Adjusted R^2	Predictive Strength
Operational Efficiency	0.352	0.343	Moderate
Environmental Sustainability	0.633	0.623	Substantial

Construct	Green Logistics	Operational Efficiency	Environmental Sustainability
Fornell-Larcker	0.828 (AVE)	0.878	1.000
HTMT Ratio	0.741 – 0.780	< 0.85 (all)	Valid

Index	Value	Fit Threshold	Status
SRMR	0.089	< 0.10	Good
NFI	0.782	> 0.70	Acceptable
Chi-square	65.961	–	Model Accepted

The R^2 values indicate that 63.3% of the variance in Environmental Sustainability is explained by Green Logistics and Operational Efficiency, while 35.2% of the variance in Operational Efficiency is accounted for by Green Logistics alone. Discriminant validity is satisfied through both the Fornell-Larcker criterion and HTMT ratios below 0.90, confirming the conceptual uniqueness of each construct. The SRMR and NFI values indicate a well-fitting model, validating its appropriateness for further interpretation and discussion.

Table 5. Path Coefficients & Significance

Pathway	β (Original)	t-Value	p-Value	Interpretation
Green Logistics → Operational Efficiency	0.593	6.644	0.000	Significant, strong
Green Logistics →Environmental Sustainability	0.485	3.951	0.000	Significant, moderate
Efisiensi Operasional → Environmental Sustainability	0.406	3.472	0.001	Significant, moderate

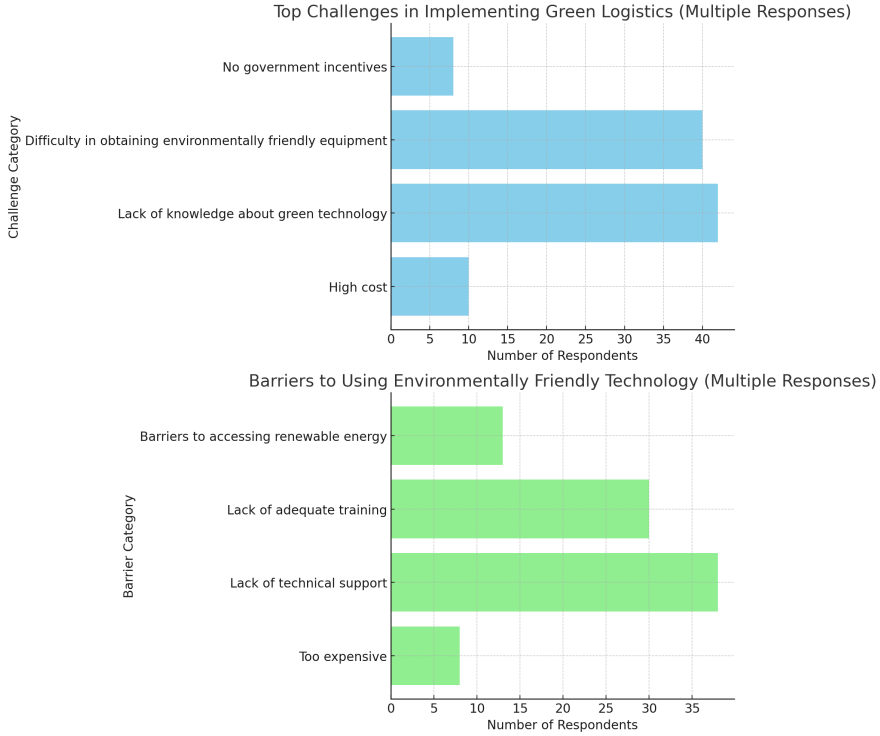
The results of the path analysis indicate that all relationships between constructs in the model are statistically significant. Green Logistics (GL) shows a strong influence on Operational Efficiency ($\beta = 0.593$, $t = 6.644$, $p < 0.001$), and a moderate yet significant effect on Environmental Sustainability ($\beta = 0.485$, $t = 3.951$, $p < 0.001$). Additionally, Operational Efficiency contributes meaningfully to Environmental Sustainability ($\beta = 0.406$, $t = 3.472$, $p = 0.001$). These findings confirm that the structural model demonstrates statistically valid relationships among the latent variables.

Tabel 6. Indirect & Total Effects

Pathway	Type	β Indirect	t-Value	p-Value	Interpretation
Green Logistics → Operational Efficiency → Environmental Sustainability	Specific Indirect	0.241	2.750	0.006	Significant mediation
Green Logistics → Environmental Sustainability	Total	0.725	10.338	0.000	Significant total effect

The indirect effect of Green Logistics on Environmental Sustainability through Operational Efficiency is also statistically significant (β = 0.241, t = 2.750, p = 0.006), indicating the presence of a partial mediation. The total effect of Green Logistics on Environmental Sustainability reaches β = 0.725 (t = 10.338, p < 0.001), highlighting that both the direct and indirect influences of GL on sustainability are substantial and significant within the context of agricultural MSMEs.

Figure 3. Visualization of Qualitative Survey Findings



The charts presented above summarize the results of multiple-response questions, where respondents could select more than one option. As such, total frequencies exceed the number of participants surveyed. The first horizontal bar chart illustrates the primary challenges in implementing Green Logistics most respondents cited limited knowledge and difficulties accessing eco-friendly equipment. The second chart highlights barriers to adopting green technology, with the majority pointing to a lack of technical support and insufficient training.

DISCUSSION

The quantitative findings demonstrate that Green Logistics (GL) has a strong influence on Operational Efficiency (β = 0.593; f^2 = 0.543) and Environmental Sustainability (β = 0.485; f^2 = 0.415). Additionally, Operational Efficiency significantly contributes to Environmental Sustainability (β = 0.406; f^2 = 0.291). High R^2 values for Environmental Sustainability (0.633) and Operational Efficiency (0.352) support the model's substantial explanatory power within the context of agricultural MSMEs.

Furthermore, the results of the path coefficient analysis confirm that all relationships between constructs in the model are statistically significant, with t-statistics values greater than 1.96 and p-values below 0.001 across all main pathways. The indirect effect of Green Logistics on sustainability through operational efficiency is also significant (β = 0.241; t = 2.750; p = 0.006), indicating a partial mediating role. Consequently, the total effect of Green Logistics on sustainability reaches β = 0.725 ($p < 0.001$), demonstrating that both direct and indirect effects are strong and substantial. These findings reinforce the Natural Resource-Based View (NRBV) framework, which articulates that sustainably managed internal efficiencies can serve as strategic advantages for micro-level enterprises (Anaman et al., 2023; Pishdar et al., 2022).

These findings regarding the critical role of digitization, waste management, and regulatory compliance in fostering supply chain efficiency for micro-enterprises are supported by the global literature, notably studies by Gao et al., 2023 and Reni et al., 2023. Specifically, indicators such as X3 (waste management), X5 (digitization), and X7 (regulatory compliance) showed substantial contributions to the structural model tested.

The qualitative findings deepen this analysis by uncovering the practical realities MSMEs face. Among 22 respondents, 42 mentioned a lack of knowledge about green technologies, and 39 cited difficulty accessing eco-friendly equipment. A respondent candidly noted, “We don’t even know what green logistics technology looks like,” (Respondent #4), indicating a stark gap in environmental literacy. Another highlighted, “Electric vehicles and solar panels are too expensive and unavailable in our village,” (Respondent #18), underscoring infrastructural and affordability constraints.

Thematic synthesis of these responses revealed:

- Knowledge and Training Gaps: Limited access to technical guidance or GL-focused education.
- Infrastructure Constraints: High costs and unavailability of green tools in rural areas.
- Policy Disconnects: Absence of incentives or institutional mechanisms to support green adoption.

These barriers are not isolated but interconnected, often compounding each other. For example, financial constraints are closely linked to poor access to training and equipment.

The discovery that Operational Efficiency serves as a partial mediator underscores the strategic importance of internal transformation. Process optimization through digital systems, targeted training, and better equipment emerges as a viable path toward environmental goals. This reinforces NRBV’s core thesis that organizational capabilities, when shaped sustainably, can be leveraged for strategic advantage (Hart, 1995). However, this study also builds upon NRBV by showing that environmental capabilities in MSMEs are not solely endogenous; they are shaped by exogenous institutional, infrastructural, and policy-related constraints.

This research thus contributes to a more contextualized NRBV one that accounts for the realities of microenterprises in rural areas of the Global South. The application of Green Supply Chain Management (GSCM) further validates that practices like certification, waste handling, and eco-material usage can drive both performance and sustainability (Novitasari, 2023; Zhu, 2008).

CONCLUSION

This study examined the extent to which Green Logistics (GL) influences Operational Efficiency and Environmental Sustainability among agricultural logistics MSMEs in Sukabumi, Indonesia. It also explored real-world constraints that affect the practical adoption of green practices. The mixed method approach combining SEM-PLS analysis with qualitative insights produced the following key findings: Green Logistics significantly improves Operational Efficiency ($\beta = 0.593$; $f^2 = 0.543$), suggesting that field-based practices such as waste management, digitalization, and workforce training can enhance distribution speed and reduce logistics costs, Green Logistics also has a positive effect on Environmental Sustainability ($\beta = 0.485$; $f^2 = 0.415$), confirming that eco-conscious logistics can reduce environmental impact while strengthening sustainable business behavior, Operational Efficiency functions as a partial mediator ($\beta = 0.406$; $f^2 = 0.291$), validating the NRBV assumption that strategically managed internal capabilities especially when shaped through local practices—serve as enablers of long-term sustainability and Qualitative data reveal deep-rooted barriers, including low environmental literacy (42 responses), inaccessible green technologies (39), lack of technical support (38), and limited training opportunities (30). These reflect a structural disconnect between green policy frameworks and MSME capacities, particularly in rural areas. In sum, this research achieves its goals by addressing both the theoretical and empirical dimensions of GL implementation. It contributes to the evolving application of NRBV in microenterprise contexts by demonstrating that sustainability capabilities are shaped not only internally, but also by institutional and infrastructural realities. By validating locally adapted GL indicators and providing a grounded analysis of MSME challenges, the study offers a robust foundation for policy and scholarly efforts to promote sustainable logistics in the Global South.

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