

Green Knowledge, Green Business Practices, and Sustainability Performance in Indonesian Batik SMEs: The Mediating Role of Green Commitment

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Abstract

This study examines green knowledge, conceptualized as green human capital within the intellectual capital framework, and green business practices as correlates of sustainability performance among batik small and medium enterprises (SMEs) in Indonesia, with green commitment as a mediating variable. Its purpose is to clarify how an environmentally oriented intangible resource and operational green practices are associated with sustainability outcomes in an emerging-market setting. Using a quantitative, cross-sectional design, survey responses were gathered from 386 owners and managers of batik SMEs located in Pekalongan, Yogyakarta, and Cirebon, Indonesia. Partial Least Squares Structural Equation Modeling (PLS-SEM) was applied to assess the associations among green knowledge, green business practices, green commitment, and sustainability performance. The results show that green knowledge and green business practices are both positively and significantly associated with sustainability performance, with coefficients of similar magnitude. Green commitment is also positively associated with sustainability performance and partially mediates the relationships of green knowledge and green business practices with that outcome; the indirect effects are significant but modest relative to the direct effects. The study contributes to intellectual capital and sustainability scholarship by specifying green knowledge as green human capital that combines codified environmental information with firm-specific, experience-based know-how; by distinguishing resources, practices, commitment, and performance within one model; and by specifying the organizational mechanisms through which green commitment links knowledge and practices to sustainability performance in a traditional, culturally rooted industry. Because the data are cross-sectional, the relationships are interpreted as associations rather than causal effects.

Keywords: *Green Knowledge; Green Human Capital; Intellectual Capital; Green Business Practices; Green Commitment; Sustainability Performance; Batik SMEs*

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INTRODUCTION

Mounting global sustainability pressures have pushed environmental concerns from the margins of corporate agendas to the center of strategic decision-making, as firms seek to weave environmental considerations into their strategies in order to secure competitive advantage and remain viable over the long run (Abdelfattah et al., 2025; Thun et al., 2024). Small and medium-sized enterprises (SMEs) are widely acknowledged as a major engine of economic growth in both developed and developing countries (Rodríguez-Carrillo et al., 2025). They represent a substantial share of business establishments (Odei & Hamplová, 2022), output (Garrido-Prada et al., 2024), and GDP (Szabó et al., 2024); estimates suggest SMEs make up more than 90% of firms worldwide, generate 50-60% of value-added in OECD economies (Al Qudah et al., 2024), and account for roughly 55% of GDP in developed economies (Aslam, 2026).

SMEs frequently encounter serious obstacles when trying to adopt sustainable practices, among them scarce financial resources (Adomako & Ahsan, 2022), limited technological capacity (Nuryakin & Qamari, 2026), and insufficient managerial expertise (Merín-Rodríguez et al., 2025). Against this backdrop, intangible resources (Ahmad-Fauzi & Saad, 2024), and knowledge-based assets in particular (Korayim et al., 2025), take on growing importance for enabling a transition toward sustainability.

Batik enterprises make a meaningful contribution to local employment and income, notably in production hubs such as Pekalongan, Yogyakarta, and Cirebon (Al-shami et al., 2024; Supadmi Irianti et al., 2025). Yet despite their cultural and economic value, batik manufacturing, especially the dyeing and washing stages, generates significant environmental burdens (Lovely et al., 2025), including wastewater contamination and chemical residues (Kusumawati et al., 2021). Heightened regulatory oversight together with growing consumer demand for sustainable products has made environmentally responsible practices increasingly necessary in this sector (Daud et al., 2022; Nisa et al., 2025).

A body of prior work has emphasized how green business practices and environmental management contribute to improved sustainability performance (Kosasih et al., 2023; Mitra, 2022; Reyes-Rodríguez, 2021). Much of this literature, however, centers on large manufacturers equipped with formal environmental systems and structured governance (Zaman et al., 2025). Empirical work addressing sustainability among traditional, family-run SMEs in emerging markets remains comparatively scarce (Isensee et al., 2020; Karuppiyah et al., 2024). Furthermore, although green knowledge is widely acknowledged as a driver of environmental innovation and competitive advantage (Achmad & Wiratmadja, 2025; Dahri et al., 2025; Hanaysha et al., 2025), relatively little attention has been paid to framing it as a dimension of intellectual capital within sustainability frameworks (Neves et al., 2025; Zaman et al., 2025).

According to intellectual capital theory, intangible assets, including knowledge, capabilities, and organizational commitment, are central determinants of firm performance (Baxter & Matear, 2004; Dang & Wang, 2022; Zhang et al., 2024). Viewed through this lens, green knowledge can be understood as a strategic environmental resource (Bhatnagar et al., 2026; Cabral & Dhar, 2019; Khan et al., 2023). In this study, it is

positioned specifically as green human capital: the environmental knowledge held by owner-managers and key personnel, which becomes valuable when it is applied in decision-making and embedded in production routines. Knowledge by itself, however, is not necessarily reflected in stronger sustainability performance (Padthar & Ketkaew, 2024; Wang & Zhang, 2025); this also requires organizational mechanisms capable of internalizing environmental values and sustaining consistent implementation (Alabdali et al., 2025; Heim et al., 2026; Juicharoen et al., 2025). Green commitment, defined as the organization's dedication to and prioritization of environmental objectives, may consequently serve as a mechanism connecting green knowledge and green practices with performance outcomes (Azhar et al., 2025; Sharma et al., 2021; Villar & Guevara, 2025).

Even with rising scholarly attention to sustainability and intellectual capital, few studies have brought green knowledge, green business practices, green commitment, and sustainability performance together within one integrated framework, particularly for traditional creative industries operating in emerging economies (Dauerer, 2025; Khizar et al., 2025; Kyambade et al., 2025; Tahir et al., 2024). This gap is particularly pertinent to Indonesia's batik SMEs, where owner values, informal organizational structures, and resource limitations often drive business decisions. How environmental knowledge and green practices relate to sustainability performance through internal commitment mechanisms therefore remains an open theoretical and practical question.

This study accordingly examines green knowledge, positioned as green human capital, and green business practices, positioned as operational environmental practices, as correlates of sustainability performance in Indonesian batik SMEs, with green commitment functioning as a mediating variable. Green business practices are treated as a co-equal predictor, because the model is designed to examine a knowledge-based resource and an operational practice side by side within the same commitment mechanism. Applying Partial Least Squares Structural Equation Modeling (PLS-SEM) to survey data gathered from batik SME owners and managers, the research aims to generate empirical evidence on the structural relationships linking these constructs.

This study makes three contributions to the literature. First, it refines the application of intellectual capital theory in sustainability research by locating green knowledge precisely as green human capital and by distinguishing firm-specific, experience-based environmental knowledge from publicly available environmental information. Second, it adds to the sustainability performance literature by separating resources (green knowledge), practices (green business practices), commitment (green commitment), and outcomes (sustainability performance) within one model, and by specifying the organizational mechanisms, namely resource allocation, policy consistency, employee participation, and investment continuity, through which green commitment links knowledge and practices to performance. Third, it offers empirical evidence drawn from a traditional creative industry operating in an emerging economy, yielding context-specific insights of value to policymakers and SME managers alike.

LITERATURE REVIEW

Theoretical Foundation: Intellectual Capital Theory, RBV, and NRBV

This study draws on three complementary perspectives, each used to explain a different element of the model. Intellectual capital theory holds that a firm's value rests substantially on intangible assets, conventionally classified into human capital (the knowledge, skills, and experience of individuals), structural capital (knowledge embedded in routines, procedures, and systems), and relational capital (knowledge embedded in relationships with external stakeholders) (Radjenovic & Krstic, 2017; Yang et al., 2026; Yuksel, 2024). Its environmental extension, green intellectual capital, applies the same three-part structure to environmental knowledge and capabilities (Chen, 2008; Dang & Wang, 2022; Nguyen-Van et al., 2025). Within this structure, the present study positions green knowledge as green human capital, that is, the environmental knowledge possessed by owner-managers and key personnel. This choice follows from the unit of measurement: the construct is reported by owners and managers and captures what they know and how they apply that knowledge. Green knowledge is therefore not modeled as a higher-order green intellectual capital construct, nor as green structural or relational capital, although knowledge sharing and integration into decision-making are the processes through which green human capital gradually becomes embedded in organizational routines.

The Resource-Based View (RBV) explains why such knowledge may matter for performance: resources that are valuable, rare, difficult to imitate, and non-substitutable can support sustained advantage (Ahn et al., 2022; Barney, 1991). Not all environmental knowledge meets these criteria. Information about environmental regulations, cleaner production techniques, and eco-friendly dyes is increasingly codified and publicly available through government programs, industry associations, and suppliers, so it is neither rare nor inimitable in itself. What can be firm-specific is the experience-based knowledge that develops when this information is applied in a particular workshop, such as tacit know-how about natural-dye recipes and mordanting, about adjusting wax, dye, and water use to reduce waste, about managing wastewater under local conditions, and about sourcing through established supplier and community relationships. Such knowledge is path-dependent and embedded in experience and routines, and is therefore harder to transfer or imitate (Ahn et al., 2022; Münch et al., 2022). The RBV argument in this study applies to this firm-specific component rather than to general environmental awareness.

The Natural Resource-Based View (NRBV) extends the RBV by arguing that capabilities for pollution prevention, waste reduction, and product stewardship underpin both environmental and economic performance (Domfeh et al., 2025; Hart, 1995). From this perspective, green business practices are not intellectual capital but operational routines and capabilities, that is, the observable activities through which a firm acts on its environmental resources. Finally, organizational commitment theory (Djunaedi et al., 2024; Meyer & Allen, 1991) explains how dedication to organizational goals shapes the consistency of behavior

over time. Together, these perspectives support a model in which green knowledge is a resource (green human capital), green business practices are operational practices and capabilities (NRBV), green commitment is an organizational orientation that governs how consistently resources and practices are deployed (commitment theory), and sustainability performance is the outcome. This distinction is maintained throughout the study.

Sustainability Performance

Sustainability performance is commonly conceptualized as the comprehensive measurement of an organization's outcomes relative to sustainable development goals, spanning environmental, social, and economic dimensions (Kurniawati et al., 2022; Zhou & Xu, 2024). Within the SME context, it denotes the achievement of integrated outcomes across these dimensions while accounting for stakeholder interests (Alwakid & Dahri, 2025; Opoku et al., 2023). For batik SMEs, whose principal sustainability challenge lies in the environmental burden of production, the present study operationalizes sustainability performance with an emphasis on environmental and product-related operational outcomes, that is, on results achieved rather than activities undertaken. Five outcome indicators are used: (1) product innovation outcomes, the extent to which new or improved products and processes that support sustainability goals have been achieved (Kurniawati et al., 2022; Zhang et al., 2022); (2) improvement in product quality with respect to durability, safety, and reduced environmental impact (Nusraningrum et al., 2025; Somwethee et al., 2023; Zhou & Xu, 2024); (3) achieved reduction in waste generated during production and operations (Opoku et al., 2023; Zhou & Xu, 2024); (4) achieved reduction in the use of raw materials harmful to health or the environment (Zhou & Xu, 2024); and (5) reduction in environmental risk, such as pollution incidents and regulatory non-compliance (Jung & Kim, 2023; Opoku et al., 2023; Zhou & Xu, 2024). Product innovation and quality outcomes partly reflect the economic dimension because they relate to market competitiveness, whereas waste, material, and risk reduction reflect environmental outcomes. The construct does not include direct financial indicators (e.g., sales growth or profitability) or social indicators (e.g., employee welfare or community relations). It is therefore interpreted in this study as environmental operational sustainability performance, and this narrower scope is acknowledged as a limitation in Section 6.1.

Green Knowledge

Intellectual capital theory (Radjenovic & Krstic, 2017) highlights intangible resources as the principal drivers of competitive advantage and sustained organizational performance. In contrast to tangible assets, intellectual capital is embedded in knowledge (Abbas et al., 2026), capabilities (Lu et al., 2026), and organizational culture (Nguyen-Van et al., 2025), and is typically classified into human capital (Sulistyanto et al., 2025; Yuksel, 2024), structural capital (Yang et al., 2026), and relational capital. As explained in Section 2.1, the present study locates green knowledge within the human capital component, as green human capital.

Green knowledge is understood as awareness and understanding of the facts, concepts, and relationships that govern the natural environment and the broader ecosystem, encompassing both objective and subjective dimensions (Kumar et al., 2026; Tudu & Mishra, 2025). Its indicators in this study are: (1) environmental preservation, whereby green knowledge raises environmental literacy and shapes protective behavior toward the environment (Maldonado Bonilla et al., 2024; Tudu & Mishra, 2025); (2) collaboration and knowledge-sharing for sustainability, meaning regular interaction among organizational members to discuss environmental developments and exchange knowledge via email, training, and workshops (Kim et al., 2023; Sulistyanto et al., 2025; Yu et al., 2022); (3) integration of environmental considerations into decision-making (Kirchner-Krath et al., 2024; Lei et al., 2023); and (4) knowledge relating to the adoption of sustainable technologies and processes (Jadayil et al., 2026; Wang & Zhang, 2024). The first indicator captures awareness, whereas the remaining three capture how knowledge is shared and applied, which is where firm-specific, experience-based knowledge is most likely to be expressed.

Green knowledge (GK) and green innovation (GI) are repeatedly found to be positively associated with sustainability performance among SMEs. Several studies document that green knowledge is positively related to multiple dimensions of SME sustainability performance (Achmad & Wiratmadja, 2025; He et al., 2022; Hossain et al., 2025). Among manufacturing SMEs specifically, environmental knowledge has been shown to predict both perceived behavioral control and green employee behavior, both of which in turn support sustainability outcomes (Galván-Mendoza et al., 2022).

Within a sustainability lens, green knowledge reflects the extent to which owner-managers comprehend environmental regulations, eco-friendly technologies, sustainable resource management practices, and the ecological consequences of their production activities. Such knowledge enables organizations to identify environmental risks, pursue cleaner production methods, and respond proactively to stakeholder expectations.

For SMEs in emerging economies, where access to advanced technology and capital may be constrained, knowledge-based capabilities take on particular importance. In traditional sectors such as batik-making, environmental improvement tends to hinge more on managerial awareness and organizational learning than on major technological investment. Green knowledge can therefore be understood as green human capital that strengthens a firm's sustainability capabilities, particularly where general environmental information has been translated into workshop-specific know-how.

Earlier empirical research points to a positive relationship between environmental knowledge and both environmental innovation and firm performance (Achmad & Wiratmadja, 2025; He et al., 2022; Hossain et al., 2025), yet relatively few studies explicitly position green knowledge as intellectual capital in the context of traditional SMEs (Neves et al., 2025; Zaman et al., 2025). Drawing on intellectual capital theory and the RBV, green knowledge is expected to be directly and positively associated with sustainability performance, because owner-managers who understand

environmental risks and cleaner production options are better able to reduce waste, avoid harmful materials, and improve product quality.

H1: Green knowledge is positively associated with sustainability performance.

Green Commitment

Within SMEs, green commitment denotes the degree to which an organization and its owner-managers are dedicated to environmental sustainability, namely the priority they assign to environmental objectives, their willingness to commit resources to them, and their long-term environmental orientation, whether driven by internal values, external pressure, or a felt obligation to meet regulatory and industry standards (Azhar et al., 2025; Khaw et al., 2023). Green commitment is thus an attitudinal and strategic orientation, distinct from the practices through which it may be enacted. In this study, it is reflected in the firm's commitment to environmental objectives in five domains: (1) environmental policy, the adoption of formal policies that embed environmental objectives into strategic planning (Ivanova-Gongne et al., 2022; Khaw et al., 2023); (2) energy, the priority given to reducing energy consumption and shifting toward renewable sources (Khaw et al., 2023; Li et al., 2024); (3) raw materials, the willingness to select eco-friendly inputs and sustainably minded suppliers (Malesios et al., 2021; Worakittikul et al., 2025); (4) waste, the dedication to reducing, reusing, and recycling waste (Malesios et al., 2021; Truong & Berrone, 2022); and (5) emissions, the long-term intention to reduce carbon emissions (Chakraborty et al., 2023; Truong & Berrone, 2022). These indicators capture intention, prioritization, and resource willingness in each domain, whereas the environmental activities actually implemented are captured separately by green business practices (Section 2.5). Because commitment and practice are closely related in small firms, where the same owner-manager both decides and implements, the empirical distinctiveness of the two constructs is examined through discriminant validity tests in Section 4.1.

Evidence across several studies supports the notion that green knowledge is positively associated with green commitment within SMEs (Galván-Mendoza et al., 2022). Research on SMEs further indicates that top-management commitment is a pivotal driver of green procurement, shaping policy formulation, resource allocation, and organizational culture, and is integral to the success of sustainability efforts (Hafish et al., 2024).

While knowledge supplies the cognitive basis for environmental action, its practical effect depends on the organization's willingness to act on it. Organizational commitment theory holds that behavior is shaped not only by knowledge and resources but also by attachment to, and acceptance of, organizational goals (Djunaedi et al., 2024; Meyer & Allen, 1991).

Green commitment thus reflects an organization's internal dedication to environmental sustainability, capturing the degree to which firms prioritize environmental values in decision-making, resource allocation, and day-to-day operations. In SMEs, where decision authority is typically

concentrated among owners or managers, commitment plays a decisive role in whether knowledge is acted upon.

Owner-managers who better understand the environmental consequences of batik production, and the options available for reducing them, are more likely to perceive environmental objectives as important and attainable, and therefore to prioritize them. Green knowledge is thus expected to be positively associated with green commitment.

H2: Green knowledge is positively associated with green commitment.

Top-management commitment likewise drives the adoption of green procurement and broader green practices, shaping organizational culture, policy, and resource allocation, and underpinning the success of sustainability initiatives in SMEs (Hafish et al., 2024; Yadegaridehkordi et al., 2023). When demonstrated by SME owners, leadership commitment has been found to be the strongest antecedent of environmental and social sustainability performance, although it shows no direct link to short-term financial performance (Yadegaridehkordi et al., 2023). Employees with stronger green commitment engage more actively in green behaviors such as recycling and energy conservation, which in turn improves workplace green performance (Azhar et al., 2025; Sharma et al., 2021; Tahir et al., 2024). Organizations with strong environmental commitment are therefore more likely to sustain their sustainability initiatives and to achieve better sustainability outcomes.

H3: Green commitment is positively associated with sustainability performance.

Green Business Practices

Green business practices comprise the observable actions, initiatives, and processes that organizations implement to limit their environmental footprint. In line with the NRBV (Section 2.1), they are treated in this study as operational practices and capabilities rather than as intellectual capital. For SMEs, such practices aim to reconcile profitability with environmental and social responsibility, commonly via renewable-energy adoption, waste reduction, sustainable sourcing, and regulatory compliance (Magazzino et al., 2025; Stekelorum et al., 2020). Indicators used to gauge their implementation include: (1) green action initiatives, such as waste reduction, recycling, energy and water conservation, and eco-design (Chaves-Castro et al., 2025; Stekelorum et al., 2020); (2) green ingredients, the use of local or organic materials to lower environmental impact and support sustainable sourcing (Majali et al., 2022; Worakittikul et al., 2025); (3) green donation, funding or participating in environmental projects and community education on green practices (Hasan & Rahman, 2023; Stekelorum et al., 2020); (4) green product innovation, developing environmentally friendly products, processes, and strategies (Achmad & Wiratmadja, 2025; Nigatu et al., 2024); (5) green supply chain management, embedding green practices across purchasing, logistics, and reverse logistics (Stekelorum et al., 2020; Wang et al., 2024); (6) green human resource management, cultivating a sustainability culture through employee participation, education, and awareness (Alshuaibi et al., 2024; Nigatu et al., 2024); and (7) green investment, allocating resources to eco-friendly projects, R&D, and sustainable technology (Nigatu et al., 2024),

along with green information systems that support decision-making and promote sustainable behavior (Kirchner-Krath et al., 2024). Whereas green commitment captures what the firm intends and prioritizes, these indicators capture what the firm actually does.

A range of studies show that adopting green practices, including green innovation, green supply chain management, and green human resource management, is positively associated with SME sustainability performance (Kosasih et al., 2023; Rasheed et al., 2024; Siedschlag et al., 2024). Green practices frequently mediate the relationship between other business strategies and sustainability outcomes (Khan et al., 2023); when paired with digital technologies and total quality management, green management practices can further enhance social and financial results for SMEs (Dzikriansyah et al., 2023; Huang et al., 2024; Rasheed et al., 2024).

Green business practices represent the operational face of environmental strategy, spanning waste reduction, efficient resource use, cleaner production, and responsible sourcing. Within SMEs, such practices tend to develop gradually through learning and experiential adaptation. Consistent with the NRBV, prior empirical evidence indicates that firms adopting environmentally sound operational practices report better sustainability performance, stronger reputations, and better market positioning (Huang et al., 2024; Kosasih et al., 2023; Siedschlag et al., 2024).

Within the batik sector, sustainable dyeing methods, wastewater treatment, and natural coloring processes are tangible expressions of green business practice, and they are expected to be associated with better sustainability performance through reduced environmental harm and improved regulatory compliance. Accordingly:

H4: Green business practices are positively associated with sustainability performance.

Top-management commitment likewise drives the uptake of green practices within SMEs, shaping culture and influencing policy and resource allocation (Hafish et al., 2024; Zarrouk et al., 2026). Leadership commitment and the ethical orientation of business leaders strongly influence the advancement of green practices, supporting ongoing green business development and a culture of social and environmental responsibility (Kosasih et al., 2023; Zarrouk et al., 2026). Adopting green practices tends to be accompanied by better social, financial, and environmental outcomes, and green business strategies have been linked to financial returns, competitive position, and brand reputation (Alwakid & Dahri, 2025; Aslam et al., 2025; Majali et al., 2022; Rasheed et al., 2024). The relationship between practices and commitment can also run from practice to commitment: when owner-managers and employees repeatedly implement green practices and observe their benefits, environmental objectives become more salient and more firmly embedded in organizational values. Consistent with this experiential reinforcement, green business practices are expected to be positively associated with green commitment, although the reverse direction is also plausible and is acknowledged in Section 6.1.

H5: Green business practices are positively associated with green commitment.

The Mediating Role of Green Commitment

Green commitment has been found to mediate the link between leadership styles, such as environmentally specific servant leadership, and pro-environmental behavior in the workplace: organizational support and environmental commitment both significantly mediate leadership's effect on employees' pro-environmental behavior (Javed et al., 2024; Ngo, 2025). In innovation contexts, employee commitment mediates the relationship between the adoption of green culture and innovation and green performance in SMEs (Sharma et al., 2021). Green commitment also mediates the relationship between green human resource management (GHRM) practices and green performance, with GHRM practices, especially when supported by technologies such as AI, enhancing green performance through increased commitment (Azhar et al., 2025).

Beyond these empirical findings, the mechanism through which green commitment operates can be specified more precisely. Knowledge and practices are associated with performance only to the extent that they are applied consistently, and commitment shapes that consistency through four organizational channels. First, resource allocation: committed owner-managers are more willing to devote scarce funds, time, and labor to environmental objectives, such as wastewater treatment or natural dyes, even when returns are uncertain. Second, policy consistency: commitment translates knowledge into stable rules and standards, so that environmental choices do not depend on ad hoc decisions or short-term cost pressures. Third, employee participation: visible owner commitment signals that environmental objectives matter, encouraging artisans and workers to apply green procedures in daily production. Fourth, investment continuity and adherence to objectives: committed firms are more likely to maintain green initiatives over time rather than abandon them when initial costs arise. Through these channels, green knowledge is expected to be associated with sustainability performance partly because it strengthens commitment, which in turn sustains the consistent application of knowledge in production.

H6: Green commitment mediates the relationship between green knowledge and sustainability performance.

In a similar vein, green business practices are expected to be associated with sustainability performance partly through green commitment. Implementing practices reinforces commitment, and stronger commitment secures the resources, policies, and employee participation needed to maintain and extend those practices, so that their association with performance is sustained rather than episodic.

H7: Green commitment mediates the relationship between green business practices and sustainability performance.

Drawing on the theoretical arguments and empirical evidence reviewed above, this study proposes a conceptual framework linking green knowledge, green business practices, green commitment, and sustainability performance among Indonesian batik SMEs. The model distinguishes four types of constructs: green knowledge as a resource (green human capital), green business practices as operational practices and capabilities, green commitment as an organizational orientation, and

sustainability performance as an outcome. Green knowledge and green business practices are expected to be associated with sustainability performance both directly and indirectly through green commitment. Figure 1 depicts the proposed model and its hypothesized relationships.

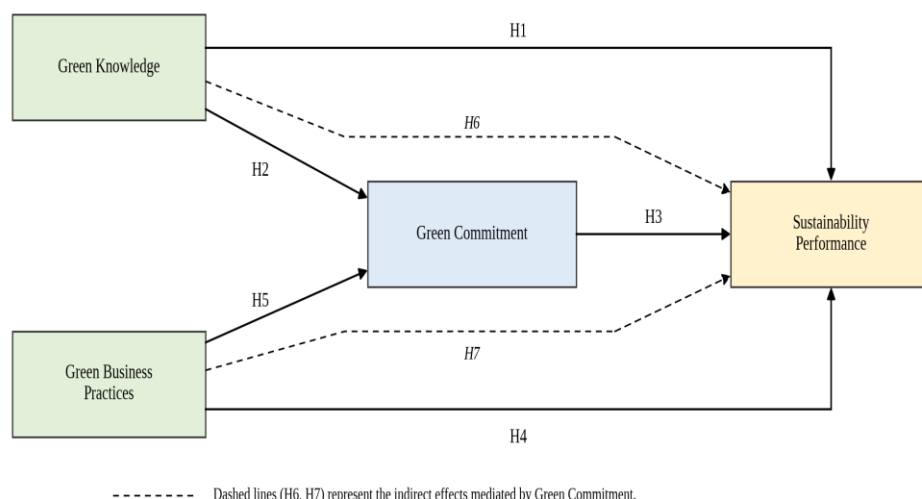


Figure 1. Conceptual Framework

Source: Authors' own work

As Figure 1 shows, the model captures both direct and indirect relationships among the constructs. Green knowledge is expected to be positively associated with both sustainability performance (H1) and green commitment (H2), and green business practices with both sustainability performance (H4) and green commitment (H5). Green commitment is expected to be positively associated with sustainability performance (H3) and to mediate the relationships of green knowledge (H6) and green business practices (H7) with sustainability performance; the dashed lines represent these indirect paths.

METHOD

This study adopts a quantitative, explanatory research design (Bougie & Sekaran, 2021; Cooper & Schindler, 2014) to investigate the relationships among green knowledge, green business practices, green commitment, and sustainability performance within Indonesian batik SMEs. Anchored in intellectual capital theory, the RBV, and the NRBV, the research treats green knowledge as green human capital that is associated with sustainability performance directly and through green commitment. Primary data were gathered from batik SME owners and managers via a cross-sectional survey, an approach suited to testing hypothesized relationships and mediation effects among latent constructs, although it does not allow causal direction to be established.

The study population (Bougie & Sekaran, 2021; Cooper & Schindler, 2014) comprises batik SMEs operating in Indonesia's principal production centers, Pekalongan, Yogyakarta, and Cirebon, which were chosen for their economic significance and active batik clusters. A purposive sampling approach was used to select respondents meeting the following criteria: classification as a micro, small, or medium enterprise; at least three years in operation; and the respondent being an owner or manager directly involved in operational and strategic decisions. Questionnaires were distributed in all three locations, and the final sample comprised 386 respondents. Using the inverse square root method (Kock & Hadaya,

2018), the minimum sample size required to detect the smallest path coefficient in the model ($\beta = 0.182$) at the 5% significance level is 187, so the sample of 386 is adequate.

All constructs were measured with multi-item scales adapted from established literature and tailored to the batik SME context, using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree) (Bougie & Sekaran, 2021; Cooper & Schindler, 2014). Green knowledge (four items) captures the extent to which owner-managers understand environmental issues and apply that understanding through knowledge sharing, decision-making, and technology adoption. Green commitment (five items) captures the firm's dedication to, prioritization of, and willingness to commit resources to environmental objectives in the policy, energy, raw-material, waste, and emissions domains. Green business practices (seven items) capture the environmental activities actually implemented. Sustainability performance (five items) captures the environmental operational outcomes achieved. Table 1 lists the items, their sources, and their outer loadings.

Data collection relied on structured questionnaires administered both in person and electronically to batik SME owners and managers. The instrument was pre-tested prior to full distribution to confirm its clarity, relevance, and contextual fit. Respondents were informed of the study's academic purpose, participation was voluntary, and confidentiality was assured (see Section 7.6); assuring confidentiality also served as a procedural remedy against common method bias (Podsakoff et al., 2003). Data were analyzed using PLS-SEM (Hair et al., 2022), chosen because the study involves latent constructs with multiple indicators, incorporates mediation effects, and draws on an SME sample that may exhibit non-normal data distributions. The analysis proceeded in two stages: first, assessment of the measurement model for indicator reliability, internal consistency, convergent validity, and discriminant validity; second, evaluation of the structural model, covering collinearity, path coefficients, significance levels, coefficients of determination (R^2), effect sizes (f^2), and mediation effects. Significance was assessed through bootstrapping, the direct, indirect, and total effects are reported, and mediation was classified following Zhao et al. (2010).

RESULT AND DISCUSSION

Measurement Model Assessment

This study relied on PLS-SEM to evaluate both the measurement and structural models. The measurement model was assessed ahead of hypothesis testing to confirm the reliability and validity of the constructs. Internal consistency was gauged via Cronbach's alpha and composite reliability (ρ_a and ρ_c), convergent validity via outer loadings and Average Variance Extracted (AVE), and discriminant validity via the heterotrait monotrait ratio (HTMT) and the Fornell Larcker criterion. Table 1 reports the item-level results. All 21 indicators have outer loadings between 0.728 and 0.861, above the recommended threshold of 0.708 (Hair et al., 2022); therefore, all items were retained and no item was deleted.

Table 1. Measurement Items, Sources, and Outer Loadings

Construct	Code	Indicator	Source	Loading	Status
Green Knowledge (GK)	GK-01	Environmental preservation awareness	(Maldonado Bonilla et al., 2024; Tudu & Mishra, 2025)	0.811	Retained
	GK-02	Collaboration and knowledge-sharing for sustainability	(Sulistyanto et al., 2025; Yu et al., 2022)	0.807	Retained
	GK-03	Integration of environmental considerations into decision-making	(Kirchner-Krath et al., 2024; Lei et al., 2023)	0.820	Retained
	GK-04	Knowledge for adopting sustainable technologies and processes	(Jadayil et al., 2026; Wang & Zhang, 2024)	0.791	Retained
Green Commitment (GC)	GC-01	Commitment to environmentally friendly company policies	(Ivanova-Gongne et al., 2022; Khaw et al., 2023)	0.764	Retained
	GC-02	Priority given to energy saving and renewable energy	(Khaw et al., 2023; Li et al., 2024)	0.779	Retained
	GC-03	Commitment to environmentally friendly raw materials	(Malesios et al., 2021; Worakittikul et al., 2025)	0.758	Retained
	GC-04	Commitment to waste reduction and eco-	(Malesios et al., 2021; Truong &	0.776	Retained

Construct	Code	Indicator	Source	Loading	Status
		friendly waste management	Berrone, 2022)		
	GC-05	Long-term commitment to carbon-emission reduction	(Chakraborty et al., 2023; Truong & Berrone, 2022)	0.728	Retained
Green Business Practices (GB)	GB-01	Green action initiatives	(Chaves-Castro et al., 2025; Stekelorum et al., 2020)	0.789	Retained
	GB-02	Green ingredients	(Majali et al., 2022; Worakittikul et al., 2025)	0.808	Retained
	GB-03	Green donation	(Hasan & Rahman, 2023; Stekelorum et al., 2020)	0.784	Retained
	GB-04	Green product innovation	(Achmad & Wiratmadja, 2025; Nigatu et al., 2024)	0.785	Retained
	GB-05	Green supply chain management	(Stekelorum et al., 2020; Wang et al., 2024)	0.818	Retained
	GB-06	Green human resource management	(Alshuaibi et al., 2024; Nigatu et al., 2024)	0.780	Retained
	GB-07	Green investment and green information systems	(Kirchner-Krath et al., 2024; Nigatu et al., 2024)	0.820	Retained
Sustainability Performance (SP)	SP-01	Product innovation outcomes	(Kurniawati et al., 2022; Zhang et al., 2022)	0.826	Retained
	SP-02	Product quality improvement	(Nusraningrum et al., 2025; Somwethee	0.852	Retained

Construct	Code	Indicator	Source	Loading	Status
			et al., 2023; Zhou & Xu, 2024)		
	SP-03	Waste reduction achieved	(Opoku et al., 2023; Zhou & Xu, 2024)	0.861	Retained
	SP-04	Reduced use of harmful raw materials	(Zhou & Xu, 2024)	0.845	Retained
	SP-05	Environmental risk reduction	(Jung & Kim, 2023; Opoku et al., 2023; Zhou & Xu, 2024)	0.841	Retained

Source: Authors' own work

Table 2. Reliability and Convergent Validity Results

	Cronbach's alpha	rho_a	rho_c	AVE
GB	0.905	0.907	0.925	0.637
GC	0.819	0.822	0.873	0.580
GK	0.822	0.824	0.882	0.652
SP	0.900	0.900	0.926	0.714

Source: Authors' own work

As shown in Table 2, every construct meets the recommended reliability benchmarks. Cronbach's alpha values range from 0.819 to 0.905, above the 0.70 minimum, and composite reliability (rho_c) ranges from 0.873 to 0.926, indicating strong internal consistency. All AVE values exceed the 0.50 threshold: green business practices (0.637), green commitment (0.580), green knowledge (0.652), and sustainability performance (0.714). Each construct therefore accounts for more than half of the variance in its indicators, and the measurement model satisfies the required reliability and convergent validity standards.

Discriminant validity was examined through both the HTMT ratio and the Fornell Larcker criterion to verify that each construct is empirically distinguishable from the others.

Table 3. HTMT Matrix

	GB	GC	GK	SP
GB				
GC	0.693			
GK	0.743	0.596		
SP	0.799	0.706	0.805	

Source: Authors' own work

All HTMT values fall below the 0.90 threshold and also below the more conservative 0.85 threshold (Henseler et al., 2015); the highest value (0.805) is between green knowledge and sustainability performance. Of

particular relevance to the conceptual distinction between green commitment and green business practices, the HTMT ratio between these two constructs is 0.693, well below both thresholds, which indicates that respondents distinguished the firm's commitment to environmental objectives from the practices it implements.

Table 4. Fornell Larcker Criterion

	GB	GC	GK	SP
GB	0.798			
GC	0.602	0.761		
GK	0.642	0.493	0.807	
SP	0.723	0.609	0.693	0.845

Source: Authors' own work

The Fornell Larcker results support this conclusion, as the square root of each construct's AVE exceeds its correlations with the other constructs. The correlation between green commitment and green business practices (0.602) is lower than the square roots of their AVEs (0.761 and 0.798), again supporting their empirical distinctiveness. Because all data were collected from a single respondent per firm at one point in time, common method bias was also considered. In addition to the procedural remedy described in Section 3, all inner-model VIF values (Table 5) are below 3.3, which gives an indication that common method bias is unlikely to be a serious concern (Kock, 2015). With reliability and validity established, attention turns to the structural model.

Structural Model Assessment

Following confirmation of the measurement model, the structural model was evaluated for collinearity, explanatory power (R^2), effect sizes (f^2), and hypothesis significance via bootstrapping. Collinearity among predictors was assessed using Variance Inflation Factor (VIF) values.

Table 5. Inner Model VIF Values

	GB	GC	GK	SP
GB		1.701		2.081
GC				1.617
GK		1.701		1.754
SP				

Source: Authors' own work

VIF values range from 1.617 to 2.081, below the critical threshold of 5.0 and the more conservative threshold of 3.3, indicating no multicollinearity concerns. The model's explanatory power was then examined through R^2 values.

Table 6. R-square and R-square Adjusted

	R-square	R-square adjusted
GC	0.382	0.378
SP	0.640	0.637

Source: Authors' own work

Green commitment has an R^2 of 0.382, meaning that green knowledge and green business practices jointly explain 38.2% of its variance, while sustainability performance has an R^2 of 0.640, indicating that 64.0% of its

variance is accounted for by green knowledge, green business practices, and green commitment. Following Hair et al. (2022), these values represent weak-to-moderate and moderate explanatory power, respectively. Bootstrapping was then used to test the significance of the path coefficients.

Table 7. Bootstrapping Results (Direct Effects)

	Original	Mean	STDEV	T statistics	P values	Result
H1: GK → SP	0.350	0.350	0.039	9.068	< 0.001	Accepted
H2: GK → GC	0.182	0.184	0.052	3.472	< 0.001	Accepted
H3: GC → SP	0.213	0.214	0.042	5.087	< 0.001	Accepted
H4: GB → SP	0.371	0.370	0.047	7.817	< 0.001	Accepted
H5: GB → GC	0.485	0.485	0.049	9.916	< 0.001	Accepted

Source: Authors' own work

All direct-effect hypotheses are supported. Green knowledge is positively associated with sustainability performance (H1: $\beta = 0.350$, $p < 0.001$) and with green commitment (H2: $\beta = 0.182$, $p < 0.001$); green commitment is positively associated with sustainability performance (H3: $\beta = 0.213$, $p < 0.001$); and green business practices are positively associated with sustainability performance (H4: $\beta = 0.371$, $p < 0.001$) and with green commitment (H5: $\beta = 0.485$, $p < 0.001$). The coefficients of green business practices (0.371) and green knowledge (0.350) on sustainability performance are of similar magnitude; because the difference between them was not formally tested, neither predictor is interpreted as statistically stronger than the other. Effect sizes were then examined to gauge each predictor's contribution.

Table 8. Effect Size (f^2)

	GB	GC	GK	SP
GB		0.224		0.183
GC				0.078
GK		0.032		0.194
SP				

Source: Authors' own work

Green business practices have a medium effect on both green commitment (0.224) and sustainability performance (0.183); green knowledge has a medium effect on sustainability performance (0.194) and a small effect on green commitment (0.032); and green commitment has a small effect on sustainability performance (0.078) (Hair et al., 2022). The effect size of green business practices on green commitment is thus considerably larger than that of green knowledge, suggesting that, in this sample, commitment is more closely related to the practices firms implement than to what owner-managers know.

Mediation Analysis

Bootstrapping was used to assess the mediating role of green commitment through the specific indirect effects (Table 9). The direct, indirect, and total effects are summarized in Table 10.

Table 9. Specific Indirect Effects

	Original	Mean	STDEV	T statistics	P values	Result
H6: GK→GC→SP	0.039	0.039	0.013	2.931	0.003	Accepted
H7: GB→GC→SP	0.103	0.104	0.025	4.134	< 0.001	Accepted

Source: Authors' own work

The results show that green commitment significantly mediates (1) the relationship between green knowledge and sustainability performance (H6: $\beta = 0.039$, $p = 0.003$) and (2) the relationship between green business practices and sustainability performance (H7: $\beta = 0.103$, $p < 0.001$). Because the direct effects also remain significant and have the same sign as the indirect effects, green commitment acts as a complementary partial mediator in both relationships (Zhao et al., 2010). The indirect effects are modest relative to the direct effects: as Table 10 shows, the indirect path accounts for approximately 10.0% of the total effect of green knowledge (0.039 of 0.389) and 21.7% of the total effect of green business practices (0.103 of 0.474) on sustainability performance. The final structural model, with standardized path coefficients, is presented in Figure 2.

Table 10. Direct, Indirect, and Total Effects

Path	Direct effect	Indirect effect via GC	Total effect	VAF	Interpretation
GK → GC	0.182		0.182		Direct only (H2)
GB → GC	0.485		0.485		Direct only (H5)
GC → SP	0.213		0.213		Direct only (H3)
GK → SP	0.350	0.039	0.389	10.0 %	Complementary partial mediation (H1, H6)

Path	Direct effect	Indirect effect via GC	Total effect	VAF	Interpretation
GB → SP	0.371	0.103	0.474	21.7 %	Complementary partial mediation (H4, H7)

Note: Total effect = direct effect + indirect effect; VAF (variance accounted for) = indirect effect / total effect. Source: Authors' own work

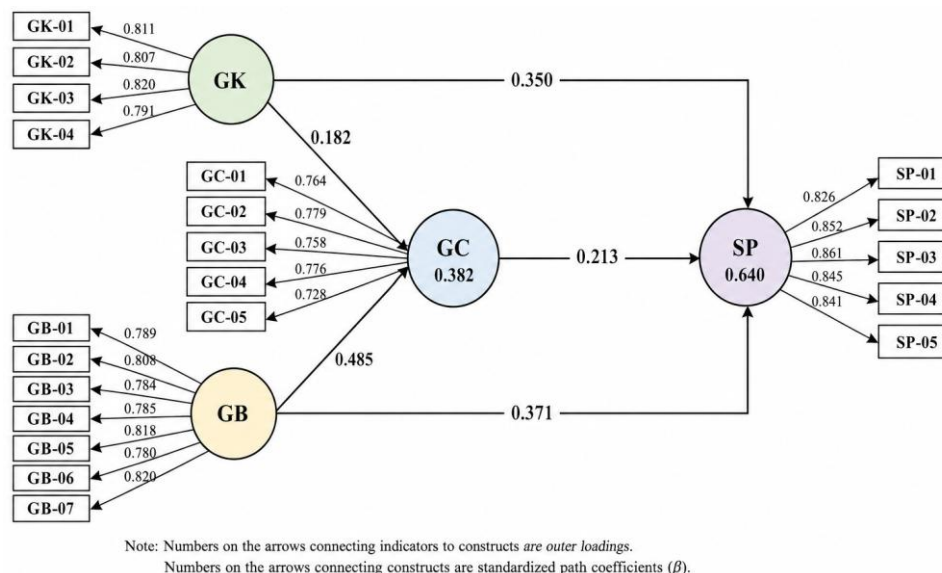


Figure 2. Structural Model with Path Coefficients

Source: Authors' own work

Figure 2 shows that green business practices have the largest coefficient on green commitment, that green knowledge and green business practices are both directly associated with sustainability performance, and that green commitment links both predictors to sustainability performance through modest but significant indirect paths.

Discussion

Green Knowledge as Green Human Capital

The findings provide empirical support for the associations of green knowledge and green business practices with sustainability performance among Indonesian batik SMEs, with green commitment acting as a complementary partial mediator (Achmad & Wiratmadja, 2025; He et al., 2022; Hossain et al., 2025). Interpreted through intellectual capital theory and the RBV, the positive association between green knowledge and sustainability performance is consistent with the view that green human capital is a valuable resource. The RBV argument, however, applies with an important qualification: general environmental information is widely accessible and cannot by itself be a source of distinctive advantage. The relevance of green knowledge in batik SMEs is more plausibly located in its firm-specific component, namely the experience-based know-how about dyes, wax, water, and waste that owner-managers develop and share within their workshops (Ahn et al., 2022; Münch et al., 2022). The present measure captures both awareness and application and cannot fully

separate the two components, so this interpretation should be tested with measures that distinguish codified from tacit green knowledge. Earlier scholarship has framed green intellectual capital as a determinant of environmental competitive advantage (Chen, 2008; Dang & Wang, 2022; Tahir et al., 2024); the present findings extend this line of research by showing that one of its components, green human capital, is associated with sustainability performance in traditional SMEs in an emerging economy, consistent with evidence that environmental knowledge supports sustainability outcomes (Galván-Mendoza et al., 2022).

Green Business Practices and the Natural Resource-Based View

The positive association between green business practices and sustainability performance is consistent with the NRBV introduced in Section 2.1, which holds that capabilities for pollution prevention and waste reduction support environmental and economic performance (Domfeh et al., 2025; Hart, 1995; Hällérstrand et al., 2023). In batik SMEs, green business practices can be understood as operational capabilities embedded in organizational routines, which are path-dependent and rooted in tacit knowledge and local craft traditions. This finding is consistent with earlier research linking proactive environmental strategy to firm performance (Magazzino et al., 2025; Stekelorum et al., 2020) and with evidence that green operational practices are associated with better sustainability outcomes (Kosasih et al., 2023; Rasheed et al., 2024; Siedschlag et al., 2024). The coefficients of green business practices (0.371) and green knowledge (0.350) on sustainability performance are similar, and their difference was not formally tested; the results therefore indicate that both are relevant, not that one is more important than the other. Green business practices do, however, show a considerably larger association with green commitment ($\beta = 0.485$, $f^2 = 0.224$) than green knowledge does ($\beta = 0.182$, $f^2 = 0.032$), suggesting that commitment in these firms is more closely tied to practical experience than to knowledge alone.

In practical terms, the results suggest that SME owners and managers should develop green knowledge and green business practices together rather than treating them as alternatives. Because implemented practices are closely related to green commitment, practical measures such as energy-efficient equipment, waste reduction, recycling systems, and sustainable materials may also help to strengthen owners' and employees' commitment to environmental objectives. The cross-sectional data do not show whether practices or knowledge yield faster or longer-lasting gains, so recommendations about sequencing should await longitudinal evidence. For policymakers, the results point to the value of combining support for implementing green practices, such as access to wastewater treatment facilities or natural-dye inputs, with training that develops SMEs' environmental knowledge and managerial capacity.

The Mediating Role of Green Commitment

The results show that green commitment partially mediates the relationships of both green knowledge and green business practices with sustainability performance. Organizational commitment theory (Djunaedi

et al., 2024; Meyer & Allen, 1991) holds that internalized values and attachment to organizational goals shape the consistency of behavior, and in sustainability research green commitment captures the degree to which environmental values are woven into organizational culture and managerial orientation (Javed et al., 2024; Ngo, 2025). Because the direct effects remain significant and the indirect effects are modest (about 10% and 22% of the total effects), the results do not imply that knowledge and practices are ineffective without commitment. Rather, they indicate that commitment reinforces these relationships: part of the association of knowledge and practices with performance runs through the firm's dedication to environmental objectives, consistent with prior work showing that environmental commitment strengthens the translation of green initiatives into performance outcomes (Azhar et al., 2025). The mechanisms proposed in Section 2.6, namely resource allocation, policy consistency, employee participation, and investment continuity, offer a plausible account of this pathway, although they were not measured directly and should be examined in future research. In family-run batik SMEs, where commitment is shaped by owner values and long-standing community reputation, these mechanisms are likely to operate through the owner-manager's personal priorities.

Implications for Emerging Economies

These findings are relevant for emerging economies, where SMEs constitute the backbone of the economy and formal enforcement mechanisms may be weak. Prior research on SMEs in emerging economies emphasizes that sustainability improvement depends on both knowledge-based capabilities and leadership commitment (Juicharoen et al., 2025; Yadegaridehkordi et al., 2023). The results imply that policy efforts should extend beyond technical training to also foster environmental commitment among SME owners; strengthening green human capital, green practices, and organizational commitment together may support the sustainability transition within traditional industries such as batik.

CONCLUSION

This study examined green knowledge, positioned as green human capital, and green business practices as correlates of sustainability performance among Indonesian batik SMEs, with green commitment as a mediating mechanism. The findings show that both green knowledge and green business practices are positively associated with sustainability performance, with coefficients of similar magnitude, and that green commitment partially mediates both relationships. Sustainability outcomes are thus associated with environmental knowledge and practices both directly and, to a smaller extent, through the firm's commitment to environmental objectives.

The results are consistent with intellectual capital theory and the RBV in showing that green knowledge, as green human capital, is associated with sustainability performance, particularly where general environmental information is converted into firm-specific know-how. They are also consistent with the NRBV in showing that implemented green practices are associated with sustainability performance. Organizational

commitment complements, rather than replaces, these direct associations by linking knowledge and practices to performance through resource allocation, policy consistency, employee participation, and investment continuity.

Within traditional, family-run batik SMEs, the sustainability transition appears to depend not only on resources and practices but also on managerial values and commitment. Green commitment acts as an internal mechanism that aligns knowledge and practice with sustainability goals, a finding that enriches the sustainability literature on emerging economies and deepens understanding of how intangible environmental resources function within culturally embedded SME settings.

Limitations and Future Research

This study has several limitations. Its cross-sectional design captures relationships among variables at a single point in time, so the findings indicate associations rather than causal effects. Reverse causality is plausible: more sustainable and better-performing firms may have more resources to acquire environmental knowledge, implement green practices, and express green commitment, and the implementation of practices may shape commitment as much as commitment shapes practices. Longitudinal or panel designs are needed to establish the direction of these relationships and to test whether the associations of knowledge and practices with performance differ in the short and long term.

The study was confined to the Indonesian context; institutional environments, environmental regulation, cultural values, and market conditions vary across countries, which may limit the generalizability of these findings to other emerging or developed economies. Cross-country comparative research could help determine whether the proposed relationships hold across different institutional and cultural settings.

The focus on batik SMEs, a traditional creative industry marked by strong cultural values, family ownership, and environmentally intensive production, means that industry-specific traits may have shaped the observed relationships. Future work could extend the model to other SME sectors, such as food processing, manufacturing, handicrafts, or services, to test the robustness and external validity of these findings.

Sustainability performance was operationalized mainly through environmental and product-related operational outcomes and does not include direct financial or social indicators; the findings should therefore be read as relating to environmental operational sustainability performance. Future studies should measure economic, environmental, and social outcomes separately, ideally supplemented by objective or archival data. Fifth, although the discriminant validity tests support the empirical distinction between green commitment and green business practices, the two constructs are conceptually close in small firms where the same owner-manager both decides and implements, and the green knowledge measure does not separate codified from tacit knowledge; future research should refine these measures. Finally, all constructs were reported by a single respondent per firm, so common method variance cannot be fully excluded despite the procedural and statistical checks undertaken.

Future research could also examine additional mediating mechanisms, such as green innovation, environmental capability, organizational culture, or green dynamic capabilities, as well as direct measures of the commitment mechanisms proposed here (resource allocation, policy consistency, employee participation, and investment continuity), to clarify how environmental knowledge and business practices are translated into sustainability outcomes among SMEs in emerging economies.

About Authors

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Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Declaration of Conflicting Interest

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

Research Ethics Statement

Participation in this study was voluntary. Before completing the questionnaire, respondents were informed of the academic purpose of the study and assured that their responses would be treated confidentially. No names of respondents or firms are reported, and the data were analyzed and presented only in aggregate form for academic purposes.

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