The Impact of Renewable Energy and Green Finance on SMEs Sustainability through Environmental Management Practices

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ABSTRACT

This study examines the mediating role of environmental management practices in the relationship between green finance, renewable energy adoption, and business sustainability among small and medium enterprises in Indonesia. The objectives are to assess the direct effects of green finance and renewable energy on business sustainability and to determine whether environmental management practices strengthen these effects. Data were collected from 200 small and medium enterprise respondents using a structured questionnaire. The green finance measurement instrument provides a validated framework specifically designed for small and medium enterprises. The results show that both green finance and renewable energy have significant positive effects on business sustainability. These effects become stronger when mediated by environmental management practices, including formal environmental policies, resource efficiency initiatives, and pollution control measures. Among the three dimensions of green finance, economic, environmental, and social, the economic dimension has the greatest impact, highlighting the importance of cost efficiency, green profitability, and return-oriented investments. The findings suggest that aligning financial and energy strategies with environmental management practices can lead to more meaningful and sustainable improvements in business performance.

Keywords*: Business Sustainability, Environmental Management Practices, Green Finance, Renewable Energy, Small and Medium Enterprises, Sustainable Performance.*

ABSTRAK

Penelitian ini meneliti peran mediasi praktik manajemen lingkungan dalam hubungan antara pembiayaan hijau, adopsi energi terbarukan, dan keberlanjutan usaha pada usaha kecil dan menengah di Indonesia. Tujuan penelitian ini adalah untuk menilai pengaruh langsung pembiayaan hijau dan energi terbarukan terhadap keberlanjutan usaha serta untuk mengetahui apakah praktik manajemen lingkungan memperkuat pengaruh tersebut. Data dikumpulkan dari dua ratus responden usaha kecil dan menengah menggunakan kuesioner terstruktur. Instrumen pengukuran pembiayaan hijau menyediakan kerangka kerja yang tervalidasi dan dirancang khusus untuk usaha kecil dan menengah. Hasil penelitian menunjukkan bahwa baik pembiayaan hijau maupun energi terbarukan memiliki pengaruh positif yang signifikan terhadap keberlanjutan usaha. Pengaruh tersebut menjadi lebih kuat ketika dimediasi oleh praktik manajemen lingkungan, termasuk kebijakan lingkungan yang formal, inisiatif efisiensi sumber daya, dan langkah pengendalian polusi. Di antara tiga dimensi pembiayaan hijau, yaitu ekonomi, lingkungan, dan sosial, dimensi ekonomi memiliki pengaruh terbesar, menekankan pentingnya efisiensi biaya, profitabilitas hijau, dan investasi yang berorientasi pada pengembalian. Temuan ini menunjukkan bahwa menyelaraskan strategi keuangan dan energi dengan praktik manajemen lingkungan dapat meningkatkan keberlanjutan kinerja usaha secara lebih berarti dan berkelanjutan.

Kata kunci*: Keberlanjutan Usaha, Praktik Manajemen Lingkungan, Pembiayaan Hijau, Energi Terbarukan, Usaha Kecil dan Menengah, Kinerja Berkelanjutan.*

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INTRODUCTION

Sustainability implementation among Small and Medium Enterprises (SMEs) in Indonesia remains critically limited in both practice and awareness. According to the Ministry of Cooperatives and SMEs, over 97% of Indonesian SMEs operate informally with a primary focus on short-term profit, and less than 15% incorporate environmental or social considerations into their business strategies. The World Bank reports that only 8% of Indonesian SMEs have access to green financing schemes, and fewer than 10% are aware of renewable energy incentives or environmental certifications. Most Indonesian SMEs lack proper waste management systems and energy-efficient equipment, particularly in food processing, textiles, and traditional manufacturing sectors. These data highlight a critical gap in SME sustainability, indicating an urgent need for financial support, policy incentives, and education to accelerate the green transition (Halik & Christina, 2025).

Green finance is recognized as a key driver of business sustainability in SMEs, encompassing both financial support for environmentally friendly initiatives and broader strategic outcomes that enhance sustainable performance (Kurniawan et al., 2023; Govindaraj et al., 2024). It is measured through three main dimensions: economic, social, and environmental (Tarigan et al., 2025). The economic dimension reflects improvements in competitiveness, operational efficiency, and long-term profitability (Zhou et al., 2022). The social dimension captures enhanced corporate reputation, stakeholder trust, and employee well-being (Nundy et al., 2021). The environmental dimension assesses contributions to emission reduction, resource conservation, and ecological preservation (Lee et al., 2023). Together, these dimensions form the foundation through which green finance drives the sustainable transformation of SMEs (Thamrin et al., 2025).

Despite growing recognition of green finance as a sustainability determinant, standardized instruments to measure it in SMEs remain limited. Most existing studies rely on secondary data or macroeconomic indicators that fail to capture the nuanced realities of small business financial behaviors. This study addresses this gap by proposing and validating a green finance measurement model based on the economic, social, and environmental dimensions adapted from Govindaraj et al. (2024). By contextualizing these dimensions for real-sector SMEs, the research provides a practical, empirically grounded tool to assess green finance perception and implementation at the microeconomic level, supporting future research, guiding policymakers, and informing financial institutions in developing effective green financing strategies for SMEs.

Renewable energy practices such as solar power, biomass, and energy-efficient technologies are widely acknowledged as key enablers of business sustainability, reducing operational costs, increasing energy security, and improving environmental reputation (Fazal et al., 2023). Integrating renewable energy signals environmental responsibility, potentially enhancing customer loyalty and stakeholder trust while contributing to climate change mitigation and alignment with sustainability targets. However, despite increasing adoption of green finance and renewable energy, many Indonesian SMEs still struggle to remain competitive and sustainable (Hartatik et al., 2025). Liu et al. (2020) argue that mere access to green resources or renewable technologies does not guarantee business survival, as the Ministry of Cooperatives and SMEs reports that approximately 60% of SMEs fail within the first five years, even with government-backed programs.

Weak management, limited market access, lack of digital capability, and poor alignment between sustainability efforts and core strategies undermine green initiative effectiveness (Cheng et al., 2024). This indicates that green finance and renewable energy must be integrated with broader capacity-building, innovation support, and ecosystem strengthening to enhance SME sustainability in Indonesia (Zhou et al., 2022; Debrah et al., 2022; Lestari et al., 2024; Sethi et al., 2024).

This study aims to identify and examine a mediating variable that can strengthen the influence of green finance and renewable energy practices on SME sustainability. Given the inconsistent outcomes of prior green initiatives, the research proposes that environmental management practices may serve as a critical mechanism through which

the positive effects of green finance and renewable energy can be actualized more effectively. By embedding structured practices such as waste management, energy efficiency, and environmental awareness into daily operations, SMEs can better convert green inputs into tangible outcomes. This approach emphasizes that green finance and renewable energy effectiveness depend not only on access and implementation but also on internal environmental capabilities. The study offers three key novelties: first, identifying environmental management practices as a mediator explaining how green finance and renewable energy influence SME sustainability; second, introducing a validated green finance measurement model for SMEs based on economic, social, and environmental dimensions contextualized for primary data; and third, examining which green finance dimension has the strongest impact on business sustainability to guide policy and financing priorities. These contributions enhance both theoretical understanding and practical implementation of sustainable finance for SMEs in developing countries.

LITERATURE REVIEW & HYPOTHESIS DEVELOPMENT

The Effect of Green Finance and Renewable Energy on Management Practices

Green finance and renewable energy practices serve as strategic enablers that strengthen sustainable management and long-term organizational viability in increasingly sustainability-driven markets (Khan et al., 2022; Hui et al., 2024). Green finance positively influences environmental management by reducing financial barriers, stimulating green innovation, and enabling environmentally responsible investments. Wang et al. (2023) demonstrate that green finance supports environmental innovation and regulatory compliance, particularly within non-state-owned enterprises, while Chen et al. (2022) find that green banking in Bangladesh improves environmental performance through targeted policy and project financing. Spatial studies show that the growth of green finance generates positive spillover effects across regions, contributing to broader sustainability outcomes (Li & Gan, 2021; Zhang et al., 2023; Yu et al., 2023; Arcuri & Pisani, 2024). Research also links green finance to reduced industrial pollution and lower energy intensity (Zhang & Mei, 2022; Li et al., 2022), and renewable energy investment is shown to enhance sustainability through technological innovation and cross-border collaboration (Khan et al., 2022). Although challenges persist, including regional disparities and insufficient clarity in causal pathways, the literature consistently identifies green finance as a central driver of improved environmental management and sustainable development (Zhou et al., 2020; Trukhachev & Dzhikiya, 2023).

Renewable energy practices have a significant positive effect on environmental management practices, as empirical studies show across regions. Adoption of solar, wind, and biomass reduces carbon emissions, improves air quality, and supports ecological sustainability (Byaro et al., 2023). In the European Union, renewable energy is central to climate policy, with regulations enhancing environmental governance (Dzwigol et al., 2023). Its integration, particularly in middle-income countries, stimulates economic growth and supports continued investment in clean technologies (Candra et al., 2023). Renewable energy fosters green economic development, economic or policy shocks may disrupt progress, and certain sources, such as hydropower, can have adverse effects if mismanaged (Khan et al., 2021; Mendieta-Vicuña & Esparcia, 2022; Liu et al., 2023). REP's success relies on strategic implementation, innovation, and regulatory alignment (Olabi & Abdelkareem, 2022).

H1: Green finance has a significant effect on environmental management practices.
H2: Renewable energy practices have a significant effect on environmental management practices.

The Effect of Green Finance, REP, and EMP on Business Sustainability

SMEs' business sustainability refers to the ability to maintain operations and long-term growth while balancing economic, environmental, and social objectives. Green finance

significantly enhances sustainability by supporting environmentally responsible practices, CSR, innovation, and green investment. It strengthens CSR, which mediates sustainable performance, and promotes technological innovation, industrial upgrading, and green productivity in advanced regions (Li & Yang, 2022; Marolt et al., 2022; Ye & Dela, 2023; Xu & Zhao, 2023). Green finance also facilitates renewable energy adoption, reducing CO_2 emissions and improving industrial sustainability, while supporting SDGs in developing economies such as Bangladesh (Zheng et al., 2021; Khan et al., 2022; Zhang et al., 2023).

Renewable Energy Practices (REP) positively influence sustainability by improving non-financial business performance in Europe and strengthening economic outcomes in middle-income countries (Haile & Min, 2022; Issa & Hanaysha, 2023). REP lowers operating costs, enhances energy efficiency, reduces emissions, and enables circular economy objectives (Sarkar & Chung, 2021; Liu et al., 2023). Wind, biomass, and geothermal energy drive growth across Asia (Anser et al., 2021). Policy mechanisms, such as grants, subsidies, tax incentives, and R&D support, accelerate adoption, although fossil fuel dependence and economic instability remain challenges (Liu et al., 2020; Bölük & Kaplan, 2021; Madaleno & Nogueira, 2023).

Environmental Management Practices (EMP) embed ecological considerations into operations through resource efficiency, pollution control, green procurement, and staff environmental training. EMP acts as a key mechanism linking green finance and renewable energy to measurable sustainability outcomes, helping SMEs comply with regulations and strengthen stakeholder trust (Zhang et al., 2022; Xu et al., 2023). EMPs enhance environmental and social risk management in South East Nigeria and improve resource efficiency and circular outcomes in Spain (Obamen et al., 2021). Green HRM stimulates green innovation and organizational sustainability, while environmental disclosure increases firm value when supported by governance and environmental CSR (Malik et al., 2020; Awwad et al., 2022; Ammer et al., 2020; Dong et al., 2022; Soomro et al., 2023).

H3: Green finance has a significant effect on business sustainability.
H4: Renewable energy practices have a significant effect on business sustainability.
H5: Environmental management practices have a significant effect on business sustainability.

The Mediating Effect of Environmental Management Practices

The relationship between green finance and business sustainability is strongly mediated by Environmental Management Practices (EMPs), which act as a key mechanism through which financial investments generate measurable sustainability outcomes. EMPs enhance the effectiveness of green finance by improving resource efficiency, reducing waste, and strengthening environmental performance, contributing to both financial and sustainability gains (Aslam et al., 2023; Hui et al., 2024). Certified Environmental Management Systems (EMS) reinforce green supply chain performance and increase market value (Jell-Ojobor & Raha, 2022). When aligned with Corporate Social Responsibility (CSR), green finance yields stronger environmental results and supports sustainable development (Guang-Wen & Siddik, 2022; Xu et al., 2023). Green innovation also plays a mediating and moderating role, linking environmental and financial outcomes through sustainable solutions (Sarfraz et al., 2023). Although high costs and technical barriers remain challenges, integrating green finance with EMPs, CSR, and innovation can enhance competitiveness, reduce long-term risks, and strengthen stakeholder trust, emphasizing the need for a holistic deployment framework (Zhang et al., 2022).

EMPs also mediate the impact of renewable energy practices on business sustainability by helping firms convert renewable energy adoption into environmental and economic value. EMS implementation supports circular economy initiatives, improving operational sustainability and resource use efficiency (Barón et al., 2022). Renewable energy

supported by smart systems contributes to carbon reduction, cost savings, and improved performance (Sarkar & Chung, 2021; Halis & Halis, 2022). Strong green capabilities further enable effective renewable energy integration, translating environmental commitment into tangible outcomes (Rehman et al., 2022). Green innovation and sustainable development strategies also act as mediators, reinforcing renewable energy's contribution to environmental performance (Sarfraz et al., 2023). However, initial investments and operational changes pose challenges; the synergy between EMPs and renewable energy adoption positions firms for long-term sustainability through improved resilience and environmental stewardship.

H6: Environmental management practices mediates the effect of green finance on business sustainability.
H7: Environmental management practices mediates the effect of renewable energy practices on business sustainability.

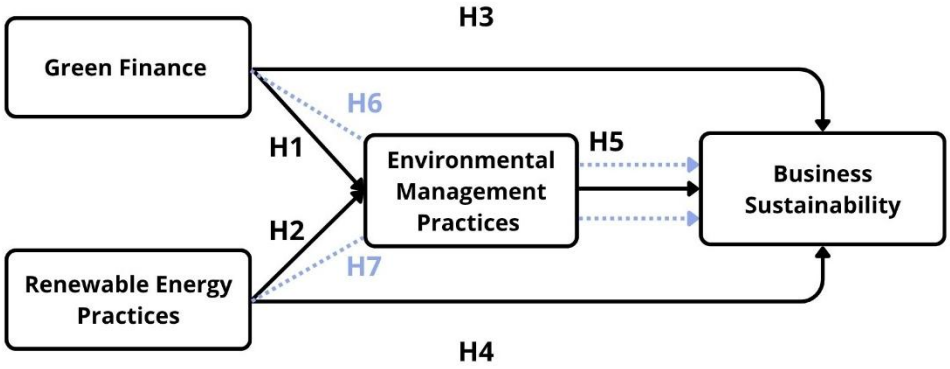

Figure 1. Research Framework

Figure 1 illustrates the conceptual framework of this study, highlighting the relationships among green finance, renewable energy practices, environmental management practices, and business sustainability. Green finance and renewable energy practices are proposed to have direct effects on business sustainability (H3 and H4) while also influencing it indirectly through environmental management practices (H6 and H7). Additionally, environmental management practices serve as a mediator between both green finance and renewable energy practices with business sustainability (H5), demonstrating how structured environmental initiatives enhance the impact of financial and energy strategies on sustainable business performance.

RESEARCH METHODS

This study adopts a quantitative, non-experimental, and causal research design to examine how Green Finance (GF) and Renewable Energy Practices (REP) affect Business Sustainability (BS) in Small and Medium-Sized Enterprises (SMEs) in Indonesia, with Environmental Management Practices (EMP) acting as a mediating variable. Data were collected from 200 SME actors through a structured questionnaire. A key contribution of this study is the development of a new essential measurement model for green finance, specifically tailored for SMEs. This model consists of 15 validated indicators categorized into three dimensions, economic, social, and environmental, sourced from Govindaraj et al. (2024). The model captures nuanced aspects of SMEs' engagement with green finance, such as cost efficiency, environmental commitment, and stakeholder involvement.

The renewable energy practices construct was measured using six indicators adapted from Fazal et al. (2023), reflecting behaviors such as using renewable energy technology, avoiding non-renewable sources, and recommending renewable practices to others.

Environmental management practices were assessed with five indicators from Oriade et al. (2021), covering initiatives such as environmental education, use of local materials, and participation in environmental programs. Business sustainability was measured using five items from Dvorsky et al. (2024), including SMEs' awareness of sustainability goals and recognition of environmental and social impacts. All constructs were tested for reliability and validity through SmartPLS 4, using a disjoint two-stage approach, which is ideal for higher-order modeling and enables accurate assessment of relationships between latent constructs.

The analysis revealed that both green finance and renewable energy practices significantly affect business sustainability directly; however, their influence is notably stronger when mediated by environmental management practices. This finding suggests that implementing green finance and renewable energy practices in a way that reinforces environmental management, such as through structured environmental policies, pollution control, and resource efficiency, produces more impactful and sustainable outcomes. Moreover, among the three dimensions of green finance, the economic dimension was found to exert the most significant influence on business sustainability. This highlights the importance of financially oriented strategies, such as cost-saving measures and green profitability, in driving long-term sustainable performance among SMEs, providing valuable direction for future green financing initiatives.

RESULTS

Based on Table 1, this study involved 200 SME actors in Indonesia, with the majority of respondents being male business owners. Most participants were in the age range of 30 to 40 years old and held a bachelor's degree as their highest level of education. In terms of business experience, the dominant group had operated their businesses for 5 to 10 years. The manufacturing sector emerged as the most represented business type among respondents, followed by trade, agribusiness, and services. These characteristics reflect a diverse yet predominantly mid-aged, moderately educated, and experienced demographic actively engaged in productive sectors of the Indonesian SME landscape.

Table 1. Profile of Respondents

Characteristic	Category	Frequency	Percentage (%)
Gender	Male	124	62
	Female	76	38
Age	< 30 years	32	16
	30- 40 years	110	55
	> 40 years	58	29
Education Level	Senior High School	22	11
	Diploma	70	35
	Bachelor Degree	80	40
	Postgraduate	28	14
Business Tenure	< 5 years	40	20
	5-10 years	100	50
	> 10 years	60	30
Business Sector (SME)	Manufacturing	80	40
	Agribusiness	40	20
	Trade	50	25
	Services	30	15

As presented in Table 2, all indicators across the constructs met the required thresholds for validity and reliability. Each item demonstrated outer loading values above 0.6, indicating adequate indicator reliability. The Average Variance Extracted (AVE) values for all constructs exceeded 0.5, confirming the presence of convergent validity. Additionally, composite reliability values were above 0.7 for every latent construct, ensuring internal consistency. These results apply not only to the established constructs of renewable energy practices, environmental management practices, and business sustainability, but also to the newly developed green finance measurement model. The

new essential green finance instrument introduced in this study includes three dimensions: economic, environmental, and social, and all 15 items demonstrated strong psychometric properties. This validation supports the utility of the model for future research, particularly in the context of SMEs. The robust measurement properties provide a solid foundation for subsequent analysis of the structural relationships among the variables. The application of PLS-SEM allowed for a comprehensive assessment of the model, including the mediation effects of environmental management practices.

Table 2. Result of Outer Model Test

Construct	Indicator	Loading Factor	AVE	Cronbach's Alpha	Composite Reliability
Business Sustainability	BS1	0.707	0.781	0.927	0.946
	BS2	0.859			
	BS3	0.961			
	BS4	0.924			
	BS5	0.943			
Environmental Management Practice	EMP1	0.95	0.838	0.951	0.963
	EMP2	0.924			
	EMP3	0.924			
	EMP4	0.952			
	EMP5	0.822			
LV_Economic	GF1	0.77	0.737	0.914	0.933
	GF2	0.937			
	GF3	0.904			
	GF4	0.754			
	GF5	0.911			
LV_Environmental	GF11	0.911	0.773	0.925	0.944
	GF12	0.908			
	GF13	0.716			
	GF14	0.921			
	GF15	0.922			
LV_Social	GF6	0.865	0.692	0.891	0.918
	GF7	0.765			
	GF8	0.886			
	GF9	0.93			
	GF10	0.691			
Renewable Energy Practices	REP1	0.906	0.757	0.935	0.949
	REP2	0.74			
	REP3	0.911			
	REP4	0.809			
	REP5	0.94			
	REP6	0.898			

Table 3. Discriminant Validity

Variable	Business Sustainability	Environmental Management Practice	Green Finance
Environmental Management Practices (EMP)	0.713		
Green Finance (GF)	0.769	0.704	
Renewable Energy Practices (REP)	0.752	0.701	0.703

Based on Table 3, this study also confirmed discriminant validity using the Heterotrait-Monotrait (HTMT) ratio. The HTMT values for all construct pairs were below the conservative threshold of 0.90, indicating that each construct is empirically distinct from the others. This result strengthens the robustness of the measurement model, ensuring that the variables Green Finance (GF), with its newly developed essential dimensions, Renewable Energy Practices (REP), Environmental Management Practices (EMP), and Business Sustainability (BS), are conceptually and statistically separable. The fulfillment of both convergent and discriminant validity provides strong evidence for the reliability and validity of the constructs used in the structural model analysis. These findings validate

the appropriateness of the instrument, especially the new green finance framework tailored for SMEs, as a credible tool for future empirical studies.

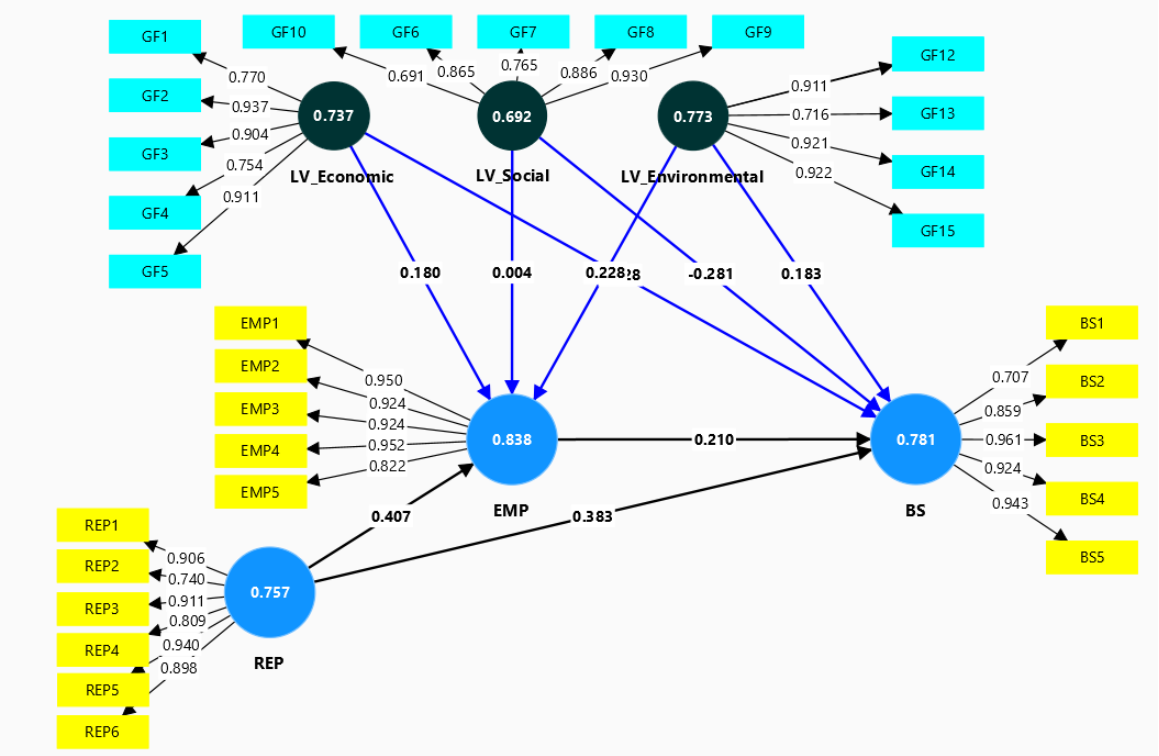

Figure 2. Outer Model Estimation Stage 1

Figure 2 shows PLS-SEM path model that examines how green finance and renewable energy practices drive business sustainability among Indonesian SMEs, with environmental management practices serving as a key mediator. The measurement model demonstrates strong validity, as all indicators for the constructs including the higher-order green finance with its economic, social, and environmental dimensions exhibit robust loadings. In the structural model, both green finance and renewable energy practices positively influence environmental management practices, which in turn significantly enhance business sustainability. Green finance also exerts a direct effect on sustainability, while its economic dimension emerges as the most influential pathway through mediation. The findings highlight that integrating green finance and renewable energy via structured environmental management yields stronger, mediated impacts on long-term SME sustainability.

Table 4. Goodness of fit Model

Variable	R-square (R^2)	Q-square (Q^2)	SRMR
Business Sustainability	0.664 (moderate)	0.498 (big predictive relevance)	0.086 (Perfect Fit)
Environmental Management Practices	0.536 (moderate)	0.445 (big predictive relevance)	

Based on Table 4, the R^2 values for business sustainability (0.664) and environmental management practices (0.536) fall within the moderate category, suggesting that the structural model explains a substantial portion of variance in the endogenous constructs. The Q^2 values 0.498 for business sustainability and 0.445 for environmental management practices indicate strong predictive relevance, reinforcing the model's capability in forecasting endogenous variables. Furthermore, the SRMR value of 0.086 indicates a perfect model fit, as it is below the recommended threshold of 0.10. These results collectively support the adequacy and robustness of the structural model in explaining the

relationships among green finance, renewable energy practices, environmental management practices, and business sustainability within the SME context.

Table 5. CVPAT

Variable	Q²_predict	RMSE	MAE
Business Sustainability	0.635	0.609	0.522
Environmental Management Practices	0.526	0.696	0.629

In addition to traditional goodness-of-fit measures, this study also employs the Cross-Validated Predictive Ability Test (CVPAT) to further validate the model's predictive power. Table 5 shows that the Q²_predict values for both business sustainability (0.635) and environmental management practices (0.526) exceed the zero threshold, indicating substantial predictive relevance. Furthermore, the Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) for both constructs remain within acceptable limits, with RMSE values of 0.609 for business sustainability and 0.696 for environmental management practices, and MAE values of 0.522 and 0.629, respectively. These results demonstrate that the model not only fits the sample data well but also has strong out-of-sample predictive performance. The inclusion of CVPAT strengthens the empirical evidence supporting the robustness and applicability of the proposed model, especially in the context of small and medium-sized enterprises.

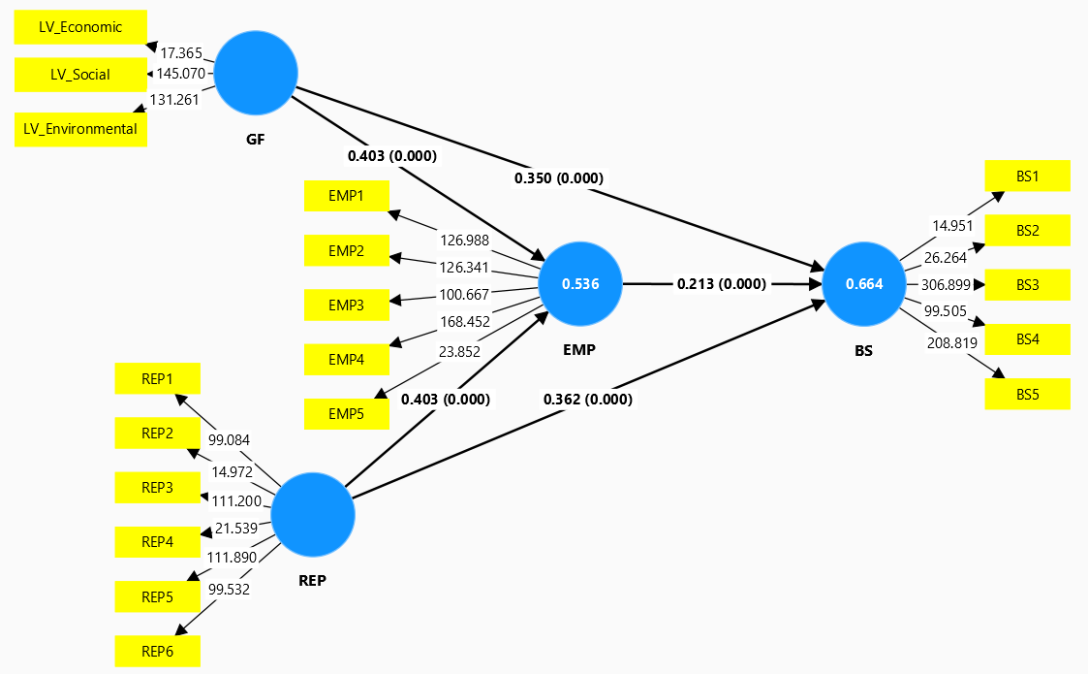

Figure 3. Inner Model Estimation

As shown in Figure 3, all structural paths in the model are statistically significant, indicating robust relationships among the latent variables. Detailed results, including path coefficients, t-values, and p-values for each hypothesis, are presented in Table 6, providing comprehensive evidence of the hypothesized causal links. These findings reinforce the theoretical framework and confirm the mediating role of environmental management practices between green finance, renewable energy practices, and business sustainability.

Table 6. Result of Inner Model Test

Path	Path Coefficient (O)	Sample Mean (M)	t-statistics	p-value	CI Lower (2.5%)	CI Upper (97.5%)
GF -> EMP	0.403	0.403	6.745	0.000	0.284	0.520
REP -> EMP	0.403	0.403	6.930	0.000	0.284	0.515
GF -> BS	0.350	0.350	6.502	0.000	0.238	0.448
REP -> BS	0.362	0.363	6.115	0.000	0.240	0.475
EMP -> BS	0.213	0.212	3.850	0.000	0.101	0.314
GF -> EMP -> BS	0.086	0.086	3.298	0.001	0.039	0.138
REP -> EMP -> BS	0.086	0.085	3.479	0.001	0.040	0.136

Note: BS= Business Sustainability, EMP=Environmental Management Practices, GF= Green Finance, REP= Renewable Energy Practices, CI= Confidence Interval.

PLS-SEM served as the main analytical technique in this study due to its suitability for testing complex models involving mediation. Based on Table 6, all structural paths in the model are statistically significant, confirming the robustness of the hypothesized relationships. Green Finance (GF) has a strong and direct effect on Business Sustainability (BS) ($\beta = 0.350$, $t = 6.502$, $p = 0.000$), and also significantly influences Environmental Management Practices (EMP) ($\beta = 0.403$, $t = 6.745$, $p = 0.000$). Similarly, Renewable Energy Practices (REP) show a significant direct effect on Business Sustainability (BS) ($\beta = 0.362$, $t = 6.115$, $p = 0.000$) and a parallel significant impact on EMP ($\beta = 0.403$, $t = 6.930$, $p = 0.000$). EMP itself positively influences Business Sustainability (BS) ($\beta = 0.213$, $t = 3.850$, $p = 0.000$), validating its strategic role. Importantly, the mediation effects of EMP are also statistically supported: GF, EMP, BS ($\beta = 0.086$, $t = 3.298$, $p = 0.001$) and REP, EMP, BS ($\beta = 0.086$, $t = 3.479$, $p = 0.001$), indicating that the indirect pathways strengthen the overall influence of green finance and renewable energy practices on sustainability outcomes. These findings confirm that environmental management practices is a significant mediating variable, amplifying the effectiveness of green financial and renewable energy practices in enhancing SMEs' business sustainability.

DISCUSSION

This study provides evidence that the 15 items across three dimensions of the green finance variable are valid and reliable, offering a new essential framework for future researchers. This measurement model facilitates a more detailed and accurate assessment of green finance, specifically tailored for SMEs, addressing the critical gap identified by Brooks and Schopohl (2020) and Roy and Shaw (2021), who criticized generalized models for failing to capture nuanced financial behaviors and sustainability practices of SMEs. This study develops a robust model consisting of 15 valid and reliable items across three critical dimensions: economic, environmental, and social, offering a more precise instrument for evaluating green finance implementation in the SME context, aligning with recent calls by Hou and Fang (2023) and Kumar et al. (2023) for context-specific measurement tools.

The measurement model was rigorously tested for internal consistency and construct validity using primary data, ensuring empirical soundness and real-world applicability. This framework addresses the critical gap identified by Trukhachev and Dzhikiya (2023) and Li et al. (2023) regarding the underrepresentation of SMEs in green finance assessments, despite their importance to sustainable economic growth. Moreover, it aligns with Xu et al. (2023), who emphasized linking financial instruments with environmental responsibility and sustainability-oriented decision-making.

A key finding reveals that although previous studies often showed Green Finance (GF) and Renewable Energy Practices (REP) do not always have significant direct impacts on business sustainability, this study identifies Environmental Management Practices (EMP) as a crucial mediating factor. This contrasts with earlier research assuming direct relationships. While Zhang et al. (2022) and Khan et al. (2022) emphasized renewable energy investments and technological innovation, they overlooked implementation

mechanisms through which these investments translate into sustainability outcomes. Our findings suggest inconsistent results in prior literature may stem from absent mediating variables in analytical models.

This new measurement model provides granular insights into how SMEs access and utilize green finance, offering a foundation for future research and enabling policymakers, financial institutions, and development agencies to design more targeted interventions supporting green transitions at the grassroots level (Kumar et al., 2022; Hou & Fang, 2023; Saarinen & Aarikka-Stenroos, 2023). Despite widespread recognition of green finance as a driver of sustainability, its direct impact on SME performance remains inconsistent. This study identifies environmental management practices as a key mediating factor, showing that green finance and renewable energy practices yield stronger sustainability outcomes when operationalized through structured EMPs, addressing inconsistencies in prior studies that overlooked this mechanism.

Furthermore, this research responds to the limited empirical evidence on which green finance dimension, economic, environmental, or social, has the strongest influence on sustainability. Previous studies by Khan et al. (2022), Zhang et al. (2022), and Zhang and Umar (2023) emphasized renewable energy investments, innovation, and partnerships or examined instruments such as green bonds within broader financial systems, but rarely analyzed dimension-specific effects in SMEs. As Debrah et al. (2022) and Yu et al. (2023) note, the evolving nature of green finance requires deeper investigation into its components, which may affect enterprises differently depending on context and environmental performance.

These findings extend stakeholder theory by showing that economic stakeholders have greater influence on small and medium enterprises' sustainability decisions than environmental or social stakeholders due to resource constraints. They also refine institutional theory, indicating that green finance adoption is driven by economic efficiency rather than mere institutional isomorphism. Small and medium enterprise managers should prioritize green finance initiatives with clear economic returns and strengthen environmental management systems, as these transform financial resources into tangible sustainability outcomes. Policymakers and financial institutions should design schemes emphasizing economic viability. Development agencies should provide capacity-building programs for environmental management practices.

CONCLUSION

This study concludes that while green finance and renewable energy practices directly influence small and medium enterprise sustainability, their impact becomes significantly stronger when mediated by environmental management practices. This critical finding reveals that green finance and renewable energy practices must be strategically channelled through structured environmental policies, resource efficiency initiatives, and pollution control mechanisms to produce substantial and lasting sustainability improvements. Furthermore, among the three green finance dimensions, economic, environmental, and social, the economic dimension demonstrates the most significant impact on business sustainability, highlighting that cost efficiency and green profitability are paramount drivers for enhancing long-term sustainable performance in small and medium enterprises.

In practical terms, small and medium enterprise managers should prioritize investments in robust environmental management practices and infrastructure before or alongside green finance initiatives to maximize sustainability outcomes. Policymakers and financial institutions should design green finance schemes emphasizing economic viability and return on investment, while bundling financial support with capacity-building programs for the implementation of renewable energy practices. However, this study has several limitations. The cross-sectional design limits causal inference, and the focus on specific geographic or sectoral contexts may affect generalizability. Additionally, reliance on self-reported data may introduce response bias. Future research should conduct longitudinal studies to examine the temporal dynamics of green finance,

environmental management practice, and sustainability relationships. Comparative research across different industries and regions would enhance understanding of contextual factors. Investigations should also explore mechanisms through which environmental and social dimensions of green finance can be strengthened, and examine the optimal sequencing and integration of economic, environmental, and social green finance strategies to achieve holistic sustainability in resource-constrained small and medium enterprise settings.

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