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Research Paper

Environmental Cost and Biological Asset Management under Carbon Tax: AHP Study of Agribusiness MSMEs in East Java, Indonesia

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Abstract

The implementation of carbon taxation in Indonesia under Law No. 7 of 2021 poses both regulatory compliance challenges and operational opportunities for Micro, Small, and Medium Enterprises (MSMEs) in the agribusiness sector. Although agribusiness activities generate environmental waste, they also involve managing biological assets, including living plants and animals, which may contribute to carbon sequestration. However, agribusiness MSMEs struggle to prioritize environmental cost allocations and to account for biological assets in accordance with applicable financial reporting standards, particularly SAK EMKM and PSAK 69. This study aims to establish a priority hierarchy for managing environmental costs and biological assets to strengthen MSMEs' preparedness for carbon taxation. A quantitative-evaluative approach was employed using the Analytic Hierarchy Process (AHP). Empirical data were collected from eight experts, including academic researchers, agribusiness owners, tax practitioners, and environmental officials. The findings indicate that Tax Regulatory Compliance (41.2%) is the highest-priority decision criterion, followed by Financial Cost Efficiency (28.5%). At the strategic alternative level, Optimizing Biological Asset Accounting and Valuation ranks first, with a global priority weight of 40.15%, followed by Green Technology Transformation (28.27%), Tax Compliance Partnerships (17.96%), and Eco-Label Certification (13.62%). The overall Consistency Ratio (CR = 0.0263) indicates an acceptable level of consistency in the aggregated expert judgments. These findings provide an empirically informed decision hierarchy to support agribusiness MSMEs in integrating environmental cost management, biological asset accounting, and regulatory compliance into their carbon-tax preparedness strategies.

Keywords: *Agribusiness MSMEs, Analytic Hierarchy Process, Biological Assets, Carbon Taxation, Environmental Costs*

INTRODUCTION

Indonesia's commitment to reducing greenhouse gas emissions has led to the enactment of Law No. 7 of 2021 on the Harmonization of Tax Regulations (UU HPP) (Ministry of Finance, 2021), which introduces a carbon tax framework. For carbon-intensive energy industries, the ripple effects of carbon taxation inevitably extend across supply chains, affecting Micro, Small, and Medium Enterprises (MSMEs), particularly in the agribusiness sector. Agribusiness MSMEs operate under a dual ecological paradigm: their operations generate organic waste, livestock methane, and energy-related emissions, yet their core production drivers consist of biological assets, living animals and plants, that possess intrinsic carbon sequestration capacity (Putra et al., 2026). Environmental costs have become increasingly important alongside growing international attention to greenhouse gas emissions reduction and the implementation of environmental economic instruments (Abidin et al., 2026).

Carbon taxation is one mechanism for internalizing the environmental externalities associated with carbon emissions. For agribusiness MSMEs, changes in taxation systems may influence operational decisions and create additional administrative challenges in managing business activities (Bhalla et al., 2023). Tax understanding is an important factor in MSME tax

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compliance behavior, indicating that knowledge of taxation can influence how MSMEs respond to tax-related obligations (Lestary et al., 2021). Tax socialization also contributes to MSME compliance by improving taxpayers' awareness and understanding of applicable taxation requirements. Changes in taxation systems may provide potential benefits for MSMEs while simultaneously creating additional administrative burdens that require managerial adaptation (Widjaja, 2024). However, the existing literature on MSME taxation predominantly addresses compliance, tax understanding, and administrative responses rather than the strategic prioritization of environmental cost management. This limitation is particularly important for agribusiness MSMEs because their operational activities involve resource utilization, energy consumption, production decisions, and the management of biological assets. Furthermore, the existing literature provides limited evidence on how carbon-related regulatory pressures can be translated into strategic priorities for environmental cost and biological asset management among agribusiness MSMEs.

The gap is therefore not limited to tax compliance but also extends to the absence of an integrated decision-making perspective that links carbon-tax preparedness, environmental cost management, and biological asset management. In this context, the Analytical Hierarchy Process (AHP) offers a structured approach for evaluating multiple criteria and prioritizing alternative management strategies based on expert judgments. Accordingly, this study focuses on identifying the relative priorities of environmental cost and biological asset management strategies for carbon-tax preparedness among agribusiness MSMEs in East Java, Indonesia. Given this research gap, the research question is formulated as follows: What are the relative priorities of environmental cost and biological asset management strategies for carbon-tax preparedness among agribusiness MSMEs in East Java, Indonesia?

The Analytic Hierarchy Process (AHP) provides a relevant and systematic multi-criteria decision-making (MCDM) approach for addressing the complexity of sustainability-related decisions, particularly when multiple criteria, competing priorities, and diverse stakeholder perspectives must be considered simultaneously. Environmental decision-making frequently involves multidimensional considerations, including regulatory compliance, financial feasibility, technological readiness, environmental performance, operational efficiency, and social responsibility. These dimensions are often interdependent and may involve conflicting objectives, making it difficult for decision-makers to establish priorities using conventional evaluation methods based solely on financial or operational indicators. In this regard, AHP offers a structured analytical framework that enables complex decision-making problems to be decomposed into a hierarchy consisting of the overall objective, main criteria, sub-criteria, and available alternatives. This hierarchical decomposition facilitates a more systematic understanding of the decision problem by identifying the relative contribution of each decision element toward achieving the overarching objective.

AHP has also demonstrated its relevance in environmental management and sustainability-oriented strategic planning. In the context of decarbonization, Raman et al. (2025) applied an AHP-based prioritization approach to incorporate environmental and social dimensions into the evaluation of alternative decarbonization strategies. This application illustrates the importance of considering multiple sustainability dimensions rather than relying exclusively on emission reduction or technological performance as the primary decision parameters. Similarly, Malmasi et al. (2010) demonstrated the relevance of AHP in prioritizing ecological impacts associated with industrial pollution management. These applications indicate that AHP can support environmental decision-making by transforming multidimensional sustainability considerations into a structured hierarchy of measurable priorities. Its methodological flexibility makes it applicable across organizational and industrial contexts, particularly where environmental objectives must be balanced against economic, technological, institutional, and operational constraints.

In the context of sustainable waste management and agribusiness micro, small, and medium enterprises (MSMEs), AHP provides an analytical foundation for identifying and prioritizing strategic interventions that integrate environmental responsibility with financial and operational considerations. The complexity of this context arises from the need to consider regulatory compliance, green technology transformation, waste utilization, environmental expenditures, financial accountability, and organizational capabilities simultaneously. These considerations cannot be adequately addressed through a single-dimensional evaluation because the effectiveness of sustainability strategies depends on the interaction among institutional requirements, technological investments, financial resources, and operational implementation. By applying AHP, expert judgments can be systematically translated into relative priority weights, enabling researchers to identify which strategic dimensions exert the greatest influence on sustainability-oriented decision-making. Consequently, AHP not only facilitates the ranking of competing criteria but also provides a transparent basis for allocating organizational attention and resources toward the most influential strategic priorities.

Prior literature on environmental taxation has heavily emphasized large corporate entities and heavy industrial sectors, leaving a noticeable research gap regarding strategic priorities for small-scale agricultural enterprises facing carbon regulation. Existing studies frequently rely on regression models to test causal impacts but fail to provide an actionable decision-making hierarchy for resource-constrained business owners. Therefore, this study aims to evaluate and establish a multi-criteria priority hierarchy for environmental cost management and biological asset accounting in Indonesian agribusiness MSMEs using the Analytic Hierarchy Process (AHP). By synthesizing expert judgments, this paper contributes a practical framework for MSME managers and tax policymakers to balance environmental sustainability with tax compliance.

LITERATURE REVIEW

Stakeholder Theory posits that an organization's long-term viability depends on its ability to satisfy the expectations of diverse stakeholders, including government regulators, local communities, and consumers. For agribusiness MSMEs, carbon taxation requires aligning operations with environmental mandates to maintain market access and regulatory goodwill (Freeman, 1984/2010). These stakeholders include government regulators, local communities, customers, suppliers, employees, financial institutions, and other business partners. Within the context of agribusiness micro, small, and medium enterprises (MSMEs), stakeholder expectations increasingly extend beyond conventional financial performance to include environmental responsibility, responsible resource utilization, waste management, and transparency in environmental reporting. Complementarily, Legitimacy Theory suggests that businesses continuously seek to ensure that their operations operate within the bounds and norms of their respective societies. Proper environmental cost management and transparent reporting of biological assets allow MSMEs to establish environmental legitimacy, thereby reducing regulatory scrutiny and potential tax liabilities (Deegan, 2019). Environmental cost management and transparent biological asset reporting can function as mechanisms for strengthening environmental legitimacy. By systematically recording environmental expenditures, documenting waste treatment activities, and disclosing relevant information concerning biological resources, enterprises can demonstrate that environmental considerations have been incorporated into their management systems.

Carbon taxation is a market-based fiscal instrument that internalizes the negative externalities of greenhouse gas emissions, grounded in the "Polluter Pays Principle." Environmental Cost Accounting involves identifying, allocating, and analyzing internal and external environmental expenses. For MSMEs, environmental costs include waste treatment, pollution prevention, and

investments in sustainable technology. Rather than viewing these costs solely as an immediate drain on cash flows, modern management accounting frames them as strategic allocations that can reduce future tax burdens and operational risks (Wijaya & Hermawan, 2023). Carbon taxation establishes an important conceptual link among environmental regulation, organizational cost management, and strategic investment decisions. For agribusiness MSMEs, the ability to identify environmental costs and evaluate alternative mitigation strategies may contribute to greater financial preparedness and improved environmental performance.

Biological assets, defined as living animals or plants, undergo biological transformation through growth, degeneration, production, and procreation. Under PSAK 69 and SAK EMKM guidelines, proper recognition and valuation of biological assets allow enterprises to reflect the economic value of their living resources (Ikatan Akuntan Indonesia [IAI], 2018, 2020). In an era of carbon pricing, well-documented biological assets such as timber, perennial crops, and livestock can provide relevant information about production resources and potential carbon-sequestration activities. Accounting treatment, however, should be distinguished from any separate legal recognition of carbon credits or tax offsets, which depends on applicable carbon-market and tax regulations. The relevance of biological asset accounting extends beyond conventional financial reporting because agricultural resources may also have environmental significance. Living plants, particularly timber plantations and perennial crops, can contribute to carbon sequestration by absorbing and storing atmospheric carbon dioxide. Similarly, sustainable agricultural and forestry practices may support biodiversity conservation, soil protection, and ecosystem restoration. Consequently, biological assets may provide relevant information for understanding the relationship between productive agricultural resources and environmental sustainability (Putra et al., 2025).

RESEARCH METHOD

This study employed a quantitative-evaluative research approach, using the Analytic Hierarchy Process (AHP) as the primary multi-criteria decision-making (MCDM) method. AHP, developed by Thomas L. Saaty, provides a systematic framework for decomposing complex decision-making problems into hierarchical structures and determining the relative importance of competing criteria and strategic alternatives through pairwise comparisons (Saaty, 2008). AHP was selected for its ability to integrate expert knowledge, professional judgment, and multidimensional evaluation into a quantitative prioritization framework. This approach is particularly relevant to sustainability-oriented decision-making because environmental cost management, biological asset accounting, carbon taxation, and operational feasibility involve interconnected dimensions that cannot be adequately evaluated by a single financial or environmental indicator. Accordingly, AHP was adopted to identify the relative priorities of strategic interventions for environmental cost and biological asset management among agribusiness micro, small, and medium enterprises (MSMEs) operating under the emerging challenges of carbon taxation.

The research was designed within the context of agribusiness MSMEs in East Java, Indonesia, with the stated research period extending from January to May 2026. East Java was selected as the geographical research context because of the relevance of its agribusiness activities, MSME development, agricultural resource utilization, and environmental management challenges. The research focused on identifying strategic priorities that could support the integration of financial efficiency, tax regulatory compliance, environmental preservation, and operational feasibility. Rather than measuring direct causal relationships between organizational variables, this study concentrated on evaluating expert judgments regarding the relative importance of decision criteria and alternative strategies. Therefore, the resulting priority weights represent the collective prioritization of the expert panel within the defined decision-making framework.

A purposive sampling technique was used to select eight domain experts with specialized knowledge in tax policy, agricultural accounting, and MSME operations. The expert panel comprised:

1. Academic Researchers in Environmental Accounting & Taxation (n=2)
2. Agribusiness MSME Owner-Managers (n=3)
3. Tax Consultants specializing in MSME Compliance (n=2)
4. Environmental Local Government Official (n=1)
5. AHP Hierarchical Structure

The decision model was structured into three levels. The goal was to determine the optimal strategic priority for environmental cost and biological asset management in agribusiness MSMEs facing carbon taxation. Criteria level: K1 Financial Cost Efficiency; K2 Tax Regulatory Compliance; K3 Environmental Preservation & Emission Reduction; K4 Operational Feasibility. Alternative strategies level: A1 Green Technology Transformation & Waste Management; A2 Optimization of Biological Asset Accounting & Valuation; A3 Allocation Efficiency for Eco-Label Certification & Prevention Costs; A4 Strategic Partnerships & Carbon Tax Compliance Education. Data collection and mathematical analysis were conducted using structured pairwise comparison questionnaires based on Saaty's 1–9 fundamental scale. Mathematical syntheses were computed to calculate priority weights and verify judgment consistency. The Consistency Index (CI) and Consistency Ratio (CR) were computed as follows, where max represents the maximum Eigenvalue, n is the matrix size (n=4), and RI is the Random Index (RI=0.90 for n=4). A judgment matrix is considered acceptable if CR<0.10 (10%).

Research respondents were selected using a purposive sampling technique, enabling the researchers to identify individuals with relevant expertise, professional experience, and specialized knowledge aligned with the research objectives. This approach was appropriate because AHP requires informed judgments from individuals who understand the substantive characteristics of the decision problem. Unlike conventional quantitative surveys that generally emphasize statistical representativeness, expert-based AHP prioritization emphasizes the relevance and quality of respondents' knowledge in evaluating the relative importance of decision elements. Consequently, experts were selected based on their professional backgrounds and familiarity with taxation, environmental accounting, agribusiness operations, and sustainable waste management.

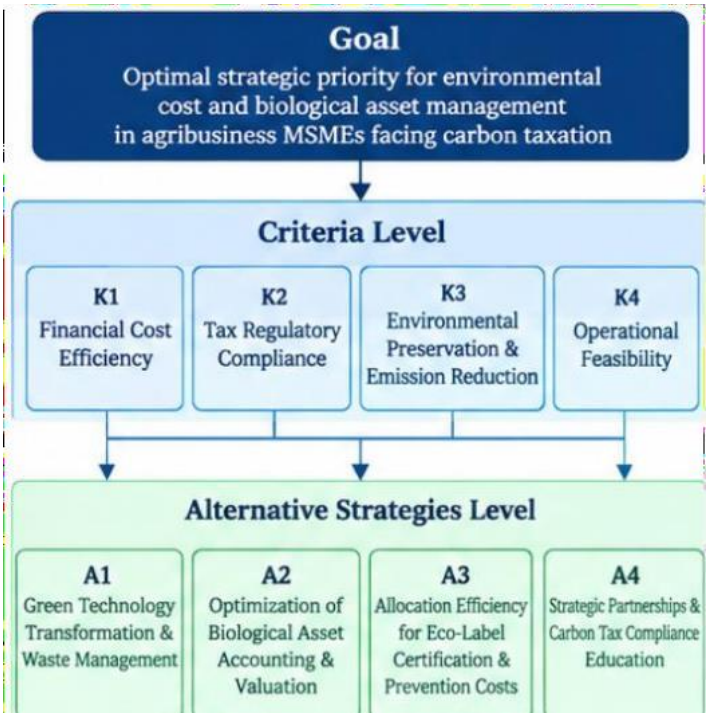


Figure 1. Research Framework

FINDINGS AND DISCUSSION

Criteria Weighting Results

The pairwise comparison results for the four main decision criteria indicate that Tax Regulatory Compliance (K2) is the highest-priority criterion in the expert decision-making process, with a normalized priority weight of 0.412 (41.2%). This finding underscores the central role of regulatory compliance in evaluating strategic alternatives for agribusiness MSMEs under carbon taxation. The relatively high weight suggests that experts regard compliance with applicable tax regulations, statutory obligations, and government policies as essential to assessing the feasibility and appropriateness of strategic decisions. Regulatory compliance is therefore not merely an administrative obligation but also an important determinant of organizational accountability, operational legitimacy, and long-term business sustainability.

The dominance of Tax Regulatory Compliance (K2) indicates that regulatory considerations strongly shape the feasibility and acceptability of strategic decisions. In particular, alternatives that minimize regulatory risks, mitigate potential tax liabilities, and strengthen compliance with applicable requirements are likely to receive greater priority. This finding underscores the importance of integrating regulatory considerations into strategic planning from the outset, rather than addressing them only after strategic alternatives have been selected. Accordingly, the priority weight of 0.412 establishes Tax Regulatory Compliance as the leading decision criterion, while Financial Cost Efficiency (K1), Environmental Preservation (K3), and Operational Feasibility (K4) provide complementary considerations for achieving balanced, accountable, and sustainable decision-making outcomes.

Table 1. Pairwise Comparison Matrix and Priority Weights for Criteria

Criteria	K1	K2	K3	K4	Eigenvalue (wj)	Priority (%)
K1 (Financial Cost Efficiency)	1.000	0.500	2.000	2.000	0.285	28.5%
K2 (Tax Regulatory Compliance)	2.000	1.000	2.000	3.000	0.412	41.2%
K3 (Environmental Preservation)	0.500	0.500	1.000	2.000	0.183	18.3%
K4 (Operational Feasibility)	0.500	0.333	0.500	1.000	0.120	12.0%
Total	4.000	2.333	5.500	8.000	1.000	100.0%

Source: Primary Data Processed (2026)

Table 1 consistency follows the formulas by:

$$\boldsymbol{CI = \frac{\lambda_{max} - n}{n - 1}}$$

$$\boldsymbol{CR = \frac{CI}{RI}}$$

With:
$\boldsymbol{\lambda_{max}}$ = eigenvalue maximum of the pairwise comparison matrix
$\boldsymbol{n}$ = number of criteria, which is 4
$\boldsymbol{CI}$ = Consistency Index
$\boldsymbol{RI}$ = Random Index
$\boldsymbol{CR}$ = Consistency Ratio

Using the given matrix and the eigenvector method:

$$\boldsymbol{\lambda \approx 4.0710}$$

$$\boldsymbol{CI = \frac{4.0710 - 4}{4 - 1} \approx 0.02367}$$

With $\boldsymbol{RI}$ = 0.90 for a 4 x 4 matrix:

$$\boldsymbol{CR = \frac{0.02367}{0.90} \approx 0.0263}$$

An AHP pairwise comparison matrix was developed based on assessments from eight experts. The experts evaluated the relative importance of the four criteria using Saaty's fundamental scale, ranging from 1 to 9, with reciprocal values for opposite comparisons. The matrix was constructed according to the actual procedure used to obtain the final expert assessments. The aggregation procedure was explicitly separated from the subsequent calculation of priority weights. Priority weights were derived from the pairwise comparison matrix using the principal eigenvector method and normalized to sum to one. The matrix's consistency was evaluated using the Consistency Index (CI) and Consistency Ratio (CR). The final matrix, priority weights, and consistency results were checked to ensure that the reported findings were consistent with the

underlying expert assessments.

Consistency verification produced λmax=4.0710, CI=0.02367, RI=0.90, and CR=0.0263. Because CR is 0.10, the criteria weights satisfy the consistency threshold. If the eight experts provided individual judgments that were subsequently aggregated using the geometric mean, the resulting aggregated values would generally not be exact Saaty-scale values, such as 0.500, 2.000, or 3.000. When the eight experts provide different judgments, the aggregated results may produce decimal values such as 1.682, 2.236, or other non-integer values. The pairwise comparison matrix uses the following values based on Saaty's fundamental scale:

- 1 = Equal importance
- 2 = Slightly more important
- 3 = Moderately more important
- 0.5 = Reciprocal of 2
- 0.333 = Reciprocal of 3

Table 2. Final Global Priority Weights for Strategic Alternatives

Alternative Strategies	K1 (28.5%)	K2 (41.2%)	K3 (18.3%)	K4 (12.0%)	Global Weight	Percentage
A1 – Green Tech & Waste Management	0.312	0.221	0.402	0.243	0.2827	28.27%
A2 – Biological Asset Accounting	0.448	0.422	0.320	0.345	0.4015	40.15%
A3 – Eco-Label Certification Costs	0.120	0.123	0.162	0.181	0.1362	13.62%
A4 – Tax Partnerships & Education	0.120	0.234	0.116	0.231	0.1796	17.96%
Total					**1.0000**	**100.00%**

Source: Primary Data Processed (2026)

The AHP synthesis ranks Biological Asset Accounting (A2) as the top alternative, with a global priority weight of 40.15%, followed by Green Technology and Waste Management (A1) at 28.27%, Tax Partnerships and Education (A4) at 17.96%, and Eco-Label Certification Costs (A3) at 13.62%. These results are based on judgments from eight experts collected between January and May 2026. Accordingly, the ranking reflects the aggregated expert assessments within the established decision hierarchy. The dominance of A2 indicates that biological asset accounting is viewed by the participating experts as a particularly important strategic consideration for agribusiness MSMEs. This finding underscores the need to improve financial measurement, recognition, and reporting practices for biological assets to support more accountable and informed business decisions. Meanwhile, the relatively high priority assigned to A1 highlights the importance of integrating green technology and waste management into operational and environmental strategies. A4 and A3 represent complementary considerations, emphasizing the role of tax partnerships, education, and the financial implications of eco-label certification. Findings should be interpreted within the scope of the eight participating experts and the specified decision hierarchy. The reliability of the AHP results depends on the transparency of the expert judgment aggregation procedure, the completeness of the pairwise comparison matrices, and the consistency of the individual and

aggregated assessments. Therefore, consistency testing and sensitivity analysis are important for assessing the robustness of the resulting priority weights and their implications for the strategic priorities of agribusiness MSMEs.

Discussion

AHP results indicate that Tax Regulatory Compliance (K2) received the highest priority weight among the evaluation criteria, at 41.2%. This finding indicates that regulatory preparedness is the primary concern for agribusiness MSMEs when evaluating strategies for environmental cost and biological asset management under an emerging carbon-tax context. The prominence of K2 is consistent with broader discussions of the implementation and administrative challenges associated with carbon taxation in Indonesia. Margono et al. (2022) and Tjoanto & Tambunan (2022) highlight the importance of regulatory clarity, implementation capacity, and administrative preparedness in developing carbon-related fiscal policies. At the alternative-strategy level, Optimization of Biological Asset Accounting and Valuation (A2) obtained the highest priority weight, at 38.56%. This finding suggests that improving the quality and systematic management of biological-asset information is a central strategic response for agribusiness MSMEs. Systematic accounting records can increase the visibility of productive biological assets. Reducing carbon-related liability would require an explicit legal and regulatory basis. This distinction is important because accounting recognition and taxation operate under different institutional purposes and rules. Investment in accounting information quality, while simultaneously indicating the need for regulatory clarity concerning how environmental and biological-asset information may be recognized for taxation purposes.

Comparison results indicate that Green Technology Transformation and Waste Management (A1) ranks second among the evaluated strategic criteria, with a priority weight of 0.2827 (28.27%). This finding demonstrates that transforming production technologies and implementing effective waste management practices constitute a substantial dimension of the experts' strategic decision-making framework. Although its relative importance remains below the information and accounting dimension represented by A2, the weight assigned to A1 indicates that physical environmental interventions continue to play a significant role in determining the feasibility and sustainability of organizational transformation. In particular, the result suggests that experts recognize the importance of translating environmental commitments into tangible operational practices through technological innovation, resource efficiency, waste reduction, and the development of value-added products derived from residual materials. Thus, green technology transformation is not simply considered an environmental responsibility but also a strategic mechanism for improving operational performance, strengthening resource productivity, and supporting the long-term competitiveness of agribusiness micro, small, and medium enterprises (MSMEs).

From an operational perspective, green technology transformation in agribusiness MSMEs encompasses various technological interventions aimed at minimizing environmental impacts while improving the efficiency of production processes. These interventions may include converting organic waste into biogas, producing compost and organic fertilizers, implementing environmentally friendly processing technologies, improving energy efficiency, and optimizing the use of water and other production resources. Such initiatives are particularly relevant to agribusiness MSMEs because their production activities frequently generate organic residues and other forms of waste that, when inadequately managed, can increase environmental burdens and create additional operational costs. Through the application of appropriate green technologies, these residual materials can be transformed into economically valuable resources, thereby supporting the development of circular production systems. A consistent environmental

expenditure can contribute to operational efficiency when investments in environmental improvements reduce waste generation, resource consumption, and production-related costs (Wijaya & Hermawan, 2023). Accordingly, environmental investments should not be evaluated solely on their initial financial requirements but also on their potential to generate long-term economic benefits through improved production efficiency and resource utilization.

Green technologies increasingly require digital capabilities for monitoring resource consumption, documenting environmental performance, managing production data, and supporting successful transformation (Rupeika-Apoga & Petrovska, 2022; Setiawan et al., 2025). Consequently, green technology transformation should be approached as an integrated organizational process rather than as an isolated purchase of environmentally friendly equipment. Implementing green technology transformation requires more than the availability of environmentally friendly equipment. It also involves developing organizational capabilities, technological knowledge, managerial competencies, and information management systems that enable enterprises to operate and evaluate environmental technologies effectively. The integration of digital capabilities is particularly important because green technology implementation increasingly depends on accurate information on resource consumption, energy use, waste generation, and environmental performance. Digital systems can facilitate monitoring of production activities, document environmental expenditures, record waste management processes, and provide measurable indicators for evaluating the effectiveness of environmental investments. In this regard, digitalization functions as an enabling mechanism that connects physical environmental interventions with organizational decision-making and performance evaluation. The relevance of digital capabilities in supporting organizational transformation and technological adaptation is increasing. These perspectives suggest that the effectiveness of green technology adoption is closely associated with an organization's ability to integrate technological infrastructure with information processing, operational coordination, and performance monitoring.

In addition, the adoption of green technologies among agribusiness MSMEs is shaped by both external institutional pressures and internal organizational conditions. Regulatory pressure, partnerships, government support, environmental awareness, technological assistance, and switching costs can jointly shape the adoption of green practices (Hamdani et al., 2024). Regulatory requirements can encourage enterprises to improve waste treatment processes and comply with environmental standards, while government incentives and technical assistance can reduce the financial and knowledge-related barriers to technological adoption. Similarly, partnerships with suppliers, customers, agricultural institutions, waste management organizations, and other business actors can facilitate access to technology, technical expertise, and alternative markets for recycled or processed materials. Nevertheless, the availability of external support does not automatically guarantee successful implementation. Enterprises must also possess sufficient internal resources, financial flexibility, technological readiness, and operational capabilities to ensure that adopted technologies are compatible with their business characteristics. Green transformation is more feasible when the technology is compatible with the firm's financial and operational capabilities (Raj et al., 2024). The appropriateness of green technology should be assessed not only in terms of its environmental benefits but also in relation to investment affordability, maintenance requirements, production capacity, technological complexity, and the expected economic returns.

From a strategic sustainability perspective, the 28.27% priority weight further indicates that green technology transformation and waste management should be positioned as an integral component of organizational development rather than as an isolated environmental initiative. This is particularly important for agribusiness MSMEs operating within interconnected supply chains,

where environmental performance is increasingly tied to supplier requirements, customer expectations, regulatory compliance, and the competitiveness of sustainable products. Transforming waste into reusable resources can create additional economic value, strengthen relationships among supply chain actors, and support the establishment of circular economy practices. For example, organic waste generated by agribusiness enterprises can be processed into compost or organic fertilizers and supplied to agricultural producers, while other recoverable materials can be directed to recycling partners or industrial users. Such arrangements create opportunities to establish resource exchange relationships between waste generators and downstream business partners, transforming waste management from a cost-oriented activity into a potential source of economic value creation.

Moreover, the relationship between green technology transformation and financial sustainability should be considered in terms of both short-term operational implications and long-term organizational benefits. Although the adoption of green technologies may initially require substantial capital expenditure, technical training, infrastructure adjustments, and additional operating resources, these investments can generate efficiency gains by reducing material losses, lowering energy consumption, improving production processes, and better utilizing previously underused resources. Consequently, the economic contribution of green technology should be evaluated through a comprehensive assessment of environmental expenditures, operational cost savings, productivity improvements, and the potential to create additional revenue streams. This integrated perspective is particularly relevant for MSMEs, which frequently face financial constraints and must carefully balance environmental investment requirements with their immediate operational needs. The strategic challenge, therefore, is to identify technological alternatives that deliver measurable environmental improvements while remaining economically feasible and operationally sustainable.

Overall, the AHP priority weight of 0.2827 (28.27%) confirms that Green Technology Transformation and Waste Management (A1) is a major strategic consideration for achieving sustainable business transformation among agribusiness MSMEs. This result reinforces the argument that environmental sustainability requires integrating technological innovation, resource efficiency, digital monitoring, organizational readiness, and circular resource utilization. Although the criterion ranks below the information and accounting dimension represented by A2, its relatively substantial priority weight shows that developing information systems and financial accountability must ultimately translate into concrete environmental improvements at the operational level. Therefore, green technology transformation should be conceptualized as an integrated organizational process involving technological investment, managerial adaptation, institutional collaboration, and continuous environmental performance evaluation. Such an approach enables agribusiness MSMEs to move beyond symbolic environmental commitments toward measurable sustainability outcomes, while strengthening operational efficiency, economic resilience, and their contribution to the development of a circular and environmentally responsible business ecosystem.

Tax incentives and supportive fiscal policies can encourage MSMEs to invest in innovation, while simplified regulations and tax education can reduce the administrative barriers to compliance (Saptono et al., 2024). This relationship is particularly relevant to the present AHP results because K2 was the dominant criterion, while A1 represented a major strategic alternative. Accounting information and physical environmental action should be treated as complementary rather than competing strategies. A2 provides the information foundation through the systematic identification, recording, and valuation of biological assets, while A1 addresses environmental performance through waste reduction, resource efficiency, and cleaner technology. Better information supports better environmental decisions, and environmental improvements generate

more meaningful operational and environmental information. Allocation Efficiency for Eco-Label Certification and Prevention Costs (A3) and Strategic Partnerships and Carbon Tax Compliance Education (A4) can therefore be viewed as complementary mechanisms. Certification may strengthen market recognition and provide incentives for environmentally responsible production, whereas partnerships and compliance education can provide technical knowledge, regulatory interpretation, and access to external resources.

Align with the broader policy discussion on the implementation and administrative challenges of carbon taxation in Indonesia (Margono et al., 2022; Tjoanto & Tambunan, 2022). Green Technology Transformation (A1=28.27%) ranked second. Converting organic waste into biogas or organic fertilizers can shift environmental expenditure toward productive resource use while reducing waste management and energy costs. This finding supports the strategic view of environmental expenditure as part of operational efficiency rather than merely a disposal expense (Wijaya & Hermawan, 2023). Taken together, these results suggest that MSME preparedness requires both improved information systems and physical environmental action. Accounting systems can provide traceable records of biological assets and environmental expenditures, while green technologies can reduce waste and resource consumption. Strategic partnerships and environmental certification remain complementary mechanisms, particularly where MSMEs need external technical assistance or market recognition.

From a Stakeholder Theory perspective, the 28.27% weight assigned to A1 can be interpreted as indicating the strategic importance of responding to the expectations of actors connected to the agribusiness value chain. Agribusiness MSMEs do not operate independently of their external environment; rather, their business continuity and market opportunities are influenced by relationships with suppliers, customers, agricultural producers, government institutions, financial institutions, and local communities. These stakeholders may increasingly expect businesses to demonstrate responsible resource utilization, minimize waste generation, adopt environmentally appropriate production technologies, and comply with relevant environmental requirements. This expectation is explained by Legitimacy Theory, particularly the need for agribusiness MSMEs to maintain the social acceptance of their business activities. Environmental initiatives can serve as organizational responses to societal expectations concerning pollution prevention, waste reduction, and responsible resource utilization. However, legitimacy should not be achieved merely through environmental declarations, promotional activities, or symbolic commitments. It requires the implementation of substantive operational practices that demonstrate observable environmental responsibility. The analysis identifies regulatory pressures, customer requirements, and internal resource capabilities as important drivers and constraints influencing the adoption of environmental management practices. The present findings therefore support the argument that technological transformation must be aligned with the financial and operational capacities of MSMEs rather than pursued as an isolated environmental investment.

CONCLUSIONS

Research presents an AHP-driven assessment of strategic priorities to strengthen environmental cost management and biological asset management in agribusiness MSMEs in East Java, Indonesia, particularly in anticipation of emerging carbon taxation policies. The assessment reveals a clear hierarchy among the proposed strategic interventions. Biological Asset Accounting emerges as the most significant alternative, accounting for 40.15% of the overall priority weight. It is followed by Green Technology and Waste Management (28.27%), Tax Partnerships and Education (17.96%), and Eco-Label Certification Costs (13.62%). At the evaluation criteria level, Tax Regulatory Compliance ranks first, with a relative weight of 41.2%. This distribution

underscores the substantial influence of regulatory considerations on strategic decision-making. More importantly, the results demonstrate that strengthening the accounting treatment of biological assets is a central organizational priority, while technological improvements, waste management initiatives, and institutional collaboration serve as complementary mechanisms for enhancing environmental and regulatory readiness.

From a theoretical perspective, the study advances strategic environmental accounting by integrating biological asset accounting, environmental cost management, and carbon-tax preparedness into a single multi-criteria decision framework. Rather than treating environmental accounting merely as a mechanism for recording environmental expenditures or fulfilling reporting obligations, this research emphasizes its strategic role in guiding resource allocation and organizational responses to regulatory developments. Identifying Biological Asset Accounting as the leading alternative also underscores the importance of reliable accounting information for supporting sustainability-oriented decisions within agribusiness enterprises. In methodological terms, the application of AHP demonstrates how multidimensional considerations across financial, environmental, operational, and regulatory aspects can be structured into a coherent priority-setting process. Consequently, the proposed framework offers an additional perspective for examining strategic preparedness among MSMEs facing increasingly complex sustainability requirements.

In managerial practice, the findings suggest that agribusiness MSMEs should begin by strengthening the quality of their biological asset information. This involves developing more reliable procedures for asset identification, physical inventory, categorization, documentation, and valuation. These improvements can provide a stronger accounting foundation for monitoring agricultural resources and supporting future sustainability-related reporting. Investment in environmentally efficient technologies and improved waste-processing systems should subsequently complement these accounting improvements. Institutional cooperation also deserves attention, particularly through engagement with tax authorities, agricultural extension agencies, professional associations, and educational institutions to facilitate access to regulatory information and technical assistance. These recommendations should nevertheless be interpreted in light of the AHP methodology: the resulting percentages reflect relative strategic preferences derived from expert assessments rather than actual investment returns, realized environmental benefits, or demonstrated effects of carbon-tax enforcement. They are valuable for determining whether improvements in biological asset accounting and environmental cost management translate into observable changes in financial performance, operational efficiency, environmental outcomes, and preparedness for carbon-related regulatory requirements.

LIMITATION & FURTHER RESEARCH

Study Limitation and Future Research should be interpreted within the methodological boundaries of the study because the reported AHP judgments are based on the expert-judgment structure used in the present analysis and do not constitute an estimate of the causal impact of carbon taxation. Future research should therefore validate the proposed hierarchy using actual field-based expert judgments and a larger and geographically broader panel of agribusiness MSMEs and relevant stakeholders. Future studies should also conduct sensitivity analysis to examine whether changes in criterion weights alter the ranking of strategic alternatives. In addition, subsequent research should distinguish between financial-reporting recognition of biological assets and environmental costs and the separate legal requirements governing carbon credits, carbon offsets, tax incentives, and carbon-tax obligations. Comparative studies across regions and agribusiness sectors could further examine whether the priority structure identified in East Java remains consistent under different institutional, regulatory, and operational conditions.

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