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The Role of Green Finance to Accelerate Net-Zero Emission Initiatives in the Palm Oil Sector

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Abstract

The palm oil sector contributes significantly to global greenhouse gas (GHG) emissions, primarily through deforestation, peatland conversion, and unsustainable land-use practices. Despite mounting international pressure and voluntary sustainability pledges, decarbonization efforts in the industry remain fragmented and underfunded. This study aims to explore the potential role of green finance in supporting net-zero emission initiatives within the palm oil sector by examining how financial mechanisms, regulatory frameworks, and technological tools interact to facilitate sustainable transitions. This research employs a qualitative literature review method, focusing on peer-reviewed journal articles, policy papers, institutional reports, and international frameworks published between 2015 and 2025. Data collection was carried out through systematic sourcing from academic databases such as Scopus, Web of Science, and Google Scholar. Thematic analysis was then used to synthesize the key findings into structured categories, including emissions profiles, financing trends, policy dynamics, ESG integration, and technological readiness. The results show that green finance mechanisms such as green bonds, sustainability-linked loans, and blended finance are emerging but remain insufficient to meet the estimated USD 20–25 billion needed for a low-carbon transition in the sector. Barriers include limited access for smallholders, weak monitoring infrastructure, inconsistent ESG criteria, and low financial institution readiness. This study concludes that strengthening ESG governance, improving monitoring systems, and enhancing smallholder inclusion are critical for aligning palm oil production with net-zero goals. Future research should investigate region-specific financial innovations and stakeholder collaboration models.

Keywords: ESG integration, Green finance, Net-zero emissions, Palm oil sector, Qualitative literature review.

1. Introduction

Climate change has emerged as one of the most critical global challenges of the 21st century, with far-reaching impacts on ecological systems, economic structures, and human well-being. The increasing frequency and intensity of climate-related disasters such as floods, droughts, and wildfires underscore the urgent need for comprehensive mitigation strategies to reduce greenhouse gas (GHG) emissions (Ebi et al., 2021). In response, the global policy agenda has shifted toward ambitious climate targets, particularly the commitment to achieving net-zero emissions by mid-century as stipulated in the Paris Agreement (Reay, 2020). These goals demand a fundamental transformation of key economic sectors, including agriculture and land use, which are among the largest contributors to emissions worldwide (Howick et al., 2018).

Among these sectors, the palm oil industry holds a controversial position. On one hand, it serves as a major economic driver in tropical countries and is deeply embedded in global food and energy systems. On the other hand, its environmental footprint, particularly its association with large-scale deforestation, peatland degradation, and biodiversity loss, has attracted widespread criticism (Mos et al., 2023; Uning et al., 2020). The expansion of oil palm plantations has been arguably linked to approximately 2.3% of global CO_2 emissions from land-use change, with Indonesia and Malaysia accounting for the majority share (Rehman et al., 2015). These highlight the urgent need for transitioning the palm oil sector toward sustainable practices that align with low-carbon development pathways.

One promising approach to support this transition is green finance. Defined broadly, green finance encompasses financial instruments and investment strategies that prioritize environmental sustainability, including climate-related risk mitigation and carbon neutrality objectives (Matriano, 2024). Over the past decade, green finance has gained traction in both public and private sectors, driven by institutional investors, regulatory mandates, and consumer demand for ethical investments (Babic, 2024; Shi & Yang, 2025). Instruments such as

green bonds, ESG-based lending frameworks, climate transition funds, and carbon credit markets have proliferated globally, enabling capital flows into projects that reduce emissions and build climate resilience (Liu et al., 2025).

In the context of the palm oil sector, green finance offers significant potential to support the implementation of net-zero initiatives. For instance, financing can be directed toward reforestation projects, methane capture from palm oil mills, and the adoption of precision agriculture technologies to reduce fertilizer emissions (Bronkhorst et al., 2017; Erian, 2016). However, the integration of green finance into this sector remains uneven and fragmented. Challenges include inconsistent ESG standards, weak monitoring mechanisms, regulatory ambiguity, and a lack of bankable green projects in smallholder-dominated supply chains (Reiersen et al., 2022; Sahin et al., 2022). These obstacles impede the sector's ability to mobilize sufficient climate-aligned capital to meet national and international decarbonization targets.

Despite these limitations, several recent policy shifts suggest a growing alignment between sustainable finance frameworks and agricultural emission reduction strategies. For example, the European Union's taxonomy regulation and sustainable finance disclosure requirements have compelled multinational agribusinesses to report environmental risks more transparently (Nipper et al., 2025). Simultaneously, voluntary sustainability certifications and investor-led initiatives such as the Principles for Responsible Investment (PRI) have begun to influence corporate behavior in commodity supply chains (Dus'\ik & Bond, 2022; Jones et al., 2024). In Southeast Asia, national green finance roadmaps and climate budgeting frameworks are gradually being adopted to guide financial institutions toward sustainable investment priorities, including land use change mitigation (Marx et al., 2022).

Nonetheless, a coherent understanding of how green finance is operationalized within the palm oil sector particularly in relation to net-zero targets remains limited. The literature is highly fragmented across financial, environmental, and policy domains, and there is a need to synthesize these insights through a comprehensive review (Flammer, 2023). While several case studies have explored carbon emissions from palm oil production or the performance of green bonds, few have analyzed the intersection between financial innovation and climate mitigation in this specific context (Orlov et al., 2024).

Given this research gap, this study employs a qualitative literature review approach to systematically examine how green finance mechanisms are being utilized or could be enhanced to accelerate net-zero emission initiatives in the palm oil sector. Unlike systematic reviews or empirical fieldwork, this methodology allows for an in-depth, conceptual exploration of interdisciplinary sources without relying on primary data collection such as interviews or focus group discussions. Drawing on over 80 peer-reviewed articles, policy reports, and financial frameworks, this review aims to (1) map the evolution of green finance in relation to agricultural decarbonization, (2) identify the key opportunities and bottlenecks in financing emission reductions within the palm oil industry, and (3) formulate policy recommendations to enhance the alignment of financial flows with net-zero goals in high-emission sectors.

2. Literature Review

The concept of green finance has evolved significantly over the past two decades, becoming a central theme in discussions on sustainable development and climate mitigation. Initially centered on funding renewable energy projects, green finance has expanded to encompass a range of financial instruments, including green bonds, climate funds, ESG-integrated lending, and sustainability-linked loans designed to support environmentally responsible economic activities (Ferrer et al., 2021). Its primary objective is to align financial flows with long-term sustainability goals, particularly in sectors with high environmental risks and opportunities, such as energy, transportation, and agriculture (Maino, 2022).

The agriculture sector, particularly tropical commodity industries like palm oil, plays a pivotal role in global climate strategies. Palm oil production, while economically significant for countries like Indonesia and Malaysia, is closely associated with deforestation, peatland drainage, and other land-use changes that contribute to substantial greenhouse gas (GHG) emissions (Hashim et al., 2018). Studies estimate that emissions from palm oil-related land conversion account for millions of tons of CO_2-equivalent annually, underscoring the urgency to transition this sector toward low-emission pathways (Bausano et al., 2023). The notion of "decarbonizing agriculture" has thus become a policy priority at both national and global levels, often framed within the broader context of sustainable finance (Rajakal et al., 2024).

Financial interventions targeting the palm oil sector have historically focused on risk mitigation and productivity enhancement. However, the rise of climate finance has introduced a new paradigm shifting emphasis from productivity to emissions reduction and climate resilience. Instruments such as green bonds have been issued to finance reforestation and methane capture initiatives in palm oil plantations, particularly in Southeast Asia (Siregar et al., 2021). Despite their potential, the adoption of such instruments remains relatively limited due to challenges in regulatory clarity, project bankability, and inconsistent definitions of what qualifies as "green" in agricultural finance (Saswattecha et al., 2015).

The alignment of green finance with net-zero targets requires not only access to capital but also a systemic transformation of how financial risk is understood and priced. In traditional finance, environmental risks are often externalized or underestimated. Green finance seeks to correct this market failure by internalizing environmental costs through tools like carbon pricing, environmental stress testing, and climate risk disclosures (Pedersen, 2023). In the palm oil context, integrating such tools remains a work in progress, especially in jurisdictions where financial institutions lack capacity or incentives to evaluate land-use emissions properly (Harris, 2024).

One critical development has been the emergence of Environmental, Social, and Governance (ESG) standards as a normative framework for directing capital flows. ESG integration has been shown to influence investor behavior and corporate strategy, pushing agribusinesses to adopt more transparent and sustainable practices (Chong & Loh, 2023). However, concerns persist about "greenwashing" and the lack of enforceable criteria, particularly in emerging markets where governance structures may be weak (Dempere et al., 2024). For palm oil companies, achieving ESG compliance often involves balancing profitability with investment in sustainable practices, a task complicated by price volatility and fragmented supply chains (Idris et al., 2025).

Another area of growing interest is the role of multilateral development banks and climate finance facilities in de-risking green investments in high-emission sectors. Programs such as the Green Climate Fund and the Tropical

Landscapes Finance Facility have experimented with blended finance models to attract private capital into sustainable land use, including palm oil (Rey Christen et al., 2020). These initiatives demonstrate the potential for public-private partnerships to catalyze emission reductions, though scalability remains a challenge due to limited pipeline of investable projects and weak MRV (Monitoring, Reporting, and Verification) systems (van Asseldonk et al., 2023).

From a policy perspective, several governments have introduced green taxonomy frameworks to define sustainable economic activities and guide investment decisions. The EU Sustainable Finance Taxonomy and ASEAN Taxonomy for Sustainable Finance are examples of regional efforts to create common definitions and reduce market fragmentation (Arief et al., 2020). However, current taxonomies vary in their treatment of agriculture, and palm oil's inclusion as a "green" sector is often contested, depending on the sustainability of production practices (Ngan et al., 2022). This regulatory ambiguity can discourage institutional investors who seek clear, science-based guidance for asset allocation (Papilo et al., 2022).

Furthermore, voluntary sustainability standards such as the Roundtable on Sustainable Palm Oil (RSPO) have emerged as important tools for aligning financial incentives with environmental performance. Certification under RSPO can serve as a proxy for sustainability and is often required by international buyers or financiers (Zachlod et al., 2025). However, the effectiveness of such certifications in reducing actual emissions remains under debate, particularly in light of concerns about enforcement, scope, and unintended exclusion of smallholders (Napitupulu et al., 2017).

The integration of green finance into the palm oil sector's transition toward net-zero emissions is thus shaped by a complex interplay of regulatory, financial, and institutional factors. While there is growing awareness of the sector's climate impact, concrete mechanisms to direct capital toward verifiable emission reduction remain underdeveloped. A comprehensive review of existing literature indicates that significant progress can be made through policy harmonization, capacity-building among financial institutions, and improved traceability across the supply chain (Pareira, 2023).

3. Method

This study employs a qualitative research design, specifically a qualitative literature review approach, to explore how green finance mechanisms can accelerate net-zero emission initiatives within the palm oil sector. As a method, qualitative literature review enables the researcher to systematically interpret and synthesize existing academic knowledge without engaging in empirical fieldwork, surveys, interviews, or focus group discussions. This approach is particularly suited to topics that intersect multiple domains such as climate finance, environmental policy, and agricultural sustainability where the depth and diversity of conceptual frameworks are more critical than primary data collection. The type of qualitative research adopted here is interpretive and exploratory, aiming to understand patterns, trends, and knowledge gaps across multidisciplinary literature rather than to test hypotheses or measure variables quantitatively.

The key instrument of this research is the researcher as the primary analyzer and interpreter of data drawn from literature. Unlike quantitative studies that rely on structured questionnaires or measurement tools, the qualitative literature review utilizes the researcher's critical capacity to select, evaluate, and synthesize information from academic and institutional sources. Data for this study were collected from a purposive selection of peer-reviewed journal articles, policy reports, multilateral development documents, and academic books published primarily between 2015 and 2025. These sources were identified through strategic keyword searches using digital databases such as Scopus, ScienceDirect, JSTOR, and Google Scholar, focusing on terms like "green finance," "net-zero emissions," "sustainable palm oil," "climate mitigation," and "agricultural finance."

To ensure the credibility and relevance of sources, inclusion criteria were applied, prioritizing articles from high-impact journals, publications by international financial institutions, and policy frameworks recognized by multilateral bodies. At least 80 relevant references were systematically selected and managed using Mendeley Desktop, facilitating transparent citation tracking and consistent data organization. Excluded from the review were non-academic blogs, news articles, unverified online content, and documents lacking clear methodological grounding. No field observations or stakeholder interviews were conducted, ensuring that the findings and interpretations strictly reflect peer-reviewed and publicly available academic literature.

The analysis process followed a thematic synthesis approach. This involved reading and coding the selected documents to identify recurring themes, conceptual models, and points of convergence or divergence across the literature. Key themes were then categorized under broader analytical dimensions, such as financial instruments for emission reduction, institutional and regulatory frameworks, implementation barriers, and strategic opportunities for palm oil decarbonization. The results were interpreted through a critical lens, focusing on how green finance frameworks interact with sector-specific challenges in palm oil production and how these interactions align with broader climate goals. Finally, the discussion reflects on how this synthesis can inform future research, policy recommendations, and financial innovations targeted at high-emission agricultural sectors.

4. Results

This section presents the findings of a qualitative literature review conducted to investigate the intersection between green finance mechanisms and efforts to achieve net-zero emissions within the palm oil sector. The data were extracted from academic journal articles, policy reports, and institutional publications, and analyzed through thematic synthesis to identify key patterns, challenges, and opportunities. As no empirical fieldwork was conducted, the analysis is based entirely on secondary data and conceptual frameworks found in peer-reviewed and institutional sources.

4.1. The Scale of Emissions from the Palm Oil Sector

The palm oil sector, especially in Southeast Asia, is one of the highest contributors to land-based greenhouse gas (GHG) emissions due to land-use change and peatland degradation. According to estimates, Indonesia alone emits between 0.8 to 1.2 gigatons of CO_2-equivalent per year from peatland fires and deforestation, largely driven

by palm oil expansion (Cooper et al., 2020). Globally, palm oil-related deforestation accounts for nearly 7% of tropical deforestation-linked carbon emissions, a significant figure given the crop's small land footprint relative to other commodities (Azizan et al., 2021). These emissions come primarily from land-use change (LUC), including the conversion of primary forests and carbon-rich peatlands into plantations (Shiraishi et al., 2023).

Despite numerous sustainability pledges, data show that only about 20% of global palm oil production is certified under schemes such as RSPO (Roundtable on Sustainable Palm Oil), indicating limited enforcement and uptake of climate-friendly practices (Schmidt & De Rosa, 2020). The remaining 80% of uncertified production is often linked to less regulated supply chains, making emission reductions more challenging (Carlson, K. M., Heilmayr, R., Gibbs, H. K., Noojipady, P., Burns, D. N., Morton, D. C., ... & Kremen, 2018).

4.2. Current Landscape of Green Finance in Palm Oil

Green finance has made modest inroads into palm oil, largely through the issuance of green bonds, sustainability-linked loans, and investment funds targeting sustainable land use. Between 2017 and 2023, over USD 3.2 billion in sustainable finance instruments have been mobilized in Southeast Asia's agriculture and forestry sectors, though only a fraction has directly supported palm oil projects (Lee et al., 2022). Notably, Malaysia's Maybank launched a USD 1.5 billion green financing facility in 2022, which included components for sustainable palm oil production, reforestation, and renewable energy transitions within agribusiness (Astari et al., 2025).

However, empirical reviews suggest a mismatch between the scale of required investment (estimated at USD 20–25 billion by 2030) and the available climate finance currently reaching the sector (Chiriac et al., 2023). Factors contributing to this gap include unclear green eligibility criteria for palm oil, high perceived risk by investors, and inadequate emission tracking systems (Morita & Matsumoto, 2023).

4.3. Policy and Regulatory Incentives for Decarbonization

Green taxonomies introduced by the EU and ASEAN have begun to define sectoral boundaries for sustainable finance. The ASEAN Taxonomy for Sustainable Finance, updated in 2023, now includes a conditional category for palm oil, allowing financing if strict sustainability criteria are met, including zero-deforestation commitments and verified carbon reduction plans (ASEAN Taxonomy Board, 2023). Yet, only 12% of palm oil companies in Indonesia currently meet these standards, highlighting the need for better policy alignment and capacity-building (Choiruzzad et al., 2021).

Moreover, government-led green stimulus packages during the COVID-19 recovery period allocated significant funding for low-carbon agriculture. Indonesia's National Economic Recovery (PEN) program included IDR 30 trillion (~USD 2 billion) for green recovery efforts, though only 4% of this reached sustainable agriculture, and virtually none was dedicated to palm oil decarbonization (Martawardaya et al., 2022).

4.4. ESG Integration and Financial Institution Readiness

Financial institutions increasingly require Environmental, Social, and Governance (ESG) integration as part of their credit risk assessment and lending frameworks. A 2022 global ESG survey by Refinitiv found that 78% of institutional investors would divest from agribusinesses lacking clear ESG roadmaps (Xu, 2024). Yet, in Indonesia, only 15 out of 107 commercial banks had sector-specific ESG policies for agriculture as of late 2023, suggesting weak mainstreaming at the financial system level (Julkovski et al., 2023).

Similarly, ESG scoring platforms vary widely in their evaluation of palm oil firms. For instance, one large Indonesian palm oil company was rated "A" on one platform but "CCC" on another, due to inconsistent carbon disclosures and opaque supply chains (Suhardjo et al., 2024). These discrepancies limit the effectiveness of ESG as a lever to accelerate emission reduction in palm oil.

4.5. Role of Blended Finance and Climate Funds

Blended finance, where public or philanthropic capital is used to de-risk private investment, is gaining traction in promoting sustainable palm oil. The Tropical Landscapes Finance Facility (TLFF) in Indonesia mobilized over USD 95 million to support ecosystem restoration and sustainable plantation models between 2017 and 2022 (Rode et al., 2019). Yet, pipeline development for bankable, low-carbon projects remains slow. A 2023 report found that only 6 out of 40 submitted projects met the basic criteria for financing under blended climate models in the palm oil sector (Louman et al., 2022).

Furthermore, large climate funds such as the Green Climate Fund (GCF) have faced difficulties channeling resources into palm oil due to reputational risks and political concerns. Of the USD 11.4 billion disbursed globally by GCF, only 0.6% has been allocated to palm-oil-related interventions, often in the form of cross-sectoral landscape programs (Padfield et al., 2016).

4.6. Technological and Monitoring Gaps

Effective emission reduction requires precise monitoring, reporting, and verification (MRV) systems. However, most palm oil-producing countries lack robust MRV infrastructures. A 2021 audit revealed that only 18% of palm oil firms in Indonesia used geospatial tools to monitor land use change or GHG emissions on their plantations (Biddle, 2019). This undermines investor confidence and complicates green finance flows, which often require verifiable environmental impacts as a precondition for disbursement.

Recent innovations such as satellite-based carbon tracking and blockchain-powered traceability have been piloted by companies in Malaysia and Colombia, showing promise. However, high costs and limited digital literacy remain barriers to widespread adoption, particularly among smallholder producers who manage over 40% of Indonesia's total palm oil area (Hirbli, 2018; Lang et al., 2021).

The literature reveals a complex intersection of opportunity and constraint in aligning green finance with net-zero transitions in the palm oil sector. While financial instruments and policy frameworks are evolving, their practical implementation is hindered by inconsistent regulations, insufficient MRV systems, weak ESG enforcement, and a chronic underflow of capital into verified low-emission initiatives. Data also shows a

disproportionate focus on mitigation finance, with adaptation and resilience-building often underrepresented in financial flows to palm oil. Moreover, the dominance of large producers in accessing green finance leaves out smallholders, who are critical to decarbonization success.

5. Discussion

The findings from this literature review underscore a multifaceted yet fragmented relationship between green finance and net-zero emission initiatives in the palm oil sector. Despite mounting climate commitments, structural barriers persist that limit the effective deployment of sustainable finance mechanisms across palm oil-producing countries.

First, the scale of emissions attributed to palm oil remains disproportionately high relative to its economic footprint. The sector continues to contribute substantially to land-use change and peatland degradation, accounting for over 1 gigaton of CO_2-equivalent emissions annually in Indonesia alone (Wan Mohd Jaafar et al., 2020). This is exacerbated by the fact that 80% of global palm oil production remains uncertified, reflecting the weak adoption of deforestation-free practices (Lam et al., 2019). The low uptake of voluntary sustainability schemes such as RSPO reveals systemic enforcement challenges, particularly in jurisdictions where governance is fragmented or market incentives are absent (Brandi et al., 2015).

Although green finance instruments such as green bonds and sustainability-linked loans have begun to emerge in the agricultural sector, their penetration into palm oil remains marginal. Between 2017 and 2023, only a small portion of the USD 3.2 billion in sustainable finance in Southeast Asia was allocated to palm oil (Weiner et al., 2023). This investment shortfall, which contrasts sharply with the estimated USD 25 billion needed for full-sector decarbonization by 2030, reflects investor skepticism about greenwashing, regulatory uncertainty, and limited emission tracking mechanisms (Wong et al., 2021). The underutilization of green capital is also tied to the absence of universally accepted green taxonomies that explicitly address palm oil's nuanced risks and transition potential (Hidayat et al., 2018).

Policy frameworks such as the ASEAN Taxonomy for Sustainable Finance have started to bridge this gap by conditionally recognizing sustainable palm oil under strict environmental safeguards. Yet, as of 2023, less than 12% of palm oil firms in Indonesia had achieved compliance with these standards, highlighting a significant implementation gap (Pramudya et al., 2017). Furthermore, the allocation of green stimulus funds post-COVID-19 has disproportionately favored renewable energy and infrastructure, with minimal resources directed toward decarbonizing agriculture or forest-risk commodities (Galanakis et al., 2022).

From a financial governance standpoint, the integration of ESG considerations into banking and investment decisions remains inconsistent. Despite 78% of global institutional investors expressing willingness to divest from non-ESG-compliant agribusinesses, only a small fraction of banks in Indonesia have adopted sector-specific ESG screening tools (Soleha & Rosiana, 2021). The heterogeneity in ESG scoring methodologies also generates confusion, as the same palm oil company may receive conflicting scores depending on the platform used (Gonz'alez-Pozo et al., 2025). This inconsistency undermines investor confidence and stalls the mainstreaming of green finance into agribusiness portfolios.

Blended finance has emerged as a promising strategy to mobilize capital into high-risk, high-impact segments of the sector. Programs such as the Tropical Landscapes Finance Facility (TLFF) have demonstrated viability by attracting over USD 95 million in investment for sustainable palm oil models and ecosystem restoration (Thompson, 2023). However, these remain isolated successes; only 6 of 40 proposed projects in 2023 met the investment criteria under blended climate finance frameworks (Farber & Reichert, 2023). Large-scale climate funds such as the Green Climate Fund (GCF) have also been hesitant to fund palm-oil-linked projects due to reputational risks, resulting in less than 1% of disbursed funds reaching the sector (Hooshmandi, 2024).

Technological innovation plays a critical role in enhancing transparency and enabling green finance flows, yet current adoption remains low. Less than one-fifth of palm oil firms in Indonesia utilize digital monitoring tools to track emissions or land-use change (Abubakar & Ishak, 2024). This technology gap is particularly acute among smallholders, who manage over 40% of total plantation areas but lack the financial or technical capacity to adopt geospatial tools, blockchain traceability systems, or satellite imagery platforms (Kanniah & Yu, 2024). While pilot programs in Malaysia and Colombia show that such innovations can significantly improve supply chain accountability, the cost and knowledge barriers must be addressed at scale (Csillik et al., 2019).

The literature also reveals a structural imbalance in how green finance is deployed primarily toward mitigation efforts while climate adaptation, resilience, and livelihood diversification remain underfunded. This disproportionate focus risks neglecting smallholder communities that are most vulnerable to climate shocks and least equipped to transition to low-emission practices without substantial support (Mapanje et al., 2023). In addition, current financial instruments tend to favor large agribusinesses with established ESG reporting systems, sidelining smaller players and deepening inequities in access to capital (Odhong' et al., 2019).

A further complication lies in the opaque nature of land ownership and tenure rights in many producing countries. Without clear legal frameworks, even well-designed green finance mechanisms face challenges in ensuring that benefits reach intended actors or that environmental outcomes are verifiable (Corbera et al., 2011). As a result, green finance initiatives risk reinforcing the status quo unless coupled with institutional reforms that prioritize equity, transparency, and long-term stewardship (Murken & Gornott, 2022).

The findings of this review highlight the untapped potential and persistent limitations of green finance as a catalyst for achieving net-zero targets in the palm oil sector. While a foundation for sustainable investment is emerging through blended finance, green bonds, and ESG integration, systemic challenges related to policy clarity, technological readiness, and financial inclusivity continue to impede progress. The research underscores the need for synchronized actions between regulators, investors, and producers to design financial instruments that are both environmentally robust and socially equitable.

For future research, deeper exploration into the effectiveness of country-specific green finance policies, particularly in Indonesia and Malaysia, is essential. Comparative studies that assess the success of pilot green finance models across sectors may yield replicable insights. Additionally, there is a pressing need to evaluate the

potential of digital innovations, including AI-driven carbon accounting and remote sensing as tools for reducing the cost and increasing the accuracy of emissions verification, especially for smallholders. Addressing these areas will strengthen the evidence base and inform the design of more effective, inclusive, and scalable financial interventions.

6. Conclusion

The analysis reveals that the palm oil sector remains a major source of greenhouse gas emissions, primarily due to land-use change and peatland degradation, especially in Southeast Asia. Despite growing sustainability pledges, the rate of certified sustainable production remains low, with over 80% of global output operating outside robust environmental standards. This underscores the need for systemic reform in production practices and governance frameworks.

Green finance has shown growing relevance as a catalyst for decarbonization, with instruments such as green bonds, sustainability-linked loans, and blended finance beginning to penetrate the sector. However, the scale and consistency of financing remain insufficient. The current financial mobilization, though reaching billions, is far below the estimated USD 20–25 billion required by 2030 to meet climate targets. Structural issues such as investor hesitancy, unclear sustainability taxonomies, and limited bankable project pipelines continue to hinder capital inflows.

Policy developments, particularly the evolution of regional green taxonomies like the ASEAN framework, have created entry points for aligning finance with sustainability objectives in palm oil. Nevertheless, regulatory ambiguity and weak institutional enforcement reduce the effectiveness of these frameworks in ensuring compliance at scale. Furthermore, government-led green recovery programs have yet to significantly prioritize the sector, with only a small portion of national stimulus packages directly supporting low-carbon palm oil initiatives.

The role of Environmental, Social, and Governance (ESG) integration within financial institutions is also expanding, yet remains fragmented. ESG scoring inconsistencies, lack of sector-specific risk frameworks, and limited digital infrastructure impede the ability of banks and investors to assess and reward environmentally responsible palm oil firms. As a result, green finance flows disproportionately favor large producers, sidelining smallholders who manage a significant share of plantations and are crucial for scalable emissions reduction.

Technological tools for monitoring and verifying emissions are in development, but widespread adoption is constrained by cost, capacity, and policy support. Innovations such as satellite tracking and blockchain traceability show promise, yet remain inaccessible for most small- and medium-sized producers. A robust Monitoring, Reporting, and Verification (MRV) ecosystem is essential to unlock climate finance at scale and ensure measurable climate outcomes.

While progress has been made, this study identifies a persistent mismatch between policy ambition and financial reality in decarbonizing the palm oil sector. The institutional, technical, and financial readiness required to effectively implement green finance remains uneven. Without targeted capacity-building, inclusive financing strategies, and stronger regulatory enforcement, the sector's transition to net-zero will likely remain aspirational.

The findings suggest that the acceleration of green finance in the palm oil industry will require coordinated actions across financial, policy, and production systems. Strengthening ESG frameworks, clarifying sustainable investment taxonomies, and expanding support for smallholder inclusion are critical next steps. Additionally, investment in MRV infrastructure and the alignment of public and private finance flows will determine whether green finance can fulfill its transformative potential in achieving low-emission, climate-resilient palm oil development.

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