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Digital Safety Management Systems and Green Finance for MSMEs Financial Sustainability: Evidence from ESG-Based Risk Management

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ABSTRACT

The rapid advancement of digital transformation and the growing global emphasis on sustainability have placed Micro, Small, and Medium Enterprises (MSMEs), particularly in emerging economies such as Indonesia, under increasing pressure to enhance financial resilience while aligning with Environmental, Social, and Governance (ESG) standards. In the context of MSMEs in Medan City, North Sumatra, digitalization offers opportunities for efficiency and market expansion but also introduces challenges, including cyber risks, weak digital security governance, and limited access to green financing. These constraints may hinder long-term financial sustainability without integrated governance and effective risk management. This study examines the influence of Digital Safety Management Systems and Green Finance on MSMEs' Financial Sustainability, with ESG-Based Budgeting and Risk Management as mediating variables. A quantitative explanatory approach was employed using purposive sampling of 230 MSMEs with digital system adoption and access to formal financing. Data collected from December 2025 to February 2026 were analyzed using SEM-PLS. The results show that Digital Safety Management Systems and Green Finance significantly enhance Financial Sustainability both directly and indirectly. The mediation analysis indicates partial mediation, with Risk Management as the most influential mechanism. This study contributes by integrating digital safety governance and green finance within an ESG-based risk management framework, offering a novel perspective that bridges fintech risk management and sustainability accounting in MSMEs. The findings provide practical insights for policymakers in developing countries to strengthen MSME sustainability.

1. Introduction

The global economy increasingly positions sustainability and digital transformation as key drivers of business resilience, particularly for Micro, Small, and Medium Enterprises (MSMEs), which play a dominant role in economic development. In Indonesia, MSMEs account for more than 64 million business units, contributing approximately 60% of national GDP and 97% of total employment, underscoring their strategic importance in sustaining economic growth and social stability (Ministry of Cooperatives and SMEs, 2023; OECD, 2023). At the regional level, MSMEs in Medan City, North Sumatra, significantly contribute to local economic activities, especially in trade and services, making their financial sustainability a critical issue.

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Despite their importance, MSMEs face increasing pressure in the digital and sustainability era. Digital transformation offers opportunities for efficiency, innovation, and market expansion; however, it also introduces challenges such as rising cyber risks, weak digital security governance, and limited technological capabilities (Bada & Nurse, 2019). Simultaneously, the growing adoption of Environmental, Social, and Governance (ESG) principles and green finance requires MSMEs to align their business practices with sustainability standards, even though access to sustainable financing remains limited (Flammer, 2021). These dual pressures indicate the need for integrated approaches that combine digital safety, financial access, and risk management to ensure long-term financial sustainability.

Previous studies have demonstrated that digital transformation enhances firm performance and sustainability when supported by strong governance (Ahmed et al., 2024), while ESG practices improve competitiveness and financial outcomes (Akhtar et al., 2025; Khan et al., 2026). In addition, green finance has been shown to encourage sustainable business practices (Flammer, 2021), and effective risk management strengthens organizational resilience (Brustbauer, 2016). However, these studies generally examine these factors in isolation and provide limited insight into how they interact within MSMEs, particularly in emerging economies. Despite this growing body of literature, there is still a lack of integrated empirical models that simultaneously examine the role of Digital Safety Management Systems and Green Finance in enhancing MSME Financial Sustainability. Moreover, the mediating roles of ESG-Based Budgeting and Risk Management remain underexplored, especially within a Structural Equation Modeling framework. This limitation restricts a comprehensive understanding of how digital transformation and sustainable finance jointly influence financial resilience in MSMEs.

To address this gap, this study develops an integrated framework that links Digital Safety Management Systems and Green Finance to Financial Sustainability through ESG-Based Budgeting and Risk Management. Grounded in the Resource-Based View (Barney, 1991), this study highlights digital security and sustainable finance as strategic resources that enhance organizational capability and resilience. By combining digital safety governance and green finance within an ESG-based risk management framework, this study offers a novel and more comprehensive explanation of MSME financial sustainability, particularly in the context of emerging economies.

Therefore, this study aims to analyze the direct and indirect effects of Digital Safety Management Systems and Green Finance on Financial Sustainability through ESG-Based Budgeting and Risk Management. The findings are expected to contribute to the literature on digital transformation and sustainable finance integration, as well as provide practical insights for policymakers and MSME practitioners in strengthening financial resilience in the digital and sustainability transition era.

2. Literature Review

2.1 Conceptual and Theoretical Foundations

2.1.1 Digital Safety Management Systems

Digital Safety Management Systems refer to a set of policies, procedures, technologies, and control mechanisms designed to protect an organization's digital assets from cyber threats, data breaches, and technology-based operational disruptions. In the context of MSMEs, these systems include customer data protection, electronic transaction security, information access management, and integrated information security governance. The literature indicates that the level of digital security readiness among MSMEs remains relatively low compared to large corporations, despite their increasing reliance on digital systems for operations and marketing activities (Bada & Nurse, 2019). In developing countries such as Indonesia, MSMEs often operate with

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limited cybersecurity awareness and infrastructure, making them more vulnerable to cyber threats compared to firms in developed economies. Recent reports indicate that a significant proportion of Indonesian MSMEs lack formal digital security protocols, increasing their exposure to fraud and data breaches (Ministry of Communication and Informatics, 2023).

From the perspective of the Resource-Based View, digital security capability can be regarded as a strategic resource that generates sustained competitive advantage by enhancing trust among customers and business partners (Barney, 1991). Previous studies also suggest that information security contributes to operational stability and corporate reputation, which ultimately influence financial performance (Kshetri, 2010). Furthermore, the implementation of sound information security governance promotes transparency and accountability, aligning with ESG principles, particularly within the governance dimension (Hahn & Kühnen, 2013). Therefore, Digital Safety Management Systems function not merely as protective mechanisms but also as governance foundations that support business sustainability. While prior studies emphasize the positive role of digital security in enhancing organizational performance, some studies argue that the adoption of digital security systems in MSMEs remains largely reactive and cost-driven rather than strategic, limiting its effectiveness in supporting long-term sustainability.

Recent research also shows that Digital Safety Management Systems are increasingly recognized as a predictive governance mechanism capable of strengthening risk governance and operational safety in digital environments (Al-Dmour et al., 2026). The integration of digital safety practices with knowledge management and organizational learning further contributes to sustainable organizational performance (Al-Edenat, 2026).

2.1.2 Green Finance

Green Finance refers to financing schemes designed to support environmentally friendly and sustainable economic activities. Green finance instruments include green bonds, green loans, and sustainability-linked project financing that require compliance with specific environmental and social standards (Flammer, 2021). In recent years, green finance has become a strategic instrument in promoting the transition toward a low-carbon economy and sustainable development (Taghizadeh-Hesary et al., 2021).

For MSMEs, access to green finance not only provides alternative capital sources but also encourages improvements in management standards and compliance with sustainability practices. Empirical studies indicate that firms receiving green financing tend to enhance the quality of ESG disclosure and improve their environmental performance (Gillani et al., 2021). Moreover, green financing is often accompanied by stricter risk management requirements, indirectly strengthening internal control systems and governance practices (OECD, 2023). Hence, Green Finance acts as a catalyst for integrating sustainability principles into MSMEs' financial strategies. In the Indonesian context, access to green finance for MSMEs remains relatively limited due to regulatory constraints, lack of awareness, and insufficient financial literacy. Although government initiatives and financial institutions have started promoting green financing schemes, their penetration among MSMEs is still uneven, particularly outside major urban areas.

Empirical evidence also indicates that green finance stimulates environmental risk management and improves sustainability-oriented investment behavior among SMEs (Li et al., 2023). Moreover, sustainable financing mechanisms increasingly interact with fintech adoption and digital financial ecosystems to enhance SME sustainability performance (Asad et al., 2025). While many studies report a positive relationship between green finance and

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sustainability performance, other findings suggest that the impact may vary depending on firm size and institutional support, with MSMEs often facing difficulties in fully utilizing green financing due to compliance costs and administrative complexity.

2.1.3 ESG-Based Budgeting

ESG-Based Budgeting is a budgeting approach that integrates environmental, social, and governance considerations into organizational planning and resource allocation processes. This concept has evolved alongside increasing attention to sustainable finance and corporate accountability toward stakeholders (Hahn & Kühnen, 2013). ESG-based budgeting extends beyond short-term financial targets by incorporating long-term social and environmental impacts into financial planning. Unlike general sustainability-oriented financial planning, ESG-Based Budgeting specifically refers to the formal integration of measurable ESG indicators into budgeting processes, including the allocation of financial resources based on environmental targets, social impact metrics, and governance compliance requirements. This distinguishes ESG-Based Budgeting from broader concepts such as sustainability reporting or green accounting, which focus more on disclosure rather than resource allocation decisions.

Research shows that firms integrating ESG principles into financial planning tend to achieve better reputations and more stable long-term performance (Friede et al., 2015). In the MSME context, ESG-Based Budgeting can help business owners allocate resources more responsibly and strategically, particularly under capital constraints. Additionally, integrating ESG considerations into budgeting enhances transparency and business legitimacy in the eyes of investors and financial institutions (Gillani et al., 2021). While sustainability reporting emphasizes transparency and external communication, ESG-Based Budgeting operates internally as a strategic decision-making tool that directly influences financial planning and resource distribution. Therefore, ESG-Based Budgeting serves as an important mechanism bridging sustainability practices and financial management.

The adoption of sustainability-oriented budgeting practices has also been linked to improvements in innovation capacity and information quality within organizations, ultimately contributing to sustainable performance outcomes (Alhasnawi et al., 2025).

2.1.4 Risk Management

Risk Management is a systematic process of identifying, analyzing, and controlling risks that may affect the achievement of organizational objectives. In MSMEs, risks include financial, operational, strategic, technological, and cybersecurity risks. Studies indicate that many MSMEs lack formal and structured risk management systems, making them more vulnerable to external shocks (Brustbauer, 2016). In the context of MSMEs in developing economies, risk management practices are often informal and unstructured, relying heavily on managerial intuition rather than systematic frameworks. This contrasts with larger firms that implement Enterprise Risk Management more comprehensively.

The implementation of Enterprise Risk Management in MSMEs has been shown to enhance business resilience and financial performance stability (Lechner & Gatzert, 2018). Effective risk management also increases investor and creditor confidence, as it reflects sound governance practices (Hoyt & Liebenberg, 2011). In the era of digital transformation and green transition, risk management becomes increasingly critical, as organizations must simultaneously manage risks related to technological change and sustainability requirements. Thus, Risk Management functions as a control mechanism that ensures long-term business continuity. Although prior research generally supports the positive impact of risk management on financial performance, some studies highlight that excessive risk control may limit innovation and

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strategic flexibility, particularly in resource-constrained MSMEs.

2.1.5 Financial Sustainability of MSMEs

Financial Sustainability refers to an organization's ability to maintain stable and sustainable financial performance over the long term without compromising operational continuity. In the MSME context, financial sustainability is not solely measured by profitability but also by resilience to risk, access to financing, and cash flow stability (Ayyagari et al., 2011). In developing countries, MSME financial sustainability is also influenced by external factors such as access to financing, institutional support, and market volatility, making it more complex compared to firms in developed economies.

The literature suggests that integrating sustainability practices and sound governance is positively associated with long-term financial performance (Friede et al., 2015). Furthermore, firms with strong risk management systems tend to experience lower income volatility and greater resilience during economic crises (Lechner & Gatzert, 2018). For MSMEs, financial sustainability is a critical indicator of business success, as it determines their capacity to survive and grow amid market dynamics. Therefore, Financial Sustainability represents a strategic outcome influenced by the integration of digital security, green finance, ESG-based budgeting, and risk management practices.

Sustainable business practices are increasingly evaluated through integrated economic, social, and environmental performance dimensions that influence organizational outcomes and long-term competitiveness (Ciuciuc et al., 2026). Additionally, sustainability considerations in capital allocation decisions have implications for corporate cost of capital and financial stability (Mielcarz et al., 2026).

2.2 Review of Empirical Studies

Recent empirical studies demonstrate consistent patterns linking digital capability, green finance, ESG integration, and risk management to sustainability outcomes.

Studies show that digital security enhances governance quality and organizational resilience (Al-Dmour et al., 2026; Al-Edenat, 2026), although MSMEs often adopt such systems reactively. Green finance has been empirically linked to improved ESG performance and sustainability-oriented investment (Gillani et al., 2021; Li et al., 2023; Asad et al., 2025), though its effectiveness varies depending on institutional support.

Similarly, ESG integration in financial planning improves long-term performance (Friede et al., 2015) and innovation capacity (Alhasnawi et al., 2025). Risk management has been consistently associated with financial stability and resilience (Lechner & Gatzert, 2018; Hoyt & Liebenberg, 2011), though excessive control may limit innovation in MSMEs.

Despite these findings, prior studies often examine these variables in isolation, with limited integration across digital, financial, and sustainability dimensions.

2.3 Identification of the Research Gap

Based on the literature, several gaps are identified. First, prior studies largely examine digital security, green finance, ESG practices, and risk management independently, with limited integration into a unified framework explaining MSME financial sustainability.

Second, empirical evidence on ESG-Based Budgeting as an internal governance mechanism remains limited, particularly in MSMEs. Third, the mediating roles of ESG-based budgeting and risk management in linking digital capability and green finance to financial sustainability are underexplored.

Finally, most studies focus on large firms or developed economies, leaving a contextual gap in MSMEs within developing countries such as Indonesia. These gaps highlight the need for an integrated model examining how digital safety and green finance influence financial

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sustainability through governance and risk mechanisms.

2.4 Development of the Conceptual Framework

This study develops a conceptual framework integrating:

- Digital Safety Management Systems
- Green Finance
- ESG-Based Budgeting
- Risk Management
- Financial Sustainability

The framework proposes that digital and financial resources influence sustainability outcomes both directly and indirectly through governance (ESG-based budgeting) and control mechanisms (risk management). ESG-Based Budgeting functions as a strategic mechanism translating sustainability commitments into financial planning, while Risk Management ensures stability and resilience. Together, these variables form an integrated system driving MSME financial sustainability.

2.5 Hypothesis Development

2.5.1 *Digital Safety Management Systems and ESG-Based Budgeting*

Digital transformation has reshaped organizational governance structures, including within the MSME sector, which increasingly relies on technology-based information systems. In this context, Digital Safety Management Systems are not merely technical protection instruments but strategic organizational capabilities. According to the Resource-Based View, valuable, rare, inimitable, and non-substitutable resources can generate sustained competitive advantage (Barney, 1991). Integrated digital security systems meet these criteria because they enhance data integrity, information reliability, and organizational credibility in the eyes of stakeholders.

From the perspective of Stakeholder Theory, organizations are required to be accountable not only for financial outcomes but also for social and environmental impacts (Freeman, 1984). The implementation of ESG-Based Budgeting requires accurate and protected information systems to systematically integrate environmental, social, and governance indicators into financial planning. Without adequate digital protection, risks of data manipulation, information leakage, and reporting inconsistencies may undermine the credibility of ESG practices (Gillani et al., 2021).

Furthermore, Legitimacy Theory explains that organizations seek to maintain social legitimacy through transparency and compliance with prevailing norms (Suchman, 1995). Digital security systems reinforce this legitimacy by ensuring that sustainability information integrated into ESG-based budgeting is valid and verifiable. (Hahn and Kühnen, 2013) found that reporting system quality is positively associated with more comprehensive sustainability disclosure.

In MSMEs with limited resources, integrating digital security may serve as a foundation for enhancing financial governance professionalism. However, some studies suggest that digital systems alone do not guarantee improved governance outcomes without complementary managerial capabilities, indicating that the relationship may depend on organizational readiness. Therefore, stronger Digital Safety Management Systems are expected to increase the likelihood of effective and consistent ESG-Based Budgeting implementation.

H1: Digital Safety Management Systems positively influence ESG-Based Budgeting.

2.5.2 Digital Safety Management Systems and Risk Management

Modern risk management extends beyond conventional financial risks to include digital, operational, reputational, and compliance risks. In the digital economy era, cyber threats represent one of the most significant risks for increasingly digitalized MSMEs (Kshetri, 2010). Dependence on information systems without adequate security increases exposure to fraud,

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data theft, and operational disruption.

Enterprise Risk Management Theory emphasizes that risk management effectiveness depends on the quality of internal control systems and monitoring mechanisms (Hoyt & Liebenberg, 2011). Digital Safety Management Systems provide infrastructure enabling early threat detection, access control, and real-time system monitoring. Thus, digital security becomes a structural component of risk management frameworks.

Lechner and Gatzert (2018) demonstrated that firms with integrated risk management systems achieve greater financial stability and lower income volatility. In MSMEs, digital security integration strengthens the identification and mitigation of increasingly complex technological risks. Without adequate security systems, risk management practices tend to be reactive and unsystematic.

From the perspective of Signaling Theory, investments in digital security send positive signals to investors and creditors regarding a firm's seriousness in managing risks (Spence, 1973). This enhances MSMEs' access to financing and strengthens market trust. Therefore, Digital Safety Management Systems not only reduce operational risk but also enhance organizational capacity for comprehensive risk management.

H2: Digital Safety Management Systems positively influence Risk Management.

2.5.3 Green Finance and ESG-Based Budgeting

Green Finance represents financing mechanisms explicitly linked to environmentally and socially sustainable projects or activities. According to Sustainable Finance Theory, green finance is not merely a financial instrument but also a policy tool encouraging organizations to adopt more responsible business practices (Flammer, 2021). Firms accessing green finance are typically required to comply with transparency standards, ESG disclosures, and environmental impact management requirements. From the perspective of Stakeholder Theory, access to green finance increases normative pressure for organizations to demonstrate genuine sustainability commitment (Freeman, 1984). This pressure translates into the need to integrate ESG indicators into planning and budgeting processes. Without integration into budgeting systems, sustainability commitments risk becoming symbolic rather than strategic.

Institutional Isomorphism Theory suggests that organizations adapt practices in response to institutional norms and standards (DiMaggio & Powell, 1983). As green finance becomes more prominent in global financial systems, MSMEs seeking to maintain financing access are incentivized to align budgeting systems with ESG principles. Empirical evidence indicates that firms receiving green financing improve ESG disclosure quality and sustainability integration into financial strategies (Gillani et al., 2021). Nevertheless, the effectiveness of green finance in influencing internal budgeting practices may vary depending on the level of institutional enforcement and firm-level absorptive capacity.

In MSMEs, green finance may act as a catalyst for financial governance transformation, encouraging shifts from conventional budgeting toward structured ESG-Based Budgeting.

H3: Green Finance positively influences ESG-Based Budgeting.

2.5.4 Green Finance and Risk Management

Green Finance often entails stricter environmental, social, and governance risk management requirements compared to conventional financing. Risk Governance Theory posits that sustainable financing integrates non-financial risk assessment into investment and credit decisions (Taghizadeh-Hesary et al., 2021). This requires organizations to strengthen risk management systems to meet comprehensive evaluation standards.

From the perspective of Signaling Theory, firms receiving green finance signal to the market that they possess adequate risk management capacity to handle environmental

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and social impacts (Spence, 1973). This signal enhances reputation and promotes internalization of risk management practices.

Contingency Theory suggests that organizational risk management structures evolve in response to environmental complexity (Donaldson, 2001). When MSMEs engage in green financing schemes with high compliance standards, they must develop more systematic risk identification, evaluation, and mitigation mechanisms. (Lechner and Gatzert, 2018) found that organizations with integrated risk management systems demonstrate more stable performance and lower risk exposure.

Thus, green finance not only provides financial benefits but also enhances risk management quality through compliance requirements and external monitoring.

H4: Green Finance positively influences Risk Management.

2.5.5 ESG-Based Budgeting and Financial Sustainability

ESG-Based Budgeting represents the integration of sustainability principles into organizational resource allocation. According to the Triple Bottom Line framework, corporate sustainability depends on balancing economic, social, and environmental performance (Elkington, 1997). ESG-based budgeting enables organizations to internalize these dimensions into strategic decisions.

A meta-analysis by (Friede et al., 2015) indicates a positive relationship between ESG performance and long-term financial performance. ESG integration in budgeting enhances resource efficiency, strengthens reputation, and reduces litigation and regulatory risks. Legitimacy Theory suggests that organizations meeting societal expectations gain greater stakeholder support (Suchman, 1995).

In MSMEs, ESG-Based Budgeting guides investments toward sustainable activities and reduces resource waste. Despite the generally positive relationship between ESG integration and financial performance, some studies report mixed results, particularly in SMEs where resource constraints may limit effective implementation.

H5: ESG-Based Budgeting positively influences Financial Sustainability.

2.5.6 Risk Management and Financial Sustainability

Risk Management functions as a control mechanism enabling organizations to anticipate and mitigate uncertainty. Within Enterprise Risk Management frameworks, effective risk management enhances cash flow stability and firm value (Hoyt & Liebenberg, 2011).

Lechner and Gatzert (2018) found that comprehensive risk management correlates positively with long-term financial performance. In MSMEs, operational and financial risks have greater impact due to limited resources and capital reserves. Thus, effective risk management becomes critical for business sustainability. Dynamic Capabilities Theory posits that the ability to identify and respond adaptively to risks is a strategic capability determining long-term survival (Teece, 2007).

H6: Risk Management positively influences Financial Sustainability.

2.5.7 *The Mediating Role of ESG-Based Budgeting in the Relationship between Digital Safety Management Systems and Financial Sustainability*

Digital Safety Management Systems directly enhance operational stability and reduce technological risks. However, in the context of long-term financial sustainability, their impact is not always direct. Digital security primarily functions as a governance infrastructure that strengthens information quality and organizational accountability. According to the Resource-Based View, superior digital capabilities create value when combined with organizational mechanisms capable of strategically exploiting those resources (Barney, 1991). In this regard, ESG-Based Budgeting acts as an organizational

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mechanism that converts digital capabilities into financial sustainability outcomes.

From the perspective of Stakeholder Theory, digital security systems increase stakeholder trust in the integrity of corporate data. This trust enables organizations to be more transparent in integrating ESG indicators into budgeting processes. Without budgeting systems aligned with ESG principles, digital security may merely enhance operational efficiency without directly influencing long-term sustainability orientation.

Moreover, Legitimacy Theory posits that organizations gain social support when their practices align with societal expectations (Suchman, 1995). Digital safety strengthens governance legitimacy, but sustainability legitimacy is achieved only when ESG principles are internalized in financial planning. Thus, ESG-Based Budgeting serves as a strategic pathway bridging digital security and financial sustainability.

Therefore, the impact of Digital Safety Management Systems on Financial Sustainability is expected to occur through improvements in ESG-Based Budgeting.

H7: ESG-Based Budgeting mediates the relationship between Digital Safety Management Systems and Financial Sustainability.

2.5.8 *The Mediating Role of Risk Management in the Relationship between Digital Safety Management Systems and Financial Sustainability*

Digital Safety Management Systems contribute to the reduction of technological and operational risks; however, long-term financial sustainability largely depends on how organizations integrate these systems into broader risk management frameworks. Enterprise Risk Management Theory explains that the economic value of internal control systems emerges when they become part of structured risk identification and mitigation processes (Hoyt & Liebenberg, 2011).

From the perspective of Dynamic Capabilities Theory, an organization's ability to reconfigure digital resources to respond to risks constitutes a key determinant of long-term sustainability (Teece, 2007). Digital safety provides technical capability, while Risk Management transforms that capability into strategic decision-making mechanisms that reduce volatility and enhance financial stability.

Additionally, Signaling Theory suggests that firms with strong risk management systems send credibility signals to investors and creditors (Spence, 1973). Consequently, digital security integrated within risk management systems improves access to financing and lowers the cost of capital, thereby strengthening financial sustainability.

Therefore, the influence of Digital Safety Management Systems on Financial Sustainability is expected to occur through enhanced Risk Management effectiveness.

H8: Risk Management mediates the relationship between Digital Safety Management Systems and Financial Sustainability.

2.5.9 *The Mediating Role of ESG-Based Budgeting in the Relationship between Green Finance and Financial Sustainability*

Green Finance directly provides MSMEs with access to capital; however, its impact on long-term financial sustainability depends significantly on how the funds are managed. According to Sustainable Finance Theory, green financing creates value when organizations internalize ESG principles within their financial strategies (Flammer, 2021). Without integration into budgeting systems, green finance may merely serve as short-term liquidity support.

Institutional Theory explains that regulatory and normative pressures from financial institutions encourage organizations to adopt formal sustainability practices (DiMaggio & Powell, 1983). ESG-Based Budgeting represents an institutional response

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that internalizes green finance requirements into financial planning processes.

A meta-analysis by (Friede et al., 2015) indicates that the positive relationship between ESG and financial performance is stronger when ESG principles are integrated into management and budgeting systems rather than being merely symbolic disclosures. Thus, ESG-Based Budgeting serves as a conversion mechanism between access to green finance and financial sustainability outcomes.

Therefore, the effect of Green Finance on Financial Sustainability is expected to be mediated by ESG-Based Budgeting.

H9: ESG-Based Budgeting mediates the relationship between Green Finance and Financial Sustainability.

2.5.10 *The Mediating Role of Risk Management in the Relationship between Green Finance and Financial Sustainability*

Green Finance often requires stricter environmental and social risk management standards compared to conventional financing. Risk Governance Theory emphasizes that sustainable financing enhances organizational capacity to manage non-financial risks that affect economic stability (Taghizadeh-Hesary et al., 2021).

From the perspective of Contingency Theory, organizational risk management structures evolve in response to financing complexity and external pressures (Donaldson, 2001). When MSMEs obtain green finance, they are encouraged to develop more formal and comprehensive risk management systems.

Moreover, Enterprise Risk Management has been shown to enhance firm value and reduce the probability of financial distress (Lechner & Gatzert, 2018). Therefore, green finance strengthens financial sustainability not only through additional capital but also through improvements in Risk Management quality.

Accordingly, the influence of Green Finance on Financial Sustainability is expected to occur through enhanced Risk Management effectiveness.

H10: Risk Management mediates the relationship between Green Finance and Financial Sustainability.

3. Research Methods

3.1 Research Design

This study employs a quantitative approach with an explanatory research design. The quantitative approach is appropriate because the study aims to test causal relationships among variables formulated in the conceptual framework. The explanatory design is used to examine both direct and indirect effects through hypothesis testing. The analytical method applied is Partial Least Squares Structural Equation Modeling (PLS-SEM).

PLS-SEM was selected for several reasons. First, the research model is complex and involves mediating variables. Second, it is prediction-oriented and suitable for theory development. Third, it does not require strict assumptions of normal data distribution. Fourth, it is appropriate for moderate sample sizes. This method is widely recommended for structural analysis in MSME contexts (Hair et al., 2022).

Additionally, this study considers potential endogeneity issues and applies diagnostic procedures to ensure robustness.

3.2 Research Context and Setting

This study was conducted in Medan City, North Sumatra, Indonesia, focusing on MSMEs operating in trade, services, and creative industries. Medan was selected due to its role as a major economic center where MSMEs actively engage in digital business practices and financial activities.

Data collection was carried out from December 2025 to February 2026, ensuring operational stability and minimizing seasonal bias. This context enhances the relevance and replicability of the study in similar emerging economy settings.

3.3 Population and Sample / Research

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Participants

3.3.1 Population

The population of this study consists of MSMEs that meet the following criteria:

a. Have been operating for at least two years
b. Utilize digital systems in transactions or business management
c. Have experience in accessing formal financing

These criteria were established to ensure alignment with the variables examined in this study, particularly Digital Safety Management Systems and Green Finance.

3.3.2 Sampling Technique

The sampling technique employed in this study is purposive sampling, which involves selecting respondents based on specific criteria relevant to the research objectives (Sekaran & Bougie, 2016).

The respondents consist of business owners, managers, or individuals responsible for financial management and operational systems within MSMEs. These respondents were selected because they possess adequate knowledge regarding digital security practices, financing decisions, budgeting processes, and risk management within their organizations.

However, the use of purposive sampling may introduce selection bias, as the sample may not fully represent the broader MSME population. In addition, the reliance on self-reported data may lead to potential response bias, including social desirability bias. To mitigate these limitations, this study ensured respondent anonymity, used clearly structured and neutral questionnaire items, and conducted preliminary validation to improve response accuracy and consistency.

3.3.3 Sample Size

The total sample size in this study is 230 MSME respondents. The determination of the sample size follows the PLS-SEM guideline, which suggests that the minimum sample size should be ten times the largest number of structural paths directed at any endogenous construct (Hair et al., 2022). In the proposed model, the construct Financial Sustainability has two direct paths, resulting in a minimum required sample of 20 respondents.

However, the use of 230 respondents in this study:

a. Significantly exceeds the minimum requirement
b. Enhances parameter estimation stability
c. Increases statistical power
d. Reduces the likelihood of Type II error

Therefore, a sample size of 230 is considered highly adequate for PLS-SEM analysis and provides more robust and reliable results.

3.4 Data Sources and Data Collection

This study utilizes both primary and secondary data sources.

3.4.1 Primary Data

Primary data were collected through the distribution of structured questionnaires to MSME respondents. The questionnaires were administered both directly and through online platforms to increase the response rate and coverage.

3.4.2 Secondary Data

Secondary data were obtained from scientific literature, reputable academic journals, official reports, and policy documents related to MSMEs, green finance, and risk management.

3.5 Measurement of Variabels and Research Instrument

The research instrument consists of a structured questionnaire using a five-point Likert scale, defined as follows:

1 = Strongly disagree
2 = Disagree
3 = Neutral
4 = Agree
5 = Strongly agree

The Likert scale was selected because it is effective in measuring respondents'

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perceptions and attitudes toward latent constructs (Sekaran & Bougie, 2016).

The measurement indicators were adapted from prior studies that have demonstrated validity and reliability and were subsequently adjusted to fit the MSME context.

Before large-scale distribution, the instrument underwent:

a. Content validity assessment
b. A limited pilot test
c. Preliminary reliability evaluation

These steps were undertaken to ensure clarity of questions and internal consistency of the instrument.

Table 1. Operational Definition of Variables

Variable	Operational Definition	Indicators
Digital Safety Management Systems	The system of information security management and digital data protection in MSME operations	Data security, access control, transaction protection, system monitoring
Green Finance	Access to and utilization of sustainability-based financing	Access to green financing, environmental compliance, ESG requirements
ESG-Based Budgeting	Integration of environmental, social, and governance principles into the budgeting process	Sustainable budget allocation, transparency, accountability
Risk Management	The process of identifying, evaluating, and mitigating business risks	Risk identification, risk evaluation, risk mitigation
Financial Sustainability	The ability to maintain long-term financial stability	Cash flow stability, sustainable profitability, business resilience

3.6 Data Analysis Technique

Data analysis was conducted using the SmartPLS software through the following stages:

3.6.1 Measurement Model Evaluation (Outer Model)

The outer model evaluation was performed to assess the validity and reliability of the constructs through:

a) Convergent validity (loading factor > 0.70; AVE > 0.50)
b) Discriminant validity (Fornell-Larcker criterion and HTMT ratio)
c) Composite reliability (> 0.70)
d) Cronbach's alpha (> 0.70)

(Hair et al., 2022; Henseler et al., 2015)

3.6.2 Structural Model Evaluation (Inner Model)

The inner model evaluation was conducted by examining:

a) R-square values
b) Path coefficients
c) Significance testing using bootstrapping with 5,000 resamples
d) Effect size (f^2)
e) Predictive relevance (Q^2)

Hypotheses were considered supported when:

a) t-statistic > 1.96
b) p-value < 0.05

3.6.3 Mediation Analysis

Mediation testing was conducted by examining the indirect effects using the bootstrapping procedure. Mediation was considered significant when the p-value was less than 0.05 (Hair et al., 2022).

3.6.4 Data Quality Assessment

To ensure data quality and reliability, the following tests were conducted:

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a. Common Method Bias test using Harman's single factor test
b. Full collinearity test (VIF < 3.3) to further detect potential common method variance
c. Multicollinearity test using Variance Inflation Factor (VIF < 5)
d. Outlier detection to identify extreme data values

In addition, procedural remedies were applied to minimize common method bias, including assuring respondent anonymity, separating measurement of predictor and criterion variables, and using different scale anchors. Furthermore, endogeneity concerns were addressed by examining model specification and conducting robustness checks through alternative model estimations to confirm the stability of the results.

3.7 Validity, Reliability, and Trustworthiness

To ensure data quality:

a. Convergent and discriminant validity tests
b. Reliability tests (Composite Reliability & Cronbach's Alpha)
c. Common Method Bias (Harman's single factor test)
d. Full collinearity test (VIF < 3.3)
e. Multicollinearity test (VIF < 5)
f. Outlier detection

Procedural remedies include anonymity, separation of variables, and neutral scale design.

3.8 Ethical Considerations

This study adheres to ethical research standards by ensuring:

a. Respondent anonymity and confidentiality
b. Voluntary participation
c. Informed consent

These measures ensure data protection and academic integrity.

3.9 Research Procedure

The research was conducted through the following stages:

a. Development of conceptual framework and hypotheses
b. Instrument design and validation
c. Pilot testing
d. Data collection
e. Data screening and cleaning
f. PLS-SEM analysis
g. Interpretation of results

3.10 Methodological Limitations

This study acknowledges several limitations:

a. Use of purposive sampling may limit generalizability
b. Reliance on self-reported data may introduce response bias
c. Cross-sectional design limits causal inference over time

Despite these limitations, mitigation strategies were applied to enhance robustness and reliability.

4. Results and Discussion

4.1 Research Results

4.1.1 Sample Description and Descriptive Statistics

This section presents an overview of the characteristics of respondents involved in the study. The respondents consisted of 230 MSME actors who met the research criteria, namely having adopted digital systems in their business operations and having access to formal financing. Respondent characteristics were analyzed based on gender, age, educational level, business duration, and business sector.

The presentation of these characteristics aims to provide a profile of respondents that serves as the foundation for subsequent analyses.

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Table 2. Respondent Characteristics (n = 230)

No	Characteristics	Category	Frequency	Percentage (%)
1	Gender	Male	128	55.7
		Female	102	44.3
2	Age	< 30 years	46	20.0
		30–40 years	89	38.7
		41–50 years	65	28.3
		> 50 years	30	13.0
3	Education Level	High School/Vocational School	72	31.3
		Diploma	54	23.5
		Bachelor's Degree	92	40.0
		Postgraduate	12	5.2
4	Business Duration	2–5 years	84	36.5
		6–10 years	91	39.6
		> 10 years	55	23.9
5	Business Sector	Trade	97	42.2
		Services	68	29.6
		Manufacturing	45	19.6
		Others	20	8.6

Source: Data Processed (2026)

Based on Table 2, the majority of respondents were male, accounting for 55.7%, while female respondents represented 44.3%. This indicates that MSME ownership or management in this study is relatively balanced in terms of gender. In terms of age, most respondents were within the 30–40-year age group (38.7%), followed by those aged 41–50 years (28.3%). These findings suggest that the majority of MSME actors are within a productive age range and possess considerable business experience.

Regarding educational background, most respondents held a Bachelor's degree (40.0%), followed by High School or Vocational School graduates (31.3%). This indicates that respondents have adequate literacy levels to understand digital systems, financial management, and access to financing.

In terms of business duration, most MSMEs had been operating for 6–10 years (39.6%), reflecting operational stability and experience in navigating business dynamics. Meanwhile, the trade sector dominated the sample (42.2%), followed by the service sector (29.6%). This composition reflects the general structure of MSMEs in Indonesia, which are predominantly engaged in trade and services.

Overall, the respondent characteristics demonstrate sufficient demographic and business diversity, enabling the sample to represent MSME conditions relevant to this study. The diverse respondent profile supports the external validity of the research and strengthens the interpretation of structural analysis results presented in the subsequent sections.

4.1.2 Data Quality and Preliminary Analysis

In the data analysis using SmartPLS, the evaluation of the outer model was conducted based on three main criteria: convergent validity, discriminant validity, and composite reliability. These criteria aim to ensure the

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quality of construct measurement within the research model. Convergent validity indicates the extent to which indicators within a construct are correlated and capable of representing the same variable, commonly assessed through loading factor values and Average Variance Extracted (AVE). Discriminant validity is used to ensure that each construct is empirically distinct from other constructs, thereby preventing measurement overlap among variables. Meanwhile, composite reliability evaluates the internal consistency of indicators in measuring a construct, reflecting the reliability of the measurement instrument used in the study.

a. Convergent Validity

Convergent validity in the measurement model with reflective indicators was evaluated based on the correlation between indicator scores and construct scores estimated using the PLS software. Reflective indicators are considered to have good convergent validity when their loading values exceed 0.70, indicating that the indicators strongly and consistently represent the intended construct.

Table 3. Outer Loadings (Measurement Model)

Indicator	Digital Safety Management Systems (X1)	ESG-Based Budgeting (Z1)	Financial Sustainability of MSMEs (Y)	Green Finance (X2)	Risk Management (Z2)
X1.1	0.751				
X1.2	0.750				
X1.3	0.722				
X1.4	0.723				
X1.5	0.756				
X2.1				0.728	
X2.2				0.761	
X2.3				0.789	
X2.4				0.783	
X2.5				0.732	
Y.1			0.728		
Y.2			0.737		
Y.3			0.724		
Y.4			0.782		
Y.5			0.742		
Z1.1		0.838			
Z1.2		0.756			
Z1.3		0.748			
Z1.4		0.857			
Z1.5		0.856			
Z2.1					0.741
Z2.2					0.737
Z2.3					0.706
Z2.4					0.762
Z2.5					0.716

Source: Data Processed (2026)

The results of data processing using SmartPLS presented in Table 3 indicate that the outer model values, or the correlations between indicators and their respective constructs, have

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met the criteria for convergent validity, as all indicators exhibit loading factors above 0.70. Therefore, the modified measurement model can be considered to have satisfied the requirements for good convergent validity.

b. Discriminant Validity

Discriminant validity is used to ensure that each latent construct in the research model is empirically distinct from the other constructs. A model is considered to have good discriminant validity when each indicator demonstrates the highest loading on the construct it is intended to measure compared to its loadings on other constructs. The results of the discriminant validity test using the Fornell–Larcker criterion are presented as follows:

Table 4. Discriminant Validity (Fornell–Larcker Criterion)

Constructs	Digital Safety Management Systems (X1)	ESG-Based Budgeting (Z1)	Financial Sustainability of MSMEs (Y)	Green Finance (X2)	Risk Management (Z2)
Digital Safety Management Systems (X1)	0.741				
ESG-Based Budgeting (Z1)	0.858	0.812			
Financial Sustainability of MSMEs (Y)	0.901	0.853	0.743		
Green Finance (X2)	0.860	0.883	0.889	0.759	
Risk Management (Z2)	0.927	0.858	0.946	0.883	0.733

Source: Data Processed (2026)

The results indicate that each construct demonstrates adequate discriminant validity according to the Fornell–Larcker criterion, as the square root of the Average Variance Extracted (AVE) for each construct is greater than the correlations between constructs. This confirms that each latent variable in the model is empirically distinct and measures a unique concept.

c. Composite Reliability

Validity and reliability criteria can also be assessed through the reliability values of each construct and the Average Variance Extracted (AVE). A construct is considered to have high reliability if its composite reliability value exceeds 0.70 and its AVE value is above 0.50.

Table 5. Composite Reliability Values

Constructs	**Cronbach's Alpha**	**Composite Reliability (rho_a)**	**Composite Reliability (rho_c)**	**Average Variance Extracted (AVE)**
Digital Safety Management Systems (X1)	0.794	0.795	0.859	0.549
ESG-Based Budgeting (Z1)	0.872	0.887	0.906	0.660
Financial Sustainability of MSMEs (Y)	0.797	0.798	0.860	0.552
Green Finance (X2)	0.816	0.816	0.872	0.576
Risk Management (Z2)	0.784	0.785	0.853	0.537

Source: Data Processed (2026)

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Based on Table 5, it can be concluded that all constructs meet the reliability criteria. This is demonstrated by composite reliability values above 0.70 and AVE values exceeding 0.50, in accordance with the recommended thresholds. Therefore, the measurement model can be considered reliable and suitable for further structural model analysis.

4.1.3 Main Analytical Results

a. Structural Model Testing (Inner Model)

The evaluation of the inner model, or structural model, was conducted to examine the relationships among constructs, the significance values, and the R-square values of the research model. The structural model was assessed by analyzing the R-square values of the endogenous constructs, the t-statistics, and the significance of the structural path coefficients.

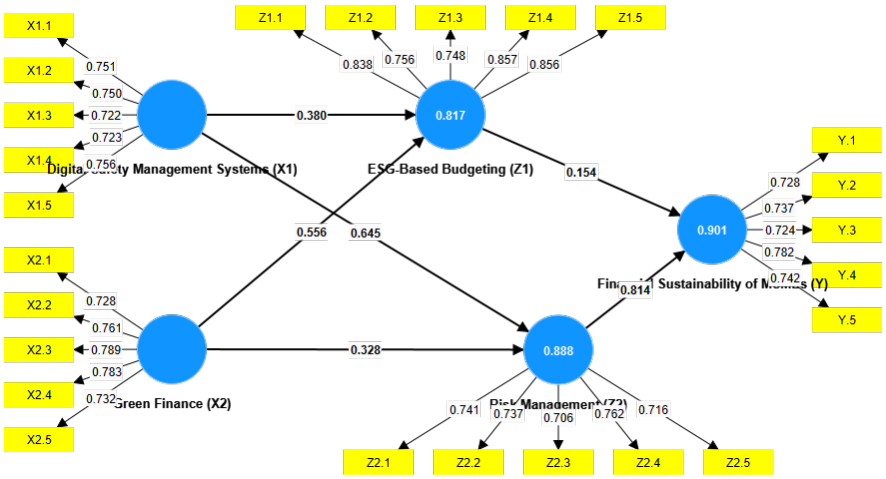

Figure 1. Tested Structural Model

In PLS analysis, model assessment begins by examining the R-square values for each endogenous latent variable. Table 6 presents the R-square estimation results obtained using SmartPLS.

Table 6. R-Square Values

Constructs	R-square	Adjusted R-square
ESG-Based Budgeting (Z1)	0.817	0.814
Financial Sustainability of MSMEs (Y)	0.901	0.900
Risk Management (Z2)	0.888	0.887

Source: Data Processed (2026)

Based on the structural model evaluation results, the R-square values indicate that the model has very strong explanatory power for the endogenous variables. The R-square value for ESG-Based Budgeting (Z1) of 0.817 indicates that 81.7% of the variance in ESG-based budgeting can be explained by Digital Safety Management Systems and Green Finance. This suggests that the better the implementation of digital security systems and green financing practices, the stronger the orientation of MSMEs toward sustainability-based budgeting.

Furthermore, the R-square value for Financial Sustainability of MSMEs (Y) of 0.901 indicates that 90.1% of the variance in MSME financial sustainability is explained by the combined influence of digital security, green finance, ESG-based budgeting, and risk management. This finding confirms that the integration of digital capabilities and sustainable financial practices plays a crucial

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role in determining the financial resilience of MSMEs.

Meanwhile, the R-square value for Risk Management (Z2) of 0.888 indicates that 88.8% of the variance in MSMEs' risk management capability can be explained by Digital Safety Management Systems and Green Finance. This implies that both factors significantly contribute to strengthening MSMEs' capacity to identify, manage, and mitigate various business risks.

4.1.4 Hypothesis Testing Results

a. Direct Effects

Table 7. Direct Effect Results

Path	Original Sample (O)	Standard Deviation	T-Statistic	P-Value	Result
Digital Safety Management Systems → ESG-Based Budgeting	0.380	0.052	7.288	0.000	Supported
Digital Safety Management Systems → Risk Management	0.645	0.058	11.088	0.000	Supported
ESG-Based Budgeting → Financial Sustainability	0.154	0.046	3.325	0.001	Supported
Green Finance → ESG-Based Budgeting	0.556	0.049	11.326	0.000	Supported
Green Finance → Risk Management	0.328	0.057	5.757	0.000	Supported
Risk Management → Financial Sustainability	0.814	0.047	17.410	0.000	Supported

Source: Data Processed (2026)

Table 7 indicates the following findings:

First, the effect of Digital Safety Management Systems on ESG-Based Budgeting shows a positive and significant relationship. This indicates that better implementation of digital security systems within MSMEs strengthens their tendency to adopt ESG-based budgeting practices. Secure, transparent, and accountable financial data management enhances the integration of sustainability principles into budgeting processes.

Second, Digital Safety Management Systems have a positive and significant influence on Risk Management. This finding suggests that stronger digital security management improves the effectiveness of risk management practices, as it helps reduce risks related to data breaches, fraud, and technology-based operational disruptions.

Third, ESG-Based Budgeting has a positive and significant effect on the Financial Sustainability of MSMEs. This indicates that the better the integration of ESG principles into budgeting processes, the stronger the financial sustainability of MSMEs. Allocating resources while considering environmental, social, and governance aspects supports long-term business performance and stability.

Fourth, Green Finance positively and significantly influences ESG-Based Budgeting. This implies that greater access to and utilization of green financing encourages MSMEs to integrate sustainability principles into their financial planning and budgeting processes.

Fifth, Green Finance has a positive and significant effect on Risk Management. This finding indicates that improved utilization of green financing enhances risk management practices, as sustainability-based financing typically involves stricter compliance standards

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and more comprehensive risk governance requirements.

Sixth, Risk Management positively and significantly affects the Financial Sustainability of MSMEs. This result suggests that effective risk management practices contribute to higher levels of financial sustainability, as they minimize potential losses, improve business stability, and strengthen MSMEs' resilience against economic uncertainty.

b. Mediation Effects

This analysis examines both direct and indirect effects to determine whether the mediating variables significantly mediate the relationship between independent and dependent variables. Mediation testing was conducted by analyzing the indirect effect output. A mediating effect is considered significant when the p-value is less than 0.05.

Table 8. Mediation Effect Results

Indirect Path	Original Sample (O)	Standard Deviation	T-Statistic	P-Value	Result
Digital Safety Management Systems → ESG-Based Budgeting → Financial Sustainability	0.059	0.019	3.139	0.002	Supported
Digital Safety Management Systems → Risk Management → Financial Sustainability	0.525	0.059	8.960	0.000	Supported
Green Finance → ESG-Based Budgeting → Financial Sustainability	0.086	0.028	3.056	0.002	Supported
Green Finance → Risk Management → Financial Sustainability	0.267	0.048	5.562	0.000	Supported

Source: Data Processed (2026)

First, ESG-Based Budgeting significantly mediates the relationship between Digital Safety Management Systems and Financial Sustainability of MSMEs. This finding indicates that digital security systems not only influence financial sustainability directly but also strengthen it through improved integration of ESG principles in budgeting practices. Strong digital security enhances data integrity and transparency, which supports more effective sustainability-oriented financial planning.

Second, Risk Management significantly mediates the relationship between Digital Safety Management Systems and Financial Sustainability. This suggests that robust digital security enhances risk management effectiveness, which subsequently strengthens financial sustainability. Digital security reduces operational and technological risks, and when integrated into structured risk management practices, it contributes to long-term financial resilience.

Third, ESG-Based Budgeting significantly mediates the relationship between Green Finance and Financial Sustainability. This result indicates that access to and utilization of green financing encourages the adoption of ESG-based budgeting practices, which in turn contribute to improved financial sustainability. Green financing therefore creates value when sustainability principles are systematically embedded in financial planning processes.

Fourth, Risk Management significantly mediates the relationship between Green

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Finance and Financial Sustainability. This finding implies that green finance enhances financial sustainability not only through capital access but also by strengthening risk management practices. Sustainability-linked financing typically requires stricter compliance and governance standards, which improve organizational resilience and long-term financial stability.

c. Effect Size (f^2)

Effect size (f^2) is used to assess the magnitude of the specific influence of an independent variable on the predictive capability of a dependent variable. The evaluation is conducted by comparing the change in the R^2 value when a particular independent variable is removed from the model. The interpretation of f^2 values is as follows:

a) $f^2 < 0.02$ indicates a very small or negligible effect
b) $0.02 \leq f^2 < 0.15$ indicates a small effect
c) $0.15 \leq f^2 < 0.35$ indicates a moderate effect
d) $f^2 \geq 0.35$ indicates a large effect

Based on the analysis results, the effect size values for each structural relationship are presented below.

Table 9. Effect Size (f^2) Results

Structural Path	f^2 Value	Effect Category
Digital Safety Management Systems → ESG-Based Budgeting	0.205	Moderate
Digital Safety Management Systems → Risk Management	0.967	Large
ESG-Based Budgeting → Financial Sustainability	0.063	Small
Green Finance → ESG-Based Budgeting	0.439	Large
Green Finance → Risk Management	0.251	Moderate
Risk Management → Financial Sustainability	1.762	Large

Source: Data Processed (2026)

First, the effect size of Digital Safety Management Systems on ESG-Based Budgeting is categorized as moderate. This indicates that digital security systems contribute meaningfully to improving the predictive power of the model regarding ESG-based budgeting. Substantively, when MSMEs possess strong digital security systems, including data protection, transaction security, and reliable information governance, they are more capable and confident in implementing ESG-based budgeting in a transparent and accountable manner.

Second, Digital Safety Management Systems demonstrate a large effect on Risk Management. This suggests that digital security plays a highly substantial role in strengthening risk management practices. Conceptually, this finding is consistent with the idea that robust digital security reduces exposure to data breaches, digital fraud, technological disruptions, and information-related uncertainties, thereby reinforcing overall risk management capabilities.

Third, ESG-Based Budgeting shows a small effect on Financial Sustainability. Although relatively modest, this effect remains meaningful, indicating that sustainability-oriented budgeting contributes to MSMEs' financial sustainability. ESG-based budgeting supports responsible resource allocation, enhances reputation, and strengthens long-term business viability, even if it is not the most dominant factor.

Fourth, Green Finance exhibits a large effect on ESG-Based Budgeting. This finding suggests that access to green financing strongly explains variations in ESG-based budgeting practices. In practical terms, greater access to sustainability-linked financing encourages

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MSMEs to integrate ESG principles into their financial planning and budgeting systems.

Fifth, Green Finance has a moderate effect on Risk Management. This indicates that sustainability-based financing contributes significantly to strengthening MSMEs' risk management practices. Green financing typically requires compliance standards, transparency, and environmental and operational risk mitigation, which indirectly enhance risk management capacity.

Finally, Risk Management demonstrates a very large effect on Financial Sustainability. This finding indicates that risk management is the most dominant variable in explaining MSMEs' financial sustainability. Substantively, MSMEs that are able to identify, analyze, and mitigate risks effectively tend to be more financially stable, more resilient to economic shocks, and more sustainable in the long term.

4.4 Research Discussion

4.4.1 Key Findings

a. The Effect of Digital Safety Management Systems on ESG-Based Budgeting

The findings indicate that Digital Safety Management Systems play a significant role in strengthening the implementation of ESG-Based Budgeting within MSMEs. This result suggests that digital security functions not merely as technical protection against cyber risks but also as a governance infrastructure that supports transparency and accountability in sustainability-oriented budgeting processes.

These findings are consistent with (Hahn and Kühnen, 2013), who argue that the quality of reporting systems and information governance is closely associated with the integration of sustainability aspects into organizational policies. (Gillani et al., 2021) further emphasize that strong governance mechanisms promote the systematic adoption of ESG practices. More recently, (Zhang and Chen, 2023) demonstrate that digital governance enhances the quality of ESG integration, particularly in firms undergoing digital transformation.

However, some prior studies suggest that digital transformation does not automatically influence sustainability practices if it is not accompanied by organizational culture change and managerial commitment (Scuotto et al., 2017). This divergence may be explained by the fact that previous research focused on general technology adoption rather than structured digital security systems, which are specifically examined in the present study.

From a practical perspective, this finding implies that MSME practitioners particularly in developing regions such as Indonesia should not treat digital security as a purely technical investment. Instead, it should be embedded within financial governance practices, such as budgeting procedures and internal reporting systems. Local MSMEs can begin with simple yet structured digital controls (e.g., transaction authentication, role-based access systems) to gradually support ESG-based financial planning.

b. The Effect of Digital Safety Management Systems on Risk Management

The results show that Digital Safety Management Systems contribute significantly to the effectiveness of Risk Management, confirming that digital security has become an integral component of modern risk governance.

This evidence supports (Kshetri, 2010), who identifies cyber risk as one of the primary risks in the digital economy. (Brustbauer, 2016) also finds that MSMEs with well-developed internal control systems tend to exhibit more structured risk management practices. More recently, (El Baz and Ruel, 2024) report that digital transformation accompanied by strengthened security systems enhances the operational resilience.

Conversely, some studies suggest that technology adoption does not necessarily improve risk management unless supported by adequate human resource competencies (Lechner & Gatzert, 2018).

Practically, this suggests that MSMEs should complement digital security investments with capacity building, such as

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basic cybersecurity training and risk awareness programs. Without human capability development, digital systems may remain underutilized.

c. The Effect of Green Finance on ESG-Based Budgeting

The findings reveal that Green Finance promotes the implementation of ESG-Based Budgeting in MSMEs, indicating that external financial pressure can drive internal governance transformation. This result aligns with (Flammer, 2021) and (Gillani et al., 2021), which highlight the role of sustainable financing in strengthening ESG integration. However, (Taghizadeh-Hesary et al., 2021) find that green finance does not always translate into substantive internal changes when firms focus only on compliance.

From a practical standpoint, MSMEs should not perceive green finance merely as an alternative funding source but as a strategic opportunity to improve financial discipline and sustainability-oriented planning. Local financial institutions and policymakers should also simplify administrative requirements to improve MSME accessibility.

d. The Effect of ESG-Based Budgeting on Financial Sustainability

The results show that ESG-Based Budgeting has a positive but relatively small effect on Financial Sustainability. While statistically significant, the effect size is weaker compared to other variables, particularly Risk Management.

This finding is consistent with (Friede et al., 2015), but also reveals an important nuance.

Critically, the relatively small effect suggests that ESG-based budgeting in MSMEs may still be at an early or symbolic stage of implementation. Many MSMEs may adopt ESG considerations in budgeting only superficially, without fully integrating them into strategic financial decision-making. Resource constraints, limited expertise, and short-term survival priorities may reduce the effectiveness of ESG budgeting practices.

Additionally, ESG budgeting may generate long-term benefits, while financial sustainability in MSMEs is often driven by short-term operational stability, explaining the weaker immediate effect.

Practically, this implies that MSMEs should move beyond symbolic ESG allocation toward measurable and outcome-based budgeting practices (e.g., cost savings from energy efficiency, waste reduction investments).

e. The Effect of Risk Management on Financial Sustainability

The findings indicate that Risk Management is the most dominant factor in enhancing MSMEs' Financial Sustainability. This result is consistent with (Hoyt and Liebenberg, 2011) and (Lechner and Gatzert, 2018), emphasizing that structured risk management reduces volatility and improves stability. Practically, this suggests that MSMEs should prioritize risk identification and mitigation as a core managerial function. Simple tools such as risk mapping, cash flow monitoring, and contingency planning can significantly enhance financial resilience, even without sophisticated systems.

f. Critical Evaluation of Model Robustness

The structural model demonstrates very high R-square values, particularly for Financial Sustainability (0.901) and Risk Management (0.888), indicating substantial explanatory power. While this suggests that the model captures key determinants of MSME sustainability, it also raises important methodological considerations.

From a methodological perspective, excessively high R-square values in PLS-SEM may indicate potential model overfitting, particularly when the model involves highly correlated constructs and perceptual data collected from a single source. In this study, the strong relationships among Digital Safety

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Management Systems, Green Finance, Risk Management, and Financial Sustainability may partially reflect shared variance arising from the measurement context rather than purely causal effects. Therefore, the findings should be interpreted with caution, especially regarding their generalizability.

Another important issue relates to common method variance (CMV). Although Harman's single-factor test did not indicate a dominant factor, prior research suggests that this approach alone may be insufficient to fully rule out CMV. To mitigate this concern, multicollinearity was assessed using Variance Inflation Factor (VIF), with all values below the recommended threshold, indicating that CMV is unlikely to severely bias the results. Nevertheless, future studies are encouraged to apply more advanced techniques, such as marker variables or full collinearity tests, to strengthen methodological rigor.

Endogeneity also represents a potential limitation, as the cross-sectional design restricts the ability to establish causal inference. It is possible that reverse causality or omitted variables may influence the observed relationships. For instance, financially sustainable MSMEs may have greater capacity to adopt digital security systems and access green finance. Future research is therefore recommended to employ longitudinal data or advanced econometric approaches, such as instrumental variables or Gaussian copula methods, to address endogeneity concerns.

Overall, while the model demonstrates strong predictive capability, these methodological considerations highlight the importance of cautious interpretation and provide direction for future research to enhance robustness and generalizability.

g. Managerial Implications for MSMEs

The findings of this study provide important contextual insights into how MSMEs interpret and respond to the increasing demands of digital governance and sustainability integration. Rather than viewing digital security, green finance, and ESG practices as independent initiatives, the results suggest that MSMEs tend to internalize these elements as part of an interconnected governance system that shapes financial sustainability outcomes.

From a contextual perspective, the dominant role of Risk Management indicates that MSMEs prioritize stability and survival over strategic transformation, particularly in uncertain business environments. This reflects the typical behavioral pattern of MSMEs in developing economies, where resource constraints encourage a more risk-averse and short-term oriented approach. Consequently, mechanisms such as ESG-Based Budgeting, although statistically significant, demonstrate a relatively smaller effect size because they require a longer-term strategic orientation and higher managerial sophistication.

Furthermore, the strong influence of Green Finance on both ESG-Based Budgeting and Risk Management suggests that external pressures particularly from financial institutions play a critical role in shaping internal governance practices. This implies that MSMEs are more responsive to externally imposed requirements than to internally driven sustainability initiatives. Such behavior aligns with institutional theory, where organizational practices are often influenced by coercive and normative pressures rather than purely strategic considerations.

Another important insight relates to the role of Digital Safety Management Systems, which appear to function as an enabling infrastructure rather than a direct driver of financial sustainability. The findings indicate that digital security contributes more significantly when it is embedded within organizational processes such as risk management and budgeting systems. This suggests that the value of digital transformation in MSMEs is contingent upon its integration into managerial and governance practices.

Overall, these findings highlight that MSME financial sustainability is not solely determined by resource availability or

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technological adoption, but by the extent to which these elements are translated into structured governance mechanisms. This contextual interpretation enriches the understanding of MSME behavior by emphasizing the importance of internal capability transformation rather than mere access to digital tools or financial resources.

4.2.2 Comparison with Previous Studies

The results are consistent with prior studies emphasizing the importance of governance and digital capability. The positive relationship between digital systems and ESG practices supports (Hahn and Kühnen, 2013) and (Gillani et al., 2021), while the role of digital risk aligns with (Kshetri, 2010). Similarly, the influence of green finance on sustainability practices confirms findings from Flammer (2021) and Taghizadeh-Hesary et al. (2021). However, the relatively small effect of ESG-Based Budgeting contrasts with Friede et al. (2015), suggesting contextual differences in MSMEs. This indicates that ESG practices in MSMEs may still be in an early stage of implementation.

4.2.3 Theoretical Contributions

This study contributes to the literature in several ways. First, it integrates Resource-Based View, Stakeholder Theory, and Risk Governance Theory into a unified framework explaining MSME financial sustainability. Second, it extends prior research by introducing ESG-Based Budgeting as an internal governance mechanism, rather than focusing solely on ESG disclosure.

Third, the study highlights the mediating roles of ESG-Based Budgeting and Risk Management, demonstrating that digital capability and green finance create value only when translated into governance processes. Thus, the findings enrich the theoretical understanding of sustainability in MSMEs by emphasizing process-based mechanisms.

4.2.4 Practical and Policy Implications

The findings provide important implications for MSMEs and policymakers. From a managerial perspective, MSMEs should:

a. Prioritize risk management practices as a foundation for sustainability
b. Integrate digital security into governance systems, not just technical operations
c. Utilize green finance strategically to improve financial planning
d. Implement ESG-based budgeting in a measurable and structured manner

From a policy perspective:

a. Financial institutions should simplify access to green finance
b. Governments should promote digital literacy and cybersecurity awareness
c. Support programs should focus on integrating sustainability into MSME financial management

4.2.5 Integration with the Research Gap

This study successfully addresses the identified research gap by:

a. Providing an integrated model linking digital capability, green finance, governance, and sustainability
b. Introducing ESG-Based Budgeting as a mediating mechanism
c. Examining MSMEs in a developing country context (Indonesia)
d. Demonstrating the importance of internal governance processes rather than isolated variables

Thus, the study offers both theoretical and empirical advancement in MSME sustainability research.

4.2.6 Acknowledgement of Study Limitations

Despite its contributions, several limitations should be acknowledged. First, the findings are context-specific to MSMEs in Medan, limiting generalizability. Second, the relatively small effect of ESG-Based Budgeting suggests that sustainability practices may still be evolving in MSMEs.

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Third, the strong relationships among variables may reflect contextual factors specific to emerging economies. Future research is encouraged to explore longitudinal designs, cross-country comparisons, and additional variables to strengthen generalizability and theoretical development.

5. Conclusion

5.1 Summary of Key Findings

This study examines the influence of Digital Safety Management Systems and Green Finance on the Financial Sustainability of Micro, Small, and Medium Enterprises (MSMEs), with ESG-Based Budgeting and Risk Management serving as mediating variables. The findings indicate that both Digital Safety Management Systems and Green Finance play important roles in improving the financial sustainability of MSMEs. Digital Safety Management Systems strengthen the implementation of ESG-Based Budgeting and enhance the effectiveness of Risk Management practices. This suggests that digital security functions not only as a technical protection mechanism but also as a governance foundation that promotes transparency, accountability, and improved risk control within MSMEs.

In addition, Green Finance encourages the integration of sustainability principles into budgeting and financial planning processes while strengthening the ability of MSMEs to manage risks. The results further demonstrate that ESG-Based Budgeting and Risk Management significantly contribute to Financial Sustainability, with Risk Management emerging as the most influential mechanism in supporting MSME financial resilience. These findings highlight that the capacity of MSMEs to identify, manage, and mitigate potential risks is a crucial factor in maintaining business stability and long-term sustainability in the digital economy.

5.2 Theoretical Contributions

This study provides several theoretical contributions to the literature on strategic management, sustainability, and MSME development. First, this research introduces an integrated conceptual framework that links Digital Safety Management Systems and Green Finance with Financial Sustainability through the mediating mechanisms of ESG-Based Budgeting and Risk Management. While previous studies have generally examined digital transformation, financial access, or sustainability practices separately, this study integrates these elements within a single structural model. By doing so, the research offers a more comprehensive explanation of how digital governance and sustainable financing jointly influence the long-term financial sustainability of MSMEs.

Second, this study extends the Resource-Based View (RBV) by demonstrating that digital resources and access to sustainable financing do not automatically generate organizational value unless they are transformed into internal capabilities through governance mechanisms. In this context, ESG-Based Budgeting and Risk Management function as organizational capabilities that convert digital infrastructure and financial resources into sustainable financial performance. This finding strengthens the RBV perspective by highlighting the importance of organizational processes and governance practices in transforming resources into sustainable competitive advantage.

Third, this research contributes to the MSME sustainability literature by positioning Digital Safety Management Systems as a strategic determinant of financial sustainability. Previous studies have primarily focused on technological adoption or financial inclusion as drivers of MSME performance. However, this study emphasizes the role of digital security governance as a critical organizational capability that supports risk mitigation, financial transparency, and sustainable financial management in digitally enabled MSMEs.

Finally, the study contributes to the growing literature on ESG-oriented governance in small business contexts. By empirically

demonstrating the mediating role of ESG-Based Budgeting and Risk Management, this research highlights how ESG principles can be operationalized in MSME financial management practices. Therefore, the study provides a theoretical foundation for understanding how digital transformation, sustainable finance, and ESG governance interact to support long-term financial sustainability in MSMEs.

5.3 Practical and Policy Implications

The findings of this study provide important practical implications for MSME actors. Business owners and managers should not only focus on expanding market opportunities but also prioritize strengthening digital security systems and implementing structured risk management practices. Integrating ESG-based budgeting into financial planning can help MSMEs better manage financial uncertainties and maintain long-term financial stability.

From a policy perspective, governments and financial institutions should encourage broader access to Green Finance programs for MSMEs while simultaneously providing governance assistance, digital security training, and risk management capacity building. The integration of digital transformation policies with sustainable financing initiatives can become an effective strategy for strengthening MSME resilience and competitiveness in the digital economy era.

5.4 Limitations of the Study

Despite its contributions, this study has several limitations. First, the research relies on a survey-based quantitative approach that captures respondents' perceptions, which may introduce subjectivity bias in the responses. Second, the study was conducted within a specific time frame, which limits the ability to capture long-term developments in digital transformation and financial sustainability. Third, the research focuses on MSMEs that have adopted digital systems and have access to formal financing, which may limit the generalizability of the findings to MSMEs that have not yet undergone digitalization or lack access to sustainable financing.

5.5 Directions for Future Research

Future research is recommended to adopt a longitudinal research design to better understand the long-term impact of digital transformation and sustainable financing on MSME financial sustainability. Such an approach would provide deeper insights into how digital governance and risk management practices evolve over time.

Additionally, future studies may combine quantitative and qualitative approaches to obtain a more comprehensive understanding of how Digital Safety Management Systems and Green Finance are implemented in MSME business practices. Expanding the research model by incorporating additional variables such as digital literacy, organizational culture, or government policy support as moderating factors may also provide deeper insights. Comparative studies across regions or countries are also recommended to explore differences in institutional environments and MSME characteristics, thereby enabling broader empirical generalization.

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