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CLIMATE RISK MANAGEMENT AND SUSTAINABLE FINANCE: CHALLENGES IN INDONESIA'S GREEN BANKING SECTOR

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Abstract : *Climate change creates material financial risks for banks through physical shocks, transition pressures, and changing stakeholder expectations. In Indonesia, these risks are particularly relevant because the banking sector is expected to support national sustainable finance policies while maintaining portfolio resilience and profitability. This study applies a Systematic Literature Review (SLR) to identify, evaluate, and synthesize research on climate risk management and sustainable finance in Indonesia's green banking sector. The review draws on peer-reviewed literature published between 2017 and 2024 from Scopus, Web of Science, ScienceDirect, ProQuest, and Google Scholar, complemented by policy documents from OJK, the World Bank, NGFS, IFRS, and UNEP FI. A total of 25 studies met the inclusion criteria and were analyzed through narrative synthesis. The findings show five major challenges: limited climate-related data, weak integration of climate risk into enterprise risk management, uneven ESG capacity among banks, uncertain profitability of green financing, and inconsistent disclosure practices. The study concludes that regulatory harmonization, technical capacity building, scenario analysis, credible taxonomy-based classification, and transparent reporting are essential to accelerate green banking implementation in Indonesia. The article contributes by offering a contextual synthesis and a practical direction for developing a climate risk management framework for Indonesian banks.*

Keywords*: climate risk management, sustainable finance, green banking, ESG, Indonesia, systematic literature review*

1. Introduction

Climate change is increasingly recognized as a systemic challenge for economic stability and financial sector resilience. For the banking industry, climate-related risks may affect credit quality, collateral value, liquidity, operational continuity, and long-term asset allocation. Physical risks, such as floods, droughts, forest fires, and sea-level rise, can disrupt economic activities and weaken borrowers' repayment capacity. Transition risks may arise from changes in environmental regulation, carbon pricing, technological shifts, and market preferences toward low-carbon products.

The global financial sector has responded to these challenges through several frameworks, including the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD), the Principles for Responsible Banking (PRB), the Network for Greening the Financial System (NGFS) guidance, and IFRS S2 Climate-related Disclosures. These frameworks emphasize

governance, strategy, risk management, metrics, targets, scenario analysis, and comparable climate-related disclosure. Their adoption encourages banks to treat climate risk not merely as a corporate social responsibility issue, but as a material financial risk that should be integrated into decision-making.

Indonesia has also strengthened its sustainable finance agenda. The Financial Services Authority (OJK) has issued sustainable finance regulations, the Sustainable Finance Roadmap Phase II 2021-2025, and the Indonesian sustainable finance taxonomy. These policy instruments are intended to guide financial institutions in classifying green economic activities, improving sustainability reporting, and directing finance toward environmentally responsible sectors. Nevertheless, the implementation of climate risk management in Indonesian banking remains uneven.

Several practical barriers continue to constrain implementation. Many banks still face limited availability of climate-related data, methodological uncertainty in measuring physical and transition risks, weak internal technical capacity, and insufficient integration of sustainability factors into credit risk assessment. In addition, green financing may be perceived as less attractive when project pipelines, incentives, and market demand remain underdeveloped. These constraints increase the risk of fragmented implementation and may reduce the effectiveness of sustainable finance policies.

Previous studies on sustainable finance in Indonesia have commonly focused on regulation, market potential, or institutional commitment. Fewer studies systematically synthesize the operational challenges faced by banks in applying climate risk management and green banking practices. This gap is important because policy adoption alone does not guarantee effective risk management. Banks need practical guidance on how climate risk can be identified, measured, monitored, disclosed, and embedded in core business strategy.

Based on this background, this study addresses the following research question: What are the main challenges and strategic responses in implementing climate risk management and sustainable finance in Indonesia's green banking sector? The objective of this article is to synthesize current evidence and provide a contextual framework that can support regulators, banks, and future researchers in strengthening green banking implementation in Indonesia.

2. Literature Review

Sustainable Finance and Green Banking

Sustainable finance refers to financial activities that incorporate environmental, social, and governance (ESG) considerations into financial decision-making. It aims to support long-term economic resilience while reducing negative social and environmental externalities. In the banking context, sustainable finance is reflected in governance practices, risk assessment, product development, reporting, and stakeholder engagement.

Green banking is a more specific expression of sustainable finance. It refers to banking policies and products that support environmentally responsible activities, including renewable energy, energy efficiency, low-carbon infrastructure, sustainable agriculture, green buildings, and environmentally

sound business practices. Green banking also requires banks to reduce exposure to environmentally harmful sectors and to improve the environmental performance of their internal operations.

Climate Risk Management in the Banking Sector

Climate risk in banking is generally classified into two main categories: physical risk and transition risk. Physical risk refers to the financial impact of acute and chronic climate events, including floods, extreme weather, heat stress, droughts, and sea-level rise. Transition risk refers to the financial impact of moving toward a low-carbon economy, including policy changes, technology substitution, market shifts, and reputational pressure.

Effective climate risk management requires banks to identify climate-sensitive sectors, assess exposure at the portfolio level, apply scenario analysis and stress testing, integrate ESG factors into credit assessment, and disclose material risks to stakeholders. These practices align climate risk management with broader enterprise risk management and support more resilient lending and investment decisions.

Indonesia's Regulatory Framework

Indonesia's sustainable finance framework has developed through a combination of regulation, roadmap instruments, taxonomy guidance, and sustainability reporting requirements. POJK No. 51/POJK.03/2017 requires financial services institutions to implement sustainable finance and submit sustainability reports. The Sustainable Finance Roadmap Phase II 2021-2025 provides policy direction for deepening sustainable finance, strengthening institutional capacity, and improving coordination among stakeholders.

The Indonesian sustainable finance taxonomy helps classify economic activities according to environmental objectives and transition pathways. In banking practice, taxonomy-based classification is important for reducing greenwashing risk, improving the credibility of green financing, and creating a common language between banks, regulators, investors, and customers. However, the effectiveness of this framework depends on data quality, supervisory consistency, and the ability of banks to translate policy requirements into operational risk management procedures.

3. Research Method

This study uses a Systematic Literature Review (SLR) approach to identify, evaluate, and synthesize scientific and policy-based knowledge on climate risk management and sustainable finance in Indonesia's green banking sector. An SLR was selected because it enables transparent, structured, and replicable review procedures. The review was guided by the logic of PRISMA, particularly in documenting identification, screening, eligibility assessment, and final inclusion.

The literature search was conducted using Scopus, Web of Science, ScienceDirect, ProQuest, and Google Scholar. These databases were selected because they provide broad coverage of finance, banking, sustainability, and management research. The academic literature was complemented by

policy documents and reports from OJK, the World Bank, NGFS, IFRS Foundation, and UNEP FI to capture the regulatory and institutional context relevant to Indonesian banking.

The search used combinations of the following keywords: "climate risk management", "sustainable finance", "green banking Indonesia", "ESG risk", "physical climate risk", "transition risk", "green finance", "sustainable finance regulation", and "climate-related disclosure". Boolean operators such as AND and OR were applied to broaden or narrow the search results. The review focused on publications from 2017 to 2024 because this period reflects the development of sustainable finance regulation and climate disclosure practices in Indonesia and globally.

The inclusion criteria were: (1) studies discussing climate risk management, sustainable finance, green banking, ESG-related risk, or climate disclosure; (2) studies focusing on banking, financial institutions, or relevant developing-country contexts; (3) peer-reviewed articles or authoritative policy documents; and (4) publications available in English or Indonesian. The exclusion criteria were: (1) articles unrelated to banking or financial institutions; (2) studies discussing environmental issues without a financial or risk management perspective; (3) duplicate records; (4) non-academic sources without institutional credibility; and (5) publications with insufficient methodological clarity.

Quality assessment was carried out by examining the clarity of research objectives, appropriateness of the method, relevance of findings, citation quality, and contribution to the research question. The data were then synthesized using narrative synthesis. This approach was appropriate because the reviewed studies used diverse methods, including qualitative case studies, surveys, mixed-method designs, and conceptual reviews. Narrative synthesis enabled the identification of recurring themes, areas of convergence, differences in findings, and remaining gaps in the literature.

Table 1. PRISMA Summary

PRISMA Stage	Number of Records	Description
Identification	420	Records were obtained from Scopus, Web of Science, ProQuest, ScienceDirect, Google Scholar, and relevant institutional sources.
Screening	210	Records were screened by title, abstract, and keywords. Irrelevant and duplicate records were removed.
Eligibility	110	Full texts were examined for relevance to climate risk management, sustainable finance, green banking, and ESG-related risks.
Inclusion	25	Final studies that met the inclusion criteria were analyzed

		using narrative synthesis.

4. Results and Discussion

The SLR results indicate that climate risk management in Indonesia's green banking sector is shaped by the interaction of physical risks, transition risks, regulatory expectations, market incentives, and internal institutional capacity. Although banks increasingly recognize climate risk as a strategic issue, implementation remains uneven across institutions. Five themes emerged from the synthesis: climate data limitations, integration of climate risk into bank risk management, ESG capacity and governance, profitability and market barriers in green financing, and disclosure consistency.

First, limited climate-related data remains one of the most persistent obstacles. Banks require location-specific, sector-specific, and borrower-level data to assess exposure to floods, droughts, forest fires, and other physical hazards. However, many climate datasets are fragmented, not standardized, or not directly connected to credit risk models. This weakens the ability of banks to conduct scenario analysis, estimate probability of default under climate stress, and price climate-related risks accurately. Without reliable data, climate risk management may remain a compliance exercise rather than a substantive risk management process.

Second, the integration of climate risk into enterprise risk management is still developing. Many banks have adopted sustainability policies and reporting commitments, but climate risk has not always been embedded into credit appraisal, collateral valuation, portfolio monitoring, and risk appetite statements. This creates a gap between policy commitment and operational implementation. Stronger integration is needed so that physical and transition risks are considered in lending decisions, sectoral exposure limits, and long-term portfolio strategy.

Third, ESG capacity and governance strongly influence the effectiveness of green banking. The reviewed literature shows that banks require trained human resources, internal guidelines, reliable ESG assessment tools, and board-level oversight. Capacity gaps are particularly relevant for smaller and medium-sized banks that may lack specialized sustainability teams or digital analytics infrastructure. This condition may lead to uneven implementation across the banking industry, even when regulatory obligations are formally similar.

Fourth, the profitability and scalability of green financing remain uncertain. Green bonds, green credit, renewable energy financing, and environmentally friendly project financing can support national sustainability targets. However, banks may face limited green project pipelines, higher transaction costs, unfamiliar risk profiles, and insufficient incentives. As a result, green finance may grow slowly unless supported by clearer taxonomy guidance, blended finance mechanisms, risk-sharing instruments, and stronger demand from customers and investors.

Fifth, disclosure inconsistency increases the risk of greenwashing and reduces comparability across institutions. International frameworks such as TCFD, NGFS, and IFRS S2 have encouraged more structured disclosure on governance, strategy, risk management, metrics, and targets. However,

Indonesian banks still need more consistent reporting practices, including clearer disclosure of climate risk exposure, methodology, scenario assumptions, financed emissions, and taxonomy alignment. Transparent disclosure is necessary to strengthen market discipline and stakeholder trust.

Overall, the findings suggest that sustainable finance in Indonesia cannot be strengthened through regulation alone. Effective green banking requires a coordinated ecosystem involving regulators, banks, investors, customers, international institutions, and data providers. Banks need to translate regulatory direction into operational tools, while regulators need to provide practical guidance, supervisory consistency, and incentives that support credible green financing. This ecosystem approach is essential for improving both financial resilience and environmental accountability.

Conceptual Direction for Indonesian Banks

Based on the synthesis, a contextual climate risk management framework for Indonesian banks should include five components. The first component is governance, including board oversight, management accountability, and clear responsibility for sustainability implementation. The second component is data and methodology, including climate data mapping, taxonomy classification, scenario analysis, and stress testing. The third component is risk integration, including credit appraisal, sectoral limits, collateral valuation, and portfolio monitoring. The fourth component is product innovation, including green credit, transition finance, green bonds, and financing for low-carbon sectors. The fifth component is disclosure and assurance, including sustainability reporting, climate metrics, and independent verification to reduce greenwashing risk.

This conceptual direction can support future empirical research. For example, future studies may test whether banks with stronger climate risk governance and ESG data infrastructure demonstrate better portfolio quality, higher green financing growth, and more credible disclosure. Future research may also compare state-owned banks, private banks, regional development banks, and Islamic banks to identify differences in implementation capacity and strategic priorities.

Table 2. Summary of Selected Previous Studies

Authors & Year	Variables Studied	Method	Main Findings
Setiawan & Prasetyo (2021)	Physical risk, green banking, operational impact	Qualitative case study	Natural disasters can disrupt bank operations and weaken asset quality.
Wibowo et al. (2022)	Transition risk, ESG integration, investment	Bank survey	Regulatory changes and customer preferences affect green investment portfolios.
Astuti & Kurniawati (2023)	ESG, credit policy, sustainable finance	Mixed method	ESG integration in credit policy helps mitigate transition risk.
Lestari et al. (2022)	Climate risk, regulatory	Qualitative	Compliance with climate-related regulation supports more stable risk

	compliance, green banking		performance.
Rahmawati & Nugroho (2021)	ESG, green products, stakeholder trust	SEM-PLS	ESG implementation and green products increase stakeholder trust.
Hidayat & Lestari (2024)	Green finance, risk assessment, bank performance	Quantitative survey	Green products contribute to risk mitigation and financial sustainability.
Kurniawan & Sari (2021)	Green bonds, financial innovation, sustainability	Case study	Green bonds support product innovation and net-zero transition financing.
Purwoko (2022)	ESG, green banking strategy	Literature review	ESG integration is a key strategy for long-term banking sustainability.
Santhi Devi (2022)	Capacity building, ESG, green finance	Qualitative	Internal capacity building strengthens sustainable finance implementation.
Liu & Park (2022)	Risk disclosure, transparency, bank performance	Quantitative	Transparent ESG reporting improves credibility and investor trust.
Wulandari et al. (2021)	Climate risk reporting, financial stability	Case study	Climate-related reporting standards support risk integration into strategy.
Santoso & Rahman (2022)	Digital transformation, climate risk mitigation	Conceptual and empirical review	Digital capability improves climate risk monitoring and reporting.
Putri et al. (2023)	Data analytics, climate risk mitigation, banking	Quantitative	Data analytics capacity influences climate risk management effectiveness.
Priyonardo & Hendar (2025)	Green banking policy, TCFD compliance	Qualitative	TCFD adoption improves consistency of climate risk and sustainability reporting.

5. Conclusion

This study concludes that climate risk management and sustainable finance are essential for strengthening the resilience and competitiveness of Indonesia's banking sector. The SLR shows that Indonesian banks face both physical risks, such as floods, droughts, and other extreme climate events, and transition risks related to environmental regulation, technological change, market preference, and ESG expectations. These risks affect not only sustainability reputation but also credit quality, portfolio strategy, and long-term financial stability.

The main challenges in Indonesia's green banking sector include limited climate-related data, weak integration of climate risk into enterprise risk management, uneven ESG capacity, uncertain profitability of green financing, and inconsistent disclosure standards. These challenges indicate that sustainable finance implementation requires more than formal regulatory compliance. Banks need operational capabilities, credible methodologies, reliable data, and governance structures that connect sustainability commitments with core banking practices.

Strategically, the implementation of green banking can be strengthened through regulatory harmonization, taxonomy-based classification, climate risk training, digital data analytics, scenario analysis, and transparent disclosure aligned with international frameworks. Collaboration among OJK, banks, investors, data providers, and international institutions is also necessary to build a credible sustainable finance ecosystem. From an academic perspective, this study provides a conceptual direction for future empirical testing. From a practical perspective, it highlights the need for banks to embed climate risk into credit assessment, portfolio monitoring, product innovation, and sustainability reporting.

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