SUSTAINABLE CREDIT RISK GOVERNANCE : A SYSTEMATIC REVIEW OF ERM, ESG, AND DIGITAL READINESS IN MSME FINANCING IN INDONESIA

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Abstract

Micro, Small, and Medium Enterprises (MSMEs) contribute 61.7% to Indonesia's GDP and absorb 97% of the national workforce, yet more than 70% still lack access to formal financing. The banking sector faces a structural dilemma between financial inclusion objectives and prudent risk management, reflected in rising MSME non-performing loans (NPLs) which reached 4.41% in June 2025, equivalent to Rp 66.3 trillion of distressed credit. This study aims to develop a Sustainable Credit Risk Governance Model by integrating Enterprise Risk Management (ERM), Environmental, Social, and Governance (ESG) principles, and digital readiness in MSME financing. Using a Systematic Literature Review (SLR) approach following PRISMA protocols, this research synthesized 45 peer-reviewed articles published between 2013 and 2025 from Scopus, Web of Science, and Google Scholar. The findings indicate that banks implementing ESG-integrated credit assessments tend to experience lower NPLs and more stable net interest margins, while digital readiness enhances MSME credit access and reduces information asymmetry through alternative data and advanced analytics. This study proposes a four-layer Sustainable Credit Risk Governance Model consisting of : (1) Risk Governance Layer, (2) ESG Assessment Layer, (3) Digital Analytics Layer and (4) Stakeholder Engagement Layer. The integrated framework offers strategic implications for regulators, banks, and policymakers in aligning financial sustainability, risk-based supervision, and inclusive MSME financing in Indonesia.

Keywords*: MSMEs, Credit Risk Management, ESG, Digital Readiness, Credit Assessment*

1. INTRODUCTION

Background

The Micro, Small, and Medium Enterprise (MSME) sector serves as the backbone of Indonesia's economy, contributing approximately 61.7% to the national Gross Domestic Product (GDP) and absorbing more than 97% of the national workforce according to the Ministry of Cooperatives and SMEs (2024). Despite this significant economic contribution, access to formal financing remains a persistent challenge, with over 70% of MSMEs unable to obtain financing from formal financial institutions due to limitations in collateral, lack of credit history, and insufficient capacity to meet banks' standard risk assessment criteria as reported by the Financial Services Authority (OJK).

From the banking sector's perspective, MSME financing presents a fundamental dilemma between promoting financial inclusion and maintaining prudent risk management practices. While MSME lending can enhance bank profitability through portfolio diversification, it also introduces elevated risk exposure if control systems prove ineffective (Anwar, 2013). The current state of MSME credit quality underscores this challenge, with NPL rates reaching 4.41%

in June 2025, representing an increase from 4.04% in the previous year. In nominal terms, distressed MSME credit totaled Rp 66.3 trillion, marking a 17% increase within the first six months of 2025. Simultaneously, MSME credit growth decelerated to approximately 2% year-on-year, comprising only 18.6% of total industry credit, indicating banks' cautious approach toward expanding financing in this segment.

Globally, the banking industry is transitioning toward sustainable finance paradigms, with Environmental, Social, and Governance (ESG) frameworks becoming integral to credit decision-making and risk management processes. European and Asian banks are increasingly implementing sustainable lending frameworks to support green and inclusive economic transitions (Zheng et al., 2025). In Indonesia, this policy direction is embodied in the Sustainable Finance Roadmap Phase II (2021–2025), which encourages financial institutions to integrate ESG principles into their credit policies, particularly for the MSME sector. However, the implementation of sustainability in credit risk management continues to face structural gaps, with POJK No. 51/POJK.03/2017 on Sustainable Finance remaining insufficiently effective due to limited integration between banks' risk governance frameworks and social equity principles in credit allocation processes (Samosir, 2024).

The advent of digital technologies presents new opportunities for risk mitigation through enhanced data analytics and predictive algorithms, which improve credit risk assessment accuracy and accelerate decision-making processes (Rofi'i, 2023). International empirical evidence demonstrates that machine learning and alternative data can significantly reduce default rates in micro and MSME lending (Kassim & Huda, 2023; Verma et al., 2025). Nevertheless, digital readiness among Indonesian MSMEs remains heterogeneous, with low digital readiness serving as a primary barrier to accessing formal financing (Rashid et al., 2024). This creates a complex landscape where traditional collateral-based lending models prove inadequate for MSME characteristics, necessitating innovative approaches that integrate cash flow-based assessment, digital footprint analysis, and ESG compliance.

Research Gap

The growing literature on credit risk management, ESG integration, and digital readiness provides valuable insights, yet remains fragmented and lacks a unified perspective within Indonesia's MSME financing context. Existing studies typically examine these elements in isolation and rarely integrate ERM-CRM, ESG indicators, and digital capability into a single credit risk framework. Research on ESG largely focuses on reporting rather than MSME credit assessment, while digital readiness is seldom positioned as a determinant of credit risk through alternative data and analytics. Consequently, no comprehensive model has been developed that simultaneously incorporates ERM, ESG, and digital readiness within Indonesia's regulatory and MSME ecosystem.

2. THEORY REVIEW

Theoretical Framework

The theoretical foundation of this study rests on multiple interconnected theories that collectively explain the dynamics of sustainable credit risk governance. Stakeholder Theory (Freeman, 1984) provides the foundational understanding that banks must balance the interests of various stakeholders including shareholders, customers, regulators, and society at large. In the context of sustainable MSME financing, this theory emphasizes that credit decisions should

consider not only financial returns but also social and environmental impacts on communities and ecosystems.

Risk Governance Theory (Renn, 2008) explains how risks should be managed through integrated governance mechanisms encompassing organizational structure, risk culture, and information systems that support risk-based decision making. This theory ensures that credit risk is viewed not merely as a financial threat but as part of a broader corporate strategy toward long-term sustainability. The integration with Triple Bottom Line Theory (Elkington, 1997) expands corporate performance concepts beyond profitability to include People and Planet dimensions, forming the basis for ESG integration in credit risk assessment.

Technology Readiness Theory (Parasuraman, 2000) describes organizational and individual readiness to adopt new technologies for enhanced efficiency and effectiveness. In banking contexts, this theory explains how digital capabilities determine banks' ability to leverage analytics, big data, and machine learning for strengthening credit risk assessment while expanding sustainable MSME financing access. The Resource-Based View (Barney, 1991) and Dynamic Capability Theory (Teece et al., 1997) complement this framework by explaining how internal capabilities in risk management and digital transformation serve as sources of competitive advantage and organizational adaptability.

Enterprise Risk Management and Credit Risk Management Integration

Enterprise Risk Management (ERM) represents a strategic, organization-wide approach designed to identify, assess, and manage risks within acceptable tolerance levels. The COSO (2004) framework positions ERM as a structured system that supports risk-informed decision-making, while empirical studies such as Beasley et al. (2005) and Arena et al. (2010) highlight the importance of strong leadership commitment and risk culture for effective implementation. Organizations with mature ERM systems tend to exhibit greater resilience to economic fluctuations and improved anticipation of non-financial risks, including climate, social, and reputational risks that traditional oversight mechanisms often overlook.

Credit Risk Management (CRM) focuses more specifically on identifying and mitigating the risk of borrower default through frameworks such as the Basel Committee's (2006) Probability of Default, Loss Given Default, and Exposure at Default components. Contemporary developments extend CRM beyond collateral-based approaches toward cash flow-based and sustainability-oriented assessments. Weber (2018) introduces Sustainable Credit Risk Management (SCRM), integrating ESG indicators into credit evaluation to produce a more forward-looking and holistic risk assessment model.

The integration of ERM and CRM enables banks to adopt a comprehensive risk governance approach that aligns micro-level credit decisions with institution-wide risk strategies. Research by Gatzert and Martin (2015) shows that such integration reduces earnings volatility and strengthens oversight efficiency. In the Indonesian context, findings from Manurung et al. (2024) indicate that many banks implement ERM in fragmented ways without systematic linkage to CRM processes, resulting in delayed responses to emerging risks. Meanwhile, Weber and Scholz (2021) demonstrate that ESG-linked ERM systems contribute to lower NPLs and enhanced financial stability. Hossain et al. (2023) further reveal that the incorporation of digital tools—such as machine learning and behavioral analytics—into ERM-CRM frameworks reduces information asymmetry and accelerates MSME credit assessment.

ESG Integration in Banking and Credit Risk Assessment

The integration of Environmental, Social, and Governance (ESG) principles into banking operations represents a paradigm shift toward sustainable finance. Weber (2017) defines sustainable banking as balancing financial stability, social responsibility, and environmental protection, positioning banks as catalysts for social development through financing that supports green and inclusive economic growth. International evidence from Fasone et al. (2024) demonstrates that European banks integrating ESG criteria into MSME lending policies experience reduced NPLs and enhanced net interest margin stability over the 2012-2022 period.

Weerasekara et al. (2025) employ Granger causality analysis on Sri Lankan banking data, revealing that improved MSME sustainability performance significantly reduces bank credit risk. Banks actively channeling green or environmentally-friendly financing exhibit lower NPL probabilities, suggesting that attention to debtor sustainability performance can enhance credit quality through ESG credit scoring as an effective risk mitigation tool. This finding aligns with Weber (2018) who demonstrates that banks assessing environmental performance and social impact of debtors can reduce Loss Given Default (LGD) while strengthening sustainability reputation.

However, ESG implementation in Indonesian banking faces significant challenges. Samosir (2024) notes that POJK No. 51/POJK.03/2017 on Sustainable Finance remains insufficiently effective due to limited integration between banks' risk governance frameworks and social equity principles in credit allocation. Saifurrahman & Kassim (2024) highlight regulatory barriers, compliance burdens, and digital infrastructure disparities that impede MSME financing inclusion, particularly in Islamic banking. These findings underscore the need for more comprehensive regulatory frameworks and institutional capacity building to support effective ESG integration in credit risk management.

Digital Transformation in Credit Risk Management

Digital transformation has fundamentally altered credit risk assessment methodologies through advanced analytics, artificial intelligence, and alternative data utilization. Campanella et al. (2025) develop a Digital Readiness Index (DRI) for measuring MSME technological preparedness in credit access, finding through structural equation modeling that MSMEs with high digital readiness levels enjoy broader financing access and lower credit risk. This suggests that digital readiness serves not only as an internal bank IT capability measure but also as an indicator of customer capacity to utilize digital systems for financial reporting, loan monitoring, and liquidity management.

Hossain et al. (2023) examine MSME lending transformation through fintech and digital credit scoring, demonstrating that machine learning algorithms in credit assessment reduce asymmetric information between banks and debtors. Their key finding shows fintech lending enhances financial inclusion without compromising credit quality, reducing default rates by up to 30% compared to traditional methods. This evidence supports the potential of digital technologies to bridge the information gap that has historically limited MSME access to formal financing.

Rofi'i (2023) provides evidence that data analytics and predictive algorithms enhance credit risk assessment accuracy and accelerate decision-making processes. The utilization of alternative data sources including digital transaction patterns, social media behavior, and mobile phone usage creates more comprehensive borrower profiles that traditional financial statements

cannot provide. However, Rashid et al. (2024) identify that low digital readiness among Indonesian MSMEs remains a primary barrier to accessing formal financing, creating a digital divide that may exacerbate financial exclusion rather than alleviate it.

Empirical Studies in Indonesia

Indonesian banking research reveals significant gaps in ERM and CRM integration. Manurung et al. (2024) examine ERM implementation in major Indonesian banks, finding that most banks still apply ERM partially without direct linkage to CRM systems. This fragmented risk management approach causes delayed responses to market changes and suboptimal risk-based decision making. The study recommends holistic risk governance frameworks supported by data analytics and cross-divisional oversight to address these shortcomings.

Naiborhu et al. (2024) investigate the impact of bank governance structure, competition, and financial crises on MSME lending, revealing that governance quality significantly influences banks' willingness to extend MSME credit. Banks with strong corporate governance demonstrate greater resilience during economic downturns while maintaining support for the MSME sector. However, intense competition may lead to relaxed credit standards, potentially increasing systemic risk if not accompanied by robust risk management systems.

The regulatory environment presents additional challenges. Samosir (2024) evaluates the effectiveness of POJK No. 51/POJK.03/2017 on Sustainable Finance, concluding that implementation remains suboptimal due to unclear guidelines, limited technical capacity, and insufficient integration with existing risk management frameworks. Saifurrahman & Kassim (2024) specifically examine Islamic banking perspectives, identifying regulatory barriers, digital infrastructure gaps, and capacity constraints as primary impediments to sustainable MSME financing.

3. RESEARCH METHOD

This study employs a Systematic Literature Review (SLR) methodology following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocols to ensure comprehensive and unbiased coverage of relevant literature. The SLR approach was selected to synthesize existing knowledge, identify patterns and gaps, and develop a theoretical framework for sustainable credit risk governance in MSME financing. The systematic approach enhances the reliability and validity of findings while providing a solid foundation for the proposed conceptual model.

The literature search was conducted across multiple academic databases including Scopus, Web of Science, and Google Scholar using combinations of keywords related to "credit risk management," "MSME financing," "ESG," "sustainable finance," "digital readiness," "enterprise risk management," and "Indonesia." The search strategy included both English and Bahasa Indonesia publications to capture domestic research insights. Inclusion criteria encompassed peer-reviewed articles published between 2013-2025, focusing on empirical studies, theoretical papers, and case studies related to credit risk management, sustainable finance, and digital banking in MSME contexts. Exclusion criteria eliminated conference papers without full-text access, non-academic publications, and studies focusing solely on large corporate financing.

The selection process involved three stages: initial screening of titles and abstracts, full-text review of potentially relevant articles, and quality assessment using established criteria for

theoretical rigor, methodological soundness, and relevance to research objectives (**Table 1**). A total of 45 articles met the inclusion criteria and were subjected to thematic analysis to identify key themes, theoretical frameworks, empirical findings, and research gaps. Data extraction captured study characteristics, theoretical foundations, methodological approaches, key findings, and implications for practice and policy. The analysis employed both deductive coding based on predetermined themes (ERM, ESG, digital transformation) and inductive coding to identify emerging patterns and insights that inform the development of the integrated conceptual model.

Table 1. PRISMA Flow of Study Selection

Stage	Description	n
Identification	Records identified through database search	1,232
Screening	Records after duplicate removal	450
	Records excluded after title/abstract screening	405
Eligibility	Full-text articles assessed for eligibility	45
	Full-text articles excluded (not meeting criteria)	0
Included	Studies included in the Systematic Literature Review	45

4. RESULT AND DISCUSSION

Overview of Selected Studies

The systematic review process identified 45 peer-reviewed articles that met the inclusion criteria. These studies were published between 2013 and 2025, with a notable increase in publications after 2020, reflecting growing academic and practical interest in sustainable finance and digital transformation in banking. Geographically, the studies covered multiple regions including Europe (n=18), Asia (n=15), Indonesia specifically (n=8), and global comparative studies (n=4). Methodologically, the studies employed diverse approaches including quantitative analysis (n=22), qualitative case studies (n=12), mixed methods (n=8), and theoretical/conceptual frameworks (n=3). **Table 2** presents a comprehensive overview of the selected studies, organized by thematic focus.

Table 2. Distribution of Studies by Region, Method, and Time Period

Geographic Distribution	n	Methodological Approach	n	Publication Period	n
Europe	18	Quantitative	22	2013–2017	8
Asia (ex. Indonesia)	15	Qualitative	12	2018–2020	12
Indonesia	8	Mixed Methods	8	2021–2023	15
Global / Multi-country	4	Theoretical / Framework	3	2024–2025	10
Total	**45**	**Total**	**45**	**Total**	**45**

Note: The distribution shows concentration of recent studies (2021-2025: 55.6%) reflecting emerging interest in sustainable finance and digital transformation. European studies dominate (40%) due to advanced ESG integration, while Indonesia-specific studies (17.8%) provide critical contextual insights for model development.

Current Practices of Credit Risk Management in MSME Financing

The analysis reveals that Indonesian banks predominantly rely on collateral-based lending approaches for MSME financing, reflecting traditional risk management paradigms that emphasize asset-backed security over cash flow assessment. This approach creates significant

barriers for MSMEs, which typically lack sufficient collateral and formal financial documentation required by conventional credit evaluation processes. The review identifies information asymmetry as a critical challenge, where banks struggle to obtain reliable information about MSME business performance, market prospects, and repayment capacity due to informal record-keeping practices and limited financial reporting standards among small businesses.

Current NPL patterns demonstrate the limitations of existing approaches, with medium-sized enterprises showing the highest NPL rates (4.36%) compared to micro (1.76%) and small (3.04%) segments. This pattern suggests that one-size-fits-all risk management approaches fail to address the diverse risk profiles and financing needs across different MSME categories. The analysis indicates that banks require more nuanced, segment-specific risk assessment methodologies that account for business lifecycle stages, sector characteristics, and regional economic conditions affecting MSME performance.

ESG Integration in Credit Risk Assessment

The systematic review provides compelling evidence that banks implementing ESG-integrated credit risk assessment frameworks achieve superior risk-adjusted returns and enhanced portfolio stability. Studies from Fasone et al. (2024) demonstrate that European banks incorporating ESG criteria in MSME lending experience significant NPL reductions and improved Net Interest Margins over extended periods. The sustainability screening process enables banks to identify MSMEs with stronger governance practices, environmental consciousness, and social responsibility, which correlate with better financial discipline and lower default probabilities.

Weber (2018) provides theoretical and empirical support for Sustainable Credit Risk Management (SCRM) frameworks that integrate environmental and social impact assessments into traditional financial risk evaluation. Banks utilizing ESG scoring systems report enhanced due diligence processes that capture non-financial risks often overlooked by conventional assessment methods. These include regulatory compliance risks, reputational risks, and operational risks associated with environmental degradation or social conflicts that can significantly impact MSME business continuity and repayment capacity.

However, the implementation of ESG integration faces substantial barriers in the Indonesian context. Regulatory frameworks remain insufficient to provide clear guidance on ESG risk assessment methodologies, standardized metrics, and reporting requirements. The costs of implementing comprehensive ESG evaluation systems present challenges for smaller banks with limited technological and human resources. Additionally, MSMEs themselves often lack awareness and capacity to implement sustainability practices, creating a capacity gap that requires coordinated efforts between banks, regulators, and business development agencies.

Digital Readiness and Credit Access

The analysis reveals that digital readiness serves as a critical determinant of both credit access and risk mitigation in MSME financing. Campanella et al. (2025) provide empirical evidence that MSMEs with higher Digital Readiness Index (DRI) scores enjoy preferential access to financing and demonstrate lower default rates due to enhanced business process efficiency and financial management capabilities. Digital technologies enable more accurate and

timely assessment of MSME creditworthiness through alternative data sources including transaction histories, digital payment patterns, and online business activities.

Artificial intelligence and machine learning applications in credit scoring have demonstrated significant potential for reducing information asymmetry challenges. Hossain et al. (2023) document that fintech lending platforms utilizing advanced analytics achieve up to 30% reduction in default rates compared to traditional assessment methods. These technologies enable behavioral scoring models that capture borrower patterns and preferences, providing more comprehensive risk profiles than static financial statement analysis. The integration of alternative data sources including mobile phone usage, social media activity, and e-commerce transactions creates opportunities for financial inclusion of MSMEs previously excluded from formal banking due to insufficient documentation.

Nevertheless, digital transformation faces significant implementation challenges. The digital divide between urban and rural MSMEs creates disparities in access to digital financing solutions. Infrastructure limitations, particularly in remote areas, constrain the effectiveness of digital risk assessment tools. Additionally, concerns about data privacy, cybersecurity, and algorithmic bias require careful attention to ensure that digital transformation enhances rather than undermines financial inclusion objectives. Banks must invest substantially in technological infrastructure, data analytics capabilities, and staff training to realize the full potential of digital transformation in MSME credit risk management.

Thematic Analysis of Literature

The thematic analysis of the 45 selected studies reveals four primary themes that form the foundation of sustainable credit risk governance: (1) Enterprise Risk Management and Credit Risk Management integration, (2) ESG integration in banking operations, (3) Digital transformation and technology readiness, and (4) Indonesia-specific contextual factors. **Table 3** presents a comprehensive thematic analysis matrix showing the distribution of studies across these themes and their key contributions to understanding sustainable MSME financing.

Table 3. Thematic Analysis Matrix

Theme	Sub-theme	No. of Studies	Key Authors	Main Findings
ERM–CRM Integration	ERM Framework	8	COSO (2004); Beasley et al. (2005); Arena et al. (2010)	ERM effectiveness depends on senior management commitment and risk culture; integrated risk approach reduces volatility.
	Credit Risk Assessment	7	Basel Committee (2006); Bouteille & Coogan-Pushner (2013); Siddik (2017)	Traditional PD-LGD-EAD models require enhancement using alternative data; credit risk influenced by bank-level and macroeconomic factors.

Theme	Sub-theme	No. of Studies	Key Authors	Main Findings
	ERM–CRM Integration	5	Gatzert & Martin (2015); Manurung et al. (2024); Weber (2018)	Integration improves performance but remains partial in Indonesia; holistic frameworks still needed.
	SME-Specific Risk	6	Berger & Udell (2006); Anwar (2013); Naiborhu et al. (2024)	Relationship lending reduces information asymmetry; governance quality improves lending resilience; MSME lending increases risk if controls are weak.
ESG Integration	Sustainable Finance Framework	6	Elkington (1997); Weber (2017); Scholtens (2017)	Triple Bottom Line essential; banks must balance stability with social-environmental impact; financial institutions central to sustainability transition.
	ESG–Credit Risk Link	7	Weber & Scholz (2021); Fasone et al. (2024); Weerasekara et al. (2025)	ESG-integrated lending reduces NPLs; higher ESG ratings correlate with lower default risk; evidence suggests causal relationship.
	Green Finance	4	Zheng et al. (2025); Ullah et al. (2024); Anh et al. (2022)	Green finance boosts SME performance and bank profitability; accelerates sustainability adoption.
	Regulation & Implementation	5	Samosir (2024); Saifurrahman & Kassim (2024); Dorfleitner et al. (2021)	Indonesia still lacks detailed ESG guidelines; capacity and infrastructure gaps hinder adoption.
Digital Transformation	Digital Readiness	5	Parasuraman (2000); Campanella et al. (2025); Rashid et al. (2024)	Technology readiness critical for reducing risk and improving access; low readiness is a major barrier.
	Fintech Lending	7	Beck et al. (2018); Buchak et al. (2018); Hossain et al. (2023)	Fintech expands credit access; ML models reduce default rates; complements bank lending.

Theme	Sub-theme	No. of Studies	Key Authors	Main Findings
	AI & Alternative Data	6	Verma et al. (2025); Kassim & Huda (2023); Galletta & Mazzù (2023)	AI improves predictive accuracy; alternative data enriches scoring; raises ethical issues.
	Digital Banking Transformation	5	Gomber et al. (2018); Demirgüç-Kunt et al. (2020); Nguyen et al. (2023)	Digital finance accelerates inclusion and changes risk management practices significantly.
Indonesia Context	Banking Sector	6	Manurung et al. (2024); Naiborhu et al. (2024); Riyanti (2020)	ERM in Indonesia remains partial; governance boosts credit quality; SOE banks more resilient.
	Regulatory Environment	4	Samosir (2024); Saifurrahman & Kassim (2024); Dorfleitner et al. (2021)	Regulations remain fragmented; capacity-building and infrastructure improvements needed to support MSME sustainable lending.

The thematic analysis reveals several critical insights. First, while ERM and CRM are well-established concepts, their integration remains limited in practice, particularly in developing countries like Indonesia. Second, ESG integration demonstrates clear benefits for credit risk management, but implementation faces regulatory and capacity constraints. Third, digital transformation offers significant potential for enhancing credit assessment and expanding access, yet digital readiness disparities create new forms of exclusion. Finally, the Indonesia-specific studies highlight unique contextual challenges including regulatory effectiveness, governance quality, and infrastructure limitations that must be addressed in any proposed framework.

Integrated Model Development

Based on the systematic literature review findings, this study proposes a Sustainable Credit Risk Governance Model for MSME financing that integrates four interconnected layers: Risk Governance Layer, ESG Assessment Layer, Digital Analytics Layer, and Stakeholder Engagement Layer (**Table 4**). The Risk Governance Layer encompasses organizational structures, policies, and risk culture that support sustainable lending practices. This includes board-level oversight of sustainability objectives, risk appetite frameworks that balance profitability with social and environmental impact, and performance measurement systems that incorporate ESG metrics alongside traditional financial indicators.

The ESG Assessment Layer integrates environmental, social, and governance considerations into credit evaluation processes. Environmental factors include resource efficiency, waste management, and climate risk exposure. Social factors encompass labor

practices, community impact, and customer satisfaction. Governance factors evaluate management quality, transparency, and compliance practices. This layer utilizes standardized ESG scoring methodologies adapted to MSME characteristics and Indonesian regulatory requirements, enabling systematic evaluation of sustainability-related risks and opportunities that affect credit quality.

The Digital Analytics Layer leverages advanced technologies including artificial intelligence, machine learning, and big data analytics to enhance credit risk assessment accuracy and efficiency. This layer incorporates alternative data sources, behavioral analytics, and predictive modeling to create comprehensive borrower profiles that complement traditional financial analysis. The integration of digital technologies enables real-time monitoring of credit performance, early warning systems for potential defaults, and automated decision-making processes that reduce assessment costs and processing times.

The Stakeholder Engagement Layer facilitates collaboration among banks, MSMEs, regulators, guarantee institutions, and business development agencies to create an supportive ecosystem for sustainable MSME financing. This layer includes capacity building programs for MSMEs to enhance their sustainability practices and digital readiness, regulatory dialogue to develop appropriate policy frameworks, and risk-sharing mechanisms that distribute credit risk across multiple stakeholders while maintaining incentives for prudent lending practices.

Table 4. Sustainable Credit Risk Governance Model for MSME Financing

Layer	Key Components	Implementation Elements	Expected Outputs
LAYER 1: Risk Governance Foundation	• Board Oversight & Risk Appetite • Risk Management Framework • Regulatory Compliance (OJK) • Internal Control Systems	• Board-level oversight of sustainability objectives • Risk appetite balancing profit and ESG impact • Organizational structure supporting sustainable lending • Risk culture embedding sustainability principles • Performance measurement using ESG metrics	Strategic direction for sustainable MSME financing with clear accountability structure
LAYER 2: ESG Assessment Integration	• Environmental Risk Scoring • Social Impact Evaluation • Governance Quality Metrics • Sustainability KPIs	• Environmental factors: resource efficiency, waste management, climate risk exposure • Social factors: labor practices, community impact, customer satisfaction • Governance factors: management quality, transparency, compliance	ESG risk profile integrated with traditional credit assessment for holistic evaluation

Layer	Key Components	Implementation Elements	Expected Outputs
		• ESG scoring methodology adapted to MSME characteristics and Indonesian context	
LAYER 3: Digital Analytics & Technology	• AI/ML Credit Scoring Models • Real-time Data Analytics • Digital Risk Monitoring • Automated Decision Support	• AI/ML for credit scoring • Alternative data: digital transactions, social media, mobile data • Behavioral analytics & predictive modeling • Real-time monitoring & early warning systems • Automated decision-making reducing assessment time	Enhanced credit risk assessment accuracy, efficiency, and reduced information asymmetry
LAYER 4: Stakeholder Engagement	• MSME Capacity Building • Investor Relations • Community Impact Programs • Regulatory Communication	• Banks: implementing sustainable lending frameworks & ESG policies • MSMEs: building sustainability practices & digital capacity • Regulators (OJK, BI): supportive policies & incentives • Guarantee institutions: risk-sharing mechanisms (e.g., KUR expansion) • Development agencies: capacity-building programs	Collaborative ecosystem supporting sustainable and inclusive MSME financing

Implications for Policy and Practice

The proposed model provides actionable guidance for strengthening MSME financing governance in Indonesia. For regulators such as OJK and Bank Indonesia, the model highlights the need for more forward-looking supervision through ESG-aligned risk indicators and digital readiness assessments, enabling regulatory frameworks that better anticipate sustainability-related risks. It also supports the development of clearer taxonomies and minimum analytical standards that enhance consistency across financial institutions.

For banks, the model offers practical direction for integrating ESG scoring, digital risk analytics, and ERM-CRM alignment into their existing credit evaluation and portfolio management processes. These enhancements can improve risk detection, support responsible lending, and expand access to sustainable funding instruments.

For policymakers and government agencies, the model serves as a reference for strengthening credit guarantee schemes, targeted capacity-building programs, and incentive mechanisms that accelerate MSME adoption of sustainability practices and digital tools. Collectively, these implications support a more resilient and inclusive MSME financing ecosystem.

Challenges and Barriers

Despite the potential benefits, implementation of the integrated model faces substantial challenges that require coordinated responses from multiple stakeholders. High technology implementation costs present significant barriers, particularly for smaller banks with limited resources to invest in advanced analytics capabilities and ESG Assessment Systems. The shortage of qualified personnel with expertise in sustainable finance, digital risk management, and MSME lending compounds implementation challenges and requires substantial investment in training and capacity building programs.

Regulatory frameworks remain incomplete, with insufficient guidance on ESG risk assessment methodologies, data privacy requirements for digital lending, and standardized reporting formats for sustainability metrics. The digital divide between urban and rural MSMEs creates disparities in access to digital financial services and may exacerbate existing inequalities if not addressed through targeted infrastructure development and digital literacy programs. Cultural resistance to change within banking organizations and among MSMEs requires change management strategies that demonstrate clear benefits and provide adequate support for transition processes.

5. CONCLUSION

This systematic literature review confirms that the integration of Enterprise Risk Management (ERM), ESG principles, and digital readiness is essential for building a sustainable credit risk governance model for MSME financing in Indonesia. The evidence demonstrates that banks adopting an integrated approach experience superior risk-adjusted outcomes, characterized by lower non-performing loans (NPLs), stronger portfolio resilience, and improved access to sustainable funding sources. The proposed four-layer Sustainable Credit Risk Governance Model advances current research by offering a comprehensive structure that aligns financial sustainability, regulatory expectations, digital transformation, and MSME inclusion objectives. This model fills a significant gap in existing Indonesian banking literature, which commonly treats ERM, ESG, and digital capability as separate domains rather than as mutually reinforcing elements.

Theoretical Implications

This study offers several theoretical contributions to the literature on sustainable finance and MSME credit risk. First, it advances risk governance theory by demonstrating that ERM and CRM should not be treated as separate mechanisms but as interdependent components of a unified governance structure, particularly in emerging-market banking systems. Second, the study extends ESG scholarship by positioning ESG indicators not only as disclosure tools but as integral determinants of MSME credit quality, thereby broadening the theoretical role of sustainability in risk assessment. Third, it incorporates digital readiness into the credit risk discourse, showing that technological capability and alternative data analytics represent an

emerging dimension of risk management that has been largely overlooked in prior research. Finally, the integrated model proposed in this study contributes a new conceptual framework that links risk governance, sustainability principles, and digital capability—providing a foundation for future empirical research and strengthening theoretical alignment with Indonesia's MSME ecosystem.

Practical Implications

The findings of this study provide several practical implications for stakeholders in Indonesia's MSME financing landscape. For banks, the proposed model offers guidance to redesign credit processes through ESG scoring tools, AI-driven credit analytics, and integrated ERM–CRM practices that enhance portfolio resilience and reduce NPLs. For regulators such as OJK and Bank Indonesia, the model supports the development of risk-based supervision frameworks, ESG-aligned reporting standards, and digital readiness requirements that strengthen financial system stability. For policymakers, the integrated approach can inform reforms in credit guarantee schemes, incentive structures, and capacity-building programs that promote sustainable and inclusive MSME financing. Finally, for MSMEs, the model highlights the importance of improving sustainability practices and digital capability to enhance creditworthiness and strengthen their long-term financial viability.

Limitation and Future Research

Although this study provides a comprehensive synthesis of ERM, ESG, and digital readiness in MSME financing, several limitations must be recognized. First, the review relies on secondary literature, and therefore empirical validation of the proposed model is recommended for future research. Second, the availability of Indonesia-specific studies remains limited, suggesting the need for more empirical investigations on ESG-linked credit scoring, digital risk analytics, and ERM-CRM alignment in MSME lending. Future studies may also employ quantitative modeling or case studies to test the effectiveness of the Sustainable Credit Risk Governance Model across different banking segments.

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