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Original Article

Understanding the Adoption of Green Technologies by Indonesian Micro and Small Enterprises: A Qualitative Study on Triple Bottom Line Practices

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Abstract. Micro and small enterprises (MSEs) dominate Indonesia's business population, yet their transition toward environmentally responsible production remains uneven because sustainability decisions are made under severe resource, capability, and market constraints. This study investigates how Indonesian MSE owners perceive, adopt, and operationalize green technologies and how these practices are translated into triple bottom line outcomes. An exploratory qualitative design was applied through semi-structured interviews with 12 MSE owners in food processing, handicraft, and retail-related sectors in Mataram and surrounding Lombok districts. Field observations and business documents were used for triangulation, and thematic analysis was conducted to identify adoption drivers, barriers, stakeholder support mechanisms, and perceived sustainability outcomes. The findings show that green technology adoption is primarily triggered by cost reduction, market differentiation, customer pressure, and external facilitation, while adoption is constrained by upfront investment, maintenance uncertainty, weak technical knowledge, and fragmented policy support. Although adoption remains incremental, it contributes to profit through lower operating costs, to people through safer and more skill-intensive work routines, and to planet through waste reduction and more efficient resource use. The study extends green innovation and sustainable entrepreneurship literature by showing how resource-constrained MSEs build informal but meaningful sustainability pathways through stakeholder-supported, practice-based adoption.

Keywords: Green Technology, Green Innovation, Sustainable Entrepreneurship, Triple Bottom Line, Micro And Small Enterprises.

1. Introduction

Micro and small enterprises (MSEs) are central to Indonesia's economic structure because they represent the overwhelming majority of business units and absorb a substantial share of employment [1]. Their collective environmental footprint is therefore significant even when each individual enterprise operates at a small scale. Waste generation, inefficient energy use, packaging dependence, water consumption, and low access to cleaner production technologies make MSE sustainability a strategic issue for both local development and national environmental governance. Green technology adoption in small firms cannot be interpreted merely as the purchase of environmentally friendly equipment. In the MSE context, it includes low-cost process changes, renewable energy applications, resource-efficient machinery, waste sorting, recycling, eco-friendly packaging, digital tools that reduce material use, and operational routines that lower environmental impacts [2]. Studies on eco-innovation show that small enterprises adopt different types of environmental innovation depending on cost pressure, market demand, knowledge access, and collaboration opportunities [3].

The theoretical relevance of green technology adoption is linked to sustainable entrepreneurship, which examines how entrepreneurial action can create economic value while also addressing social and environmental challenges [4]. From a resource-based perspective, environmentally oriented capabilities may become strategic assets when they reduce waste, support differentiation, or improve legitimacy in markets that increasingly value sustainability [5]. This view is reinforced by the argument that

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environmental improvement can support competitiveness when firms learn to redesign processes, reduce inefficiencies, and discover new value propositions [6].

The triple bottom line (TBL) framework provides a useful lens for evaluating such adoption because it requires attention to profit, people, and planet outcomes rather than financial performance alone [7]. In entrepreneurship research, this multidimensional lens is important because sustainable development-oriented firms often combine commercial logic with social and ecological value creation [8]. However, the way MSEs operationalize TBL is rarely formal; it is often embedded in everyday business routines, owner values, community expectations, and pragmatic responses to cost or market pressure. Recent studies in Indonesia and other emerging economies have strengthened understanding of green innovation in small firms, but much of the evidence remains survey-based and determinant-oriented. Lestari and Sunyoto showed that green innovation in Indonesian small enterprises is shaped by external pressure, internal capabilities, management commitment, and sustainability performance goals [9]. Indrawati et al. found that technological, organizational, and environmental factors influence green innovation adoption among Indonesian SMEs, with organizational factors playing a decisive role [10]. These findings are important, but they leave open questions about how owners narrate adoption decisions, how barriers are negotiated in practice, and how TBL outcomes are recognized in daily operations.

International SME research also suggests that sustainability outcomes require more than environmental intention. Munoz-Pascual et al. demonstrated that the TBL pillars can shape sustainable product innovation performance, while technology adoption models explain how perceived usefulness, social influence, and enabling conditions affect adoption decisions [11]. In small firms, these mechanisms must also be understood through the technology-organization-environment logic and diffusion processes because adoption depends on organizational readiness and external support [12]. Accordingly, this study asks three research questions: (1) How do Indonesian MSE owners perceive and adopt green technologies? (2) What drivers and barriers shape adoption decisions? (3) How does green technology adoption contribute to profit, people, and planet outcomes? The study contributes by providing a qualitative explanation of green technology adoption as an incremental, stakeholder-supported, and capability-building process among resource-constrained MSEs.

2. Literature Review

2.1 Green Technology Adoption in MSEs

Technology adoption in small firms is shaped by the interaction between the attributes of the innovation, organizational readiness, and the external environment. The technology-organization-environment framework is relevant because MSEs rarely make adoption decisions on technical grounds alone; they also consider affordability, employee skills, maintenance capacity, supplier reliability, and institutional support [13]. Diffusion theory adds that adoption is more likely when an innovation is perceived as advantageous, compatible with existing routines, simple to trial, and visible in its benefits [14]. For green technologies, adoption is often motivated by resource efficiency and market positioning rather than environmental concern alone. Evidence from process eco-innovation shows that firms are encouraged by competitive pressure, operational savings, and performance expectations [15]. A broad review of eco-innovation drivers further indicates that regulation, customer pressure, managerial commitment, and knowledge networks jointly influence adoption [16].

2.2 Sustainable Entrepreneurship and Green Innovation

Green innovation research links sustainability with product, process, and business model change. Dangelico and Pujari emphasized that environmental sustainability can be integrated into product innovation through energy minimization, material reduction, and pollution prevention [17]. Later research showed that green product innovation is increasingly viewed as a strategic capability rather than a peripheral environmental activity [18]. At the business model level, sustainability-oriented innovation requires firms to redesign how they create, deliver, and capture value. Sustainable business model archetypes highlight efficiency, circularity, stewardship, and social value as routes toward more sustainable value creation [19]. Business model research also shows that sustainable innovation requires alignment between value proposition, stakeholder relationships, and revenue mechanisms [20].

2.3 Triple Bottom Line in Small Enterprises

The TBL framework is attractive for MSE analysis because small firms often experience sustainability as a combined economic, social, and environmental challenge. Unlike large corporations, MSEs rarely have dedicated sustainability departments or formal reporting systems. Sustainability practices are often owner-led, informal, and shaped by local relationships, which makes qualitative inquiry important for understanding the meaning of adoption [21]. Small business CSR research similarly shows that owner values and community legitimacy strongly influence responsible business behavior [22]. Environmental responsiveness literature suggests that firms go green for multiple reasons, including competitiveness, legitimation, and ecological responsibility [23]. In MSEs, these motivations may overlap. Green technology may be adopted to reduce electricity bills, meet customer expectations, satisfy local government programs, or align with the owner's personal values. The empirical challenge is to understand how such motives become operational practices.

2.4 Capability Constraints and Resource-Based Explanations

Resource-based theory explains why green technology adoption is uneven among firms facing similar environmental pressures. Firms with valuable and difficult-to-imitate resources are more likely to turn sustainability practices into competitive advantage [24]. Dynamic capability theory further argues that firms must sense opportunities, seize them, and reconfigure internal routines as technologies and markets change [25]. In small enterprises, these capabilities are often informal and owner-dependent rather than systematically managed [26]. Empirical evidence from China indicates that eco-innovation can improve performance when internal capabilities and external pressures are aligned [27]. Research on environmental innovation also shows that innovation is influenced by regulation, technological opportunity, market demand, and organizational learning [28]. These insights frame the present study's expectation that MSE adoption depends on the fit between perceived benefits, available capabilities, and external support.

3. Method

3.1 Research Design and Context

This study used an exploratory qualitative design because the research problem concerns meanings, decision processes, and contextual practices rather than hypothesis testing. Case-oriented qualitative inquiry is appropriate when the objective is to understand how and why a phenomenon occurs in real-life settings [29]. The study focused on MSEs in Mataram and surrounding Lombok districts that had adopted or were in the process of adopting at least one green technology or sustainability-oriented operational practice. Green technology was defined broadly as any product, equipment, process, or operational routine that reduced energy use, material consumption, waste, emissions, or harmful environmental impacts. This definition allowed the study to include both hardware-based adoption, such as energy-efficient equipment, and routine-based adoption, such as waste separation and recyclable packaging.

3.2 Participants and Sampling

Purposive sampling was used to select MSE owners who could provide direct accounts of green technology adoption. The final sample consisted of 12 enterprises from food processing, handicraft, and retail-related sectors. Participants were selected based on three criteria: micro or small business classification, evidence of at least one green technology or sustainability-oriented practice, and willingness to participate in interviews and follow-up clarification. Table 1 summarizes the sample profile and indicates the types of green technology practices represented in the study.

Table 1. Profile of participating MSEs

Sector	Number of MSEs	Typical green practice	Observed business rationale
Food processing	5	Energy-efficient equipment, waste sorting, reduced plastic packaging	Lower electricity costs, cleaner production, customer trust
Handicraft	4	Recycled materials, natural dyes, reusable packaging	Product differentiation and market reputation
Retail and services	3	LED lighting, paperless promotion, reusable shopping materials	Cost saving, brand image, operational convenience

3.3 Data Collection

Data were collected through semi-structured interviews, field observations, and supporting business documents. Interviews were conducted between January and March 2025 and lasted approximately 45-90 minutes. Guiding questions explored the initial decision to adopt green technology, perceived benefits, barriers, financial implications, employee effects, environmental outcomes, and the role of government, universities, NGOs, suppliers, and customers.

Field observations were used to verify the presence of reported practices, such as packaging changes, recycling routines, energy-efficient equipment, and waste handling. Secondary materials, including product labels, social media content, brochures, and informal operational records, were reviewed where available to support triangulation.

3.4 Data Analysis and Trustworthiness

Data were analyzed using thematic analysis. The analysis followed familiarization, initial coding, theme searching, theme review, theme definition, and reporting [30]. The coding process combined inductive coding from participant narratives with sensitizing concepts from green innovation, adoption theory, and the TBL framework. Qualitative rigor was strengthened through iterative coding comparison and transparent theme development [31].

The sample size was considered adequate because the interviews produced repeated patterns across drivers, barriers, TBL outcomes, and stakeholder support. Qualitative sampling literature shows that saturation can occur within relatively small samples when the research scope is focused and participants are information-rich [32]. Credibility was strengthened through triangulation, member checking, an audit trail, and thick description, consistent with qualitative trustworthiness criteria [33].

4. Result and Discussion

4.1 Result

Motivations for adoption, barriers and capability gaps, integration into TBL practices, and stakeholder collaboration. Table 2 presents the thematic structure and representative evidence from the interviews.

Table 2. Thematic structure of green technology adoption

Theme	Core meaning	Representative evidence	Analytical interpretation
Motivations and drivers	Adoption is triggered by cost saving, reputation, and customer expectations.	"Customers now ask whether our packaging is recyclable" (R3).	Green technology is framed as both efficiency improvement and market differentiation.
Barriers and capability gaps	Upfront costs and weak technical knowledge delay adoption.	"The machine price was too high without subsidies" (R2).	Adoption depends on external finance, maintenance knowledge, and confidence in use.
TBL integration	Adoption creates economic, social, and environmental effects.	"Electricity bills went down by 30 percent" (R5).	Benefits are recognized informally through daily business outcomes rather than formal reporting.
Stakeholder collaboration	Government, universities, NGOs, suppliers, and students support adoption.	"Students helped us design eco-friendly packaging" (R1).	External actors reduce knowledge and resource constraints for MSEs.

4.1.1 Motivations and Drivers of Adoption

Participants described green technology adoption as a pragmatic response to cost pressure and market expectations. Rising electricity costs, packaging concerns, and waste handling problems encouraged owners to seek operational changes. In food processing enterprises, energy-efficient machinery and waste sorting were valued because they directly affected daily expenses. In handicraft enterprises, recycled materials and eco-friendly packaging were used to strengthen product identity. These findings align with green supply chain and operational sustainability studies showing that environmental practices become attractive when they improve operational efficiency and market legitimacy [34]. They also support evidence that environmental improvement can generate economic returns when it reduces waste, saves energy, or improves differentiation [35].

4.1.2 Barriers and Capability Gaps

Despite positive attitudes, participants faced substantial barriers. The most frequently mentioned constraint was the high upfront cost of equipment. Several owners also expressed uncertainty about maintenance, spare parts, supplier reliability, and whether employees could operate new tools safely. These concerns were especially strong among micro enterprises with unstable cash flow. Knowledge barriers were equally important. Some owners had heard about solar panels, recycling machines, or energy-efficient equipment but did not understand technical specifications, payback periods, or maintenance risks. As a result, adoption was often delayed until an external actor provided training, demonstration, or financial assistance.

4.1.3 Integration into Triple Bottom Line Practices

Green technology adoption influenced the three TBL dimensions, but the outcomes were usually informal and practice-based. Profit outcomes appeared through lower electricity costs, reduced packaging expenses, and improved customer appeal. People outcomes were reported through safer equipment, cleaner workspaces, new employee skills, and stronger customer trust. Planet outcomes appeared through waste reduction, reduced plastic use, paperless promotion, and more efficient energy use. The findings are consistent with circular economy research, which emphasizes resource efficiency, reuse, and waste reduction as pathways to sustainability [36]. They also reflect the view that circular practices require operational translation, not merely conceptual commitment [37].

4.1.4 Stakeholder Collaboration

External stakeholders played a decisive role in adoption. Government grants enabled equipment purchase, universities supported packaging design and knowledge transfer, NGOs introduced recycling practices, and suppliers provided technical explanations. Participants rarely described adoption as a fully independent decision; instead, adoption emerged through interaction with actors who lowered risk or provided missing knowledge. This collaborative pattern is important because resource-constrained enterprises often need inter-organizational support to convert environmental intention into practice. SME circular economy research similarly shows that small firms benefit from networks that provide knowledge, finance, and legitimacy [38]. The Indonesian digital SME literature also suggests that owners' learning roles and external support can reinforce innovation capability in small enterprises [39].

4.2 Discussion

4.2.1 Green Technology Adoption as Pragmatic Sustainability

The findings show that Indonesian MSE owners adopt green technologies primarily when sustainability becomes operationally useful. Rather than beginning with a formal environmental strategy, owners usually start from a concrete business pressure: high energy cost, customer complaints about packaging, waste accumulation, workplace safety, or the need to create a distinctive product identity. This explains why adoption is incremental. Owners rarely move directly toward comprehensive environmental management; they begin with small changes that are visible, affordable, and compatible with existing routines. This pattern is consistent with diffusion theory because adoption becomes more likely when the innovation is perceived as advantageous and manageable within current business conditions. Theoretically, this result suggests that green technology adoption among MSEs should not be judged against the formal sustainability systems used by large firms. MSEs are not simply smaller versions of corporations; they operate with different resource bases, managerial structures, and risk tolerances. The practices observed in this study are informal but not insignificant. Energy-efficient equipment, recyclable packaging, paperless marketing, and waste sorting may appear modest when assessed individually, yet they represent meaningful transitions when interpreted within the constraints of micro and small business operations.

Compared with prior Indonesian survey evidence, this study provides a practice-level explanation of why organizational factors matter. Indrawati et al. reported that organizational factors are dominant determinants of green innovation adoption among Indonesian SMEs, but survey-based findings cannot fully show how owners interpret organizational readiness. The present study shows that readiness is not only about formal resources; it is about owner confidence, employee adaptability, supplier support, and the ability to test a technology without threatening business continuity. This means that green adoption programs should focus not only on promoting technology but also on reducing perceived operational risk.

4.2.2 Economic Logic and the Profit Dimension

The profit dimension was the most visible entry point into green technology adoption. Participants repeatedly connected adoption with lower operating costs, reduced waste, or improved market image. The strongest quantitative signal in the interviews was the statement from one participant that electricity bills decreased by approximately 30 percent after switching to energy-efficient machinery. Although this figure is self-reported and should not be generalized statistically, it provides a concrete indication of how owners translate green technology into business value. For MSEs with thin margins, even modest reductions in electricity, packaging, or material waste can influence survival and reinvestment capacity. This finding supports the Porter hypothesis logic that environmental improvement may reveal inefficiencies and create competitiveness when firms redesign processes. However, the evidence also shows that this relationship is conditional. Green technology does not automatically create profit; it creates profit when the technology fits the production process, when maintenance is manageable, and when customers recognize or reward the environmental improvement. The observed 30 percent bill reduction in one case therefore functions as an illustrative outcome rather than a universal effect. Compared with process eco-innovation studies, the findings confirm that cost-saving motivations are especially strong for process-related changes. Triguero et al. found that cost-saving factors are closely linked to process eco-innovation among SMEs, while market share factors matter more for product and organizational eco-innovation. The present study extends that insight qualitatively: food-processing MSEs emphasized energy and material savings, while handicraft businesses emphasized product identity and reputational differentiation. This sectoral variation indicates that green technology policy should avoid one-size-fits-all instruments.

4.2.3 Social Outcomes and the People Dimension

The people dimension appeared through safer work routines, improved employee comfort, skill development, and stronger relationships with customers and community actors. Participants did not use formal social performance indicators, but they recognized that cleaner equipment, safer packaging processes, and better waste handling improved the quality of daily work. This finding is important because TBL implementation in MSEs is often dismissed as weak when it lacks formal reporting. The evidence here suggests that social value may be embedded in everyday routines rather than expressed through formal sustainability metrics. The social dimension also reflects learning. Employees had to learn how to operate energy-efficient machines, sort waste, manage new packaging materials, or communicate green product attributes to customers. This learning process is part of adoption. If employees do not understand the technology, owners perceive adoption as risky. Therefore, training is not an additional policy accessory; it is a core adoption mechanism. This supports dynamic capability theory because green technology requires reconfiguration of routines, not simply acquisition of equipment. Compared with sustainable entrepreneurship literature, the findings show that entrepreneurial will is necessary but insufficient. Owners may be willing to adopt greener practices, but employee capability, supplier explanations, and customer acceptance determine whether adoption becomes stable. This explains why stakeholder collaboration emerged as a major theme. Universities, NGOs, and local government programs functioned as bridges between owner intention and organizational capability.

4.2.4 Environmental Outcomes and the Planet Dimension

The planet dimension was visible in reduced waste, lower plastic use, recycled materials, and more efficient energy consumption. These outcomes were not measured with laboratory precision, but they were consistently described by participants and supported by observations. The absence of formal measurement is a limitation, yet it also reflects the reality of MSE sustainability practice. Most participating businesses did not calculate emissions, lifecycle impacts, or formal waste reduction percentages. Instead, they evaluated environmental improvement through observable reductions in waste volume, lower electricity bills, cleaner work areas, and positive customer responses. This finding has two implications. First, MSE-focused sustainability policy should provide simple measurement tools. If owners can track electricity use, packaging reduction, or waste diversion using simple templates, environmental benefits become more visible and easier to communicate. Second, researchers should develop methods that combine qualitative insight with light quantitative monitoring. A future mixed-methods design could measure before-and-after electricity use, packaging volume, or monthly waste disposal while still capturing owner narratives. The circular economy literature helps explain why these small practices matter. Waste sorting, recyclable packaging, reuse of materials, and paperless promotion are not isolated gestures; they are early forms of circular behavior. However, they remain fragile without supporting infrastructure such as recycling markets, supplier networks, local collection systems, and consumer education. Thus, MSE green technology adoption should be viewed as part of a local sustainability ecosystem rather than as an individual firm decision alone.

4.2.5 Stakeholder Support as an Adoption Infrastructure

One of the clearest contributions of the study is the finding that stakeholder collaboration operates as adoption infrastructure. Government grants reduced financial barriers, universities provided design and technical assistance, NGOs introduced sustainability routines, and suppliers helped explain equipment. These forms of support did not merely encourage adoption; they made adoption possible. Without such support, participants often remained interested but inactive. This finding qualifies technology adoption theory in the MSE context. Perceived usefulness and perceived ease of use are important, but for resource-constrained enterprises they are shaped by external actors. A technology becomes easier to use when a university provides a demonstration, when suppliers offer maintenance guidance, or when a government program reduces upfront cost. Adoption is therefore distributed across a network of actors rather than located only inside the firm. Compared with prior eco-innovation studies, the finding supports the role of collaboration but adds a stronger qualitative explanation. Collaboration is not only a knowledge channel; it reduces uncertainty, legitimizes experimentation, and allows owners to adopt without bearing all risks alone [40]. This is particularly important in Lombok, where many MSEs operate through local relationships and informal knowledge exchange. Green technology programs should therefore be designed as relational interventions involving training, demonstration, mentoring, financing, and follow-up maintenance support.

5. Conclusion

This study examined how Indonesian MSEs adopt green technologies and how adoption contributes to triple bottom line practices. The findings show that adoption is driven by cost reduction, market differentiation, customer expectations, and external facilitation. However, adoption remains constrained by upfront investment, limited technical knowledge, maintenance uncertainty, and fragmented policy support. The study concludes that green technology adoption among MSEs is best understood as pragmatic sustainability. Owners adopt practices that are affordable, visible, and compatible with daily business routines. These practices contribute to profit through efficiency and market differentiation, to people through safer and more skill-intensive work routines, and to planet through reduced waste and more efficient resource use. The study has limitations. It involved 12 MSEs in Mataram and surrounding Lombok districts, so the findings should not be generalized statistically to all Indonesian MSEs. The environmental and financial outcomes were based largely on participant accounts and observation rather than longitudinal measurement. Future research should combine qualitative interviews with before-and-after monitoring of electricity use, waste volume, packaging reduction, and sales changes to provide stronger quantitative evidence.

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7. Declaration

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