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Carbon Footprint of Indonesia's Tropical Forests: Between Conservation, Commodity, and Climate Crisis

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ABSTRACT

Indonesia's tropical forests play a central role in the global climate system because they act as significant carbon sinks while also possessing the potential to become major sources of emissions under deforestation pressure. This study examines the complex relationship between conservation policy, commodity-driven land expansion, and the climate crisis in shaping the carbon footprint of Indonesia's forests. A qualitative systematic review approach was used to synthesize academic publications from the last decade, focusing on forest carbon dynamics, governance mechanisms, and environmental policy. Findings show that conservation strategies grounded in ecosystem services, community participation, and integrated terrestrial and coastal management offer long-term mitigation potential, whereas commodity-based economic growth models intensify carbon emissions and undermine climate pledges. The study demonstrates that technological solutions alone cannot substitute structural governance reforms, especially when land tenure and benefit-sharing remain unclear. The conclusion emphasizes that climate resilience and sustainable carbon sequestration can be realized only when forest conservation is embedded into national development models that reduce reliance on extractive industries and ensure equitable socio-institutional participation. The research contributes novelty by integrating conservation, commodity, and climate governance dimensions to evaluate whether Indonesia's tropical forests will remain net carbon sinks or shift into permanent carbon sources.

INTRODUCTION

Indonesia hosts the world's third-largest tropical forest cover, yet its landscapes are simultaneously a carbon sink and a major carbon source because of deforestation, land conversion, and forest fires driven by economic expansion and global commodity chains. Tropical forests are increasingly positioned at the center of climate crisis debates because they store tremendous amounts of carbon, preserve biodiversity, and regulate ecosystem services that are crucial for climate stability at regional and global scales. Empirical evidence shows that Indonesia's forests contribute significantly to the global carbon cycle, where degradation triggers escalating emissions that offset global climate mitigation commitments and increase national vulnerability to long-term

environmental change (Adnan & Dadi, 2023). While conservation initiatives exist, the impact of logging, mining, and plantation-based commodity production is growing stronger and threatens the function of forests as carbon sinks, raising global concern about the future of climate governance and sustainability outcomes.

The transformation of forests into carbon commodities, particularly through carbon offsetting schemes, illustrates the complex narrative of climate mitigation, local livelihoods, and political economy. Many regions in Indonesia have been included in forest carbon markets, often labelled as invisible commodities because they circulate as tradable emissions without being visibly extracted in physical form, creating both economic opportunity and social uncertainty for local communities (Miles, 2021). At the same time, recurring forest fires intensify carbon emissions especially in peatland-dominated provinces, amplifying regional air pollution and health hazards while weakening national climate commitments (Alisjahbana & Busch, 2017). The combination of offset markets and forest exploitation demonstrates a structural dilemma in which forests serve both as objects of conservation and as sites of extractive economic interest.

The crisis is not purely national but embedded in global patterns of consumption and international supply chains. A multi-country analysis on deforestation footprints revealed that consumption patterns in high-income and middle-income countries continue to drive forest loss in tropical regions including Indonesia, showing the asymmetrical burden of decarbonization policies borne by developing countries (Hoang & Kanemoto, 2021). The ecological implications are multidimensional, affecting biodiversity, water regulation, and community resilience. Studies in the tropical region further highlight the interconnectedness of human activities, biodiversity loss, and climate disaster, confirming that the erosion of forest ecosystems escalates ecological vulnerability while reducing adaptive capacity (Rahmaditio, 2023). Consequently, the carbon footprint of Indonesian forests cannot be isolated from global socio-economic dynamics but needs to be contextualized within the transnational economy of conservation, extractivism, and climate obligations.

Indonesia has attempted to reduce forest-related emissions through regulatory interventions such as the moratorium on forest concessions. While the moratorium has proven to be cost-effective in reducing emissions from industrial forestry, its contribution to achieving the Paris climate pledge remains disproportionately low due to systemic leakages and persistent reliance on extractive development models (Groom et al., 2022). Emerging technological innovations such as blockchain-enabled environmental governance are increasingly explored to address transparency and accountability in forest-related transactions, although substantial concerns remain regarding feasibility and socio-economic equity (Howson, 2019). These conditions demonstrate that climate mitigation instruments must be interlinked with systemic reforms in environmental governance rather than relying on market-centric solutions alone.

Current debates around the carbon footprint of tropical forests also critique conventional conservation approaches that prioritize tree planting over community-centered governance. Tree-planting programs often overlook socio-environmental complexities and tend to fail when they ignore local institutions and indigenous knowledge critical to sustaining forest ecology (Fleischman et al., 2020). At the same time, transition toward renewable energy is often assumed to be a universal solution to the climate crisis, even though mining for renewable energy infrastructure can intensify

biodiversity risks in tropical forest regions (Sonter et al., 2020). These contradictions indicate the need for sustainability paradigms that recognize ecological limits, social justice, and economic viability.

Debates also emerge at the ideological level, with some scholars proposing radical reconfigurations of global development models to halt biodiversity loss and climate emergency, illustrating the philosophical tensions between growth-driven capitalism and ecological conservation (Vettese & Pendergrass, 2024). Similar discourse appears in discussions on agricultural land use and national policy frameworks, in which conventional regulatory strategies often fail to confront the powerful influence of global commodity demand as a primary driver of deforestation (Henders et al., 2018). These perspectives suggest that assessing the carbon footprint of Indonesia's forests requires a broader analytical framework beyond emissions accounting, addressing drivers from economic governance to global market dependency.

Efforts to mainstream ecosystem services into forest policy show increasing awareness that forests are not merely carbon reservoirs but also essential providers of ecological benefits for economic development, community livelihoods, and national resilience (Nugroho et al., 2022). The expanding recognition of blue carbon ecosystems similarly shows the importance of protecting coastal forests such as mangroves to complement terrestrial climate mitigation strategies and carbon stock management (Hilmi et al., 2021). Meanwhile, sustainable management initiatives emphasize the compatibility of reduced emissions and stable timber production when ecosystem-based approaches are applied consistently under long-term governance schemes (Sasaki et al., 2016). These dimensions reveal that strategies for reducing Indonesia's forest-related carbon footprint must be integrated across terrestrial, coastal, and socio-institutional systems.

Despite the vast body of academic literature on Indonesia's forests, clear research gaps remain. First, research by Miles (2021) titled "The invisible commodity: Local experiences with forest carbon offsetting in Indonesia" predominantly analyzes market mechanisms and social outcomes but does not quantify their implications for national-level carbon footprint trends. Second, the study by Groom et al. (2022) titled "Carbon emissions reductions from Indonesia's moratorium on forest concessions are cost-effective yet contribute little to Paris pledges" evaluates policy efficacy but does not integrate interactions between commodity extraction and forest-based mitigation. Third, the work of Hoang and Kanemoto (2021) titled "Mapping the deforestation footprint of nations reveals growing threat to tropical forests" focuses on global supply-chain impacts without embedding them in Indonesia's climate governance context. These gaps indicate the lack of research connecting conservation policy, commodity-driven deforestation, and climate crisis outcomes through the lens of Indonesia's forest carbon footprint.

Therefore, the novelty of this research lies in its integrated analysis of Indonesia's tropical forests by connecting three dimensions simultaneously: conservation mechanisms, commodity-driven extractivism, and climate change mitigation outcomes. This article seeks to evaluate how competing economic and environmental interests shape the carbon footprint of Indonesia's forests while exploring the implications for future climate governance. The purpose of this study is to provide a comprehensive understanding of the structural dynamics that determine

whether Indonesia's forests remain carbon sinks or become enduring carbon sources in the global climate system.

METHODOLOGY

This research uses a qualitative analytical approach based on a systematic review of peer-reviewed publications related to forest carbon, climate change, and tropical forest governance in Indonesia. A qualitative synthesis enables the examination of complex interactions between policy interventions, economic drivers, and environmental outcomes, aligning with methodological perspectives that emphasize interpretive analysis in climate governance research (Snyder, 2019). The review process focused on journal articles published in the last ten years to ensure relevance to current climate and conservation debates, with thematic coding used to categorize findings into conservation, commodity extraction, and climate crisis dynamics.

The selection criteria included empirical and review studies that addressed Indonesia's tropical forests within the context of carbon emissions, forest management, global commodity chains, sustainability initiatives, and climate mitigation. Articles were retrieved using academic databases including Scopus, Web of Science, and ScienceDirect. Each article was evaluated for methodological rigor, conceptual contribution, and relevance to research objectives, following recommended practices for qualitative evidence synthesis in environmental studies (Xiao & Watson, 2019). The analytical process triangulated cross-country forest governance studies, Indonesia-focused environmental policy publications, and interdisciplinary climate research to develop a holistic understanding of how competing forest functions impact national and global climate outcomes.

RESULT AND DISCUSSION

Conservation Policies and the Carbon Sink Function of Indonesia's Tropical Forests

The carbon footprint of Indonesia's tropical forests cannot be separated from the dual function these ecosystems play as both agents of climate mitigation and sources of emissions when degraded. Conservation initiatives that emphasize emissions reduction recognize tropical forests as critical elements in preventing climate instability because of their capacity to store atmospheric carbon in biomass, soils, and peat layers. Recent empirical evidence suggests that forest conservation programs significantly enhance the resilience of carbon sinks when protection is combined with ecological restoration and strict governance enforcement (Adnan & Dadi, 2023). The scale of Indonesia's rainforests and peatlands creates a unique situation in which conservation decisions have implications not only for regional biodiversity and livelihoods but also for global atmospheric carbon concentration, underscoring the national urgency to maintain an effective conservation framework.

Policy instruments have been central in shaping Indonesia's forest conservation trajectory, most notably through the moratorium on forest concessions enacted to halt primary forest clearing and peatland exploitation. This moratorium has been shown to reduce carbon emissions at a relatively low policy cost and is therefore considered a cost-effective climate intervention within the forestry sector (Groom et al., 2022). Yet the moratorium has not achieved the magnitude of emission reductions needed to support Indonesia's Paris climate goals, a limitation attributed to geographical exemptions, legal loopholes, and persistent reliance on resource-driven development.

The findings suggest that conservation efficiency is constrained when market-driven expansion in the agricultural and resource sectors continues uninterrupted, placing the moratorium within a broader structural challenge rather than an isolated regulatory deficiency.

Conservation is increasingly framed within the ecosystem services paradigm, highlighting the multiple benefits of forest preservation beyond carbon storage. The mainstreaming of ecosystem services in forest policy seeks to increase public and institutional awareness of how forests support water systems, agricultural productivity, climate regulation, and economic stability for rural communities (Nugroho et al., 2022). When policy actors internalize ecosystem service valuation within environmental decision-making, conservation becomes more robust because ecological benefits are no longer treated as intangible elements of governance. This approach reinforces the narrative that conservation can serve both economic and ecological interests and that long-term sustainability depends on integrating forest services into broader development planning.

Furthermore, scientific discussions show that coastal and terrestrial conservation efforts need alignment to optimize climate mitigation outcomes. Blue carbon ecosystems such as mangroves and seagrasses, though often neglected in national forest frameworks, play a key role in preventing coastal erosion and absorbing atmospheric carbon (Hilmi et al., 2021). In the Indonesian context where coastal forests are vulnerable to land-use conversion and climate-related disasters, a unified conservation agenda that incorporates terrestrial and coastal ecosystems is essential to sustaining long-term carbon sequestration. This demonstrates that conservation must be multisystemic instead of focusing solely on land-based forests.

Ecologically centered conservation, however, cannot be separated from sociopolitical realities. The success of conservation depends on localized governance, where indigenous and rural communities have historically acted as custodians of forest landscapes. The failure of externally imposed conservation schemes often stems from the absence of community-centered governance and disregard for local social dynamics (Fleischman et al., 2020). Evidence reveals that conservation outcomes are directly proportional to the integration of local knowledge, land rights recognition, and decentralized decision-making. Without these elements, conservation programs risk becoming extractive in a different form, where environmental protection is pursued but communities bear the socioeconomic costs.

The tension between global conservation objectives and local livelihood needs remains a persistent challenge in sustaining Indonesia's forests as carbon sinks. Local economies frequently rely on timber extraction, plantation work, or land conversion, placing conservation in conflict with immediate income needs. The existence of carbon offset projects, although profitable in theory, is not evenly distributed across communities, and many forest-dependent populations experience uncertainty over land rights and access to economic benefits (Miles, 2021). This asymmetry illustrates that conservation efforts are not inherently equitable unless they incorporate social safeguards and transparent benefit-sharing mechanisms.

Technology-based solutions, such as blockchain for climate governance, have been proposed to enhance transparency in carbon transactions and minimize corruption in environmental financing (Howson, 2019). While promising, technological solutions cannot function effectively without institutional and legal coherence. The implementation of new governance tools requires alignment between centralized

climate policies, decentralized forest governance, and private sector participation. The lack of clarity in land ownership and carbon rights remains a major limitation in upscaling technological interventions, illustrating that conservation challenges are fundamentally institutional rather than merely technological.

Viewed holistically, conservation has the potential to sustain Indonesia's tropical forests as long-term carbon sinks, yet the outcome depends heavily on legal certainty, community participation, and systemic integration across ecological, economic, and governance levels. Without addressing the structural drivers that weaken conservation effectiveness, forest preservation strategies risk becoming symbolic rather than transformative. Therefore, conservation must be conceptualized not only as ecological protection but also as institutional reform and socio-economic restructuring that ensures sustainability for both forest ecosystems and human communities.

Commodity Production, Extractive Economies, and the Carbon Source Profile of Indonesia's Forests

The carbon footprint of Indonesia's forests is deeply intertwined with the expansion of commodity-driven economies, particularly palm oil, mining, timber, and agricultural exports. Economic growth strategies centered on resource extraction continue to incentivize land clearing, which transforms forest spaces from carbon sinks into major carbon emitters. Global analyses demonstrate that forest loss in Indonesia is driven significantly by international consumption patterns, where demand for agricultural and mining inputs contributes to increased deforestation pressure (Hoang & Kanemoto, 2021). This relationship highlights the structural dependency between Indonesia's economic model and global markets, resulting in a persistent conflict between climate mitigation commitments and export-oriented development.

The transition to renewable energy further complicates forest-based emissions because, although designed to reduce fossil fuel dependence, the mining of minerals required for renewable infrastructure exacerbates threats to biodiversity and tropical forest stability (Sonter et al., 2020). These findings challenge the mainstream assumption that renewable energy automatically equates to environmental sustainability; instead, they reveal that green technology can reproduce extractive dynamics when it disregards ecological limits and regional socioeconomic contexts. In Indonesia, mining expansion for renewable energy materials such as nickel generates new spatial pressures on forest regions, contributing indirectly to emissions and habitat degradation.

Economic models prioritizing growth and resource exploitation also shape institutional behavior, influencing how governments and private stakeholders view forest governance. Modern critiques argue that conventional capitalist growth strategies are incompatible with long-term biodiversity preservation because they require continuous extraction and land conversion to sustain market expansion (Moranta et al., 2022). This ideological tension extends to climate policy implementation because high reliance on extractive revenue creates financial disincentives for strict conservation enforcement. As a result, the same forests that are necessary to meet climate mitigation goals become collateral in the pursuit of economic growth.

To illustrate the dynamics between conservation policy and commodity extraction, Table 1 presents a synthesized comparison of how different development pathways influence carbon outcomes in Indonesia's tropical forests.

Development Model	Primary Land Use Orientation	Carbon Outcome	Policy Incentive	Climate Governance Risk
Conservation-centered	Protected areas, ecosystem services, community forestry	Carbon sink strengthened	High regulatory protection	Risk of social conflict if community rights not secured
Commodity extraction-centered	Timber, plantations, mining expansion	Carbon source intensified	High economic gains	Deforestation leakage and weakened climate commitments
Hybrid sustainability model	Mixed land use with sustainability certification	Variable depending on compliance	Moderate, market-based	Greenwashing and external dependency
Moratorium-based restriction	Limited industrial concessions	Moderate sink performance	Low implementation cost	Weak legal enforcement and loopholes
Global carbon market mechanism	Carbon offset projects and tradable credits	Sink potential, uneven distribution	High international financing	Land rights disputes and inequity

The table reinforces that Indonesia's forests exist within competing development logics that directly determine their carbon profile. Commodity-driven development produces high emissions in the short term but remains institutionally dominant because of its contribution to GDP, foreign investment, and regional employment. Meanwhile, conservation-centered pathways generate long-term climate benefits yet require structural shifts in fiscal policy, land governance, and community empowerment for sustainable implementation. Hybrid models, including sustainability certification schemes, provide middle-ground solutions but are vulnerable to inconsistencies, selective compliance, and market fluctuations, which can reduce their effectiveness in curbing emissions.

Land tenure is a pivotal dimension connecting commodity extraction, emissions, and governance outcomes. Most forest land in Indonesia remains under contested ownership frameworks where formal legal status does not align with traditional land claims. These inconsistencies enable overlapping concessions and systematic encroachment by extractive industries, intensifying carbon emissions and social conflict (Cetera, 2022). The lack of land clarity also undermines carbon rights, which restricts the equitable distribution of benefits in carbon trading markets and discourages local participation in conservation. Without resolving land governance issues, climate mitigation instruments risk reinforcing existing power inequalities.

Socioeconomic pressures further reinforce extractive pathways because rural households often rely on plantation or logging industries for livelihoods. Although

conservation policies emphasize long-term ecological benefits, they do not immediately provide income alternatives comparable to resource extraction, making land conversion economically rational at the household level. This structural dependence demonstrates that emissions cannot be reduced without integrating economic transition policies that support forest-dependent communities. International financing mechanisms linked to carbon markets can contribute to economic transformation but must ensure transparent, inclusive, and accountable governance aligned with local needs (Miles, 2021).

The commodity-driven orientation of development also creates political inertia, where short-term financial gain outweighs long-term climate resilience. Governments may avoid strict enforcement of conservation policies when they are perceived as a threat to economic performance, employment rates, or investor confidence. Weak institutional capacity at local levels further complicates monitoring and compliance, fostering conditions under which illegal logging and unregulated expansion continue despite national climate pledges (Alisjahbana & Busch, 2017). Climate governance therefore becomes negotiable when policy implementation depends on economic interests rather than ecological necessity.

Discussion within this subsection highlights that Indonesia's tropical forests remain vulnerable to becoming net carbon sources when commodity extraction outweighs conservation commitments. The challenge is not simply reversing deforestation but restructuring the economic logic that drives forest exploitation. Mitigating the carbon footprint requires reorienting development models away from short-term resource gains toward diversified green economies that do not compromise forest integrity. The sustainability of Indonesia's climate future depends on resolving unresolved tensions between conservation, commodity, and institutional capacity to transform forests from emission sources back into stable long-term carbon sinks.

Climate Crisis Trajectory and the Future of Forest-Based Carbon Governance in Indonesia

The climate crisis has intensified the urgency to reassess the role of Indonesia's tropical forests in global carbon dynamics, particularly as rising temperatures, extreme weather patterns, and biodiversity collapse create cascading ecological and socioeconomic risks. Tropical forest degradation accelerates climate instability because carbon stored in biomass and peat layers is rapidly released through land clearing and fires, amplifying feedback loops that further weaken ecosystem resilience. Regional studies show that the pace of climate-driven vulnerabilities escalates where deforestation rates are high, revealing the compounding interaction between anthropogenic drivers and climatic stressors (Rahmaditio, 2023). Indonesia, situated within the tropics and containing extensive peat forests, faces a disproportionately high risk of entering a spiraling crisis in which ecosystems lose their natural capacity to function as carbon sinks, threatening both national and global climate stability.

Long-term governance of forest carbon requires shifting from reactive mitigation responses toward systemic resilience-building strategies. Current climate trends show that the carbon carrying capacity of forests diminishes when institutional arrangements fail to protect ecological integrity and prioritize short-term industrial profit over long-term sustainability. The expansion of global supply chains, market dependency, and dependency on extractive sectors remains a key factor that undermines climate commitments by locking economic development into deforestation-intensive pathways (Hoang & Kanemoto, 2021). Even though Indonesia participates in

international climate agreements, emission reduction targets cannot be fulfilled unless forest-based climate governance becomes structurally embedded in the formulation of development plans rather than treated as an environmental add-on.

Effective climate mitigation also demands a reassessment of technological interventions in the forest sector. Blockchain-assisted environmental governance has been promoted as a transparency-enhancing mechanism for monitoring carbon markets and improving accountability in financing flows (Howson, 2019). Technological improvements, however, cannot compensate for political or institutional weaknesses, especially when land rights, benefit-sharing mechanisms, and government oversight remain unclear. Carbon projects that rely solely on technological infrastructure risk reinforcing existing power asymmetries when community access to economic benefits remains restricted, which could threaten the social license of conservation projects and indirectly undermine carbon governance. Thus, climate-smart approaches must be anchored in both credible technology and equitable socio-institutional frameworks.

A transformative governance approach also requires confronting the ideological assumption that continuous economic growth is compatible with ecological stability. Critics argue that dominant global economic models remain inherently extractive because they rely on perpetual expansion, thus rendering forest protection structurally difficult (Moranta et al., 2022). In this discourse, Indonesia is situated within a global economy that pressures developing countries to supply commodities while industrialized nations outsource environmental burdens. Without structural changes in both global and domestic policy orientation, forest conservation risks becoming peripheral to economic planning rather than a central pillar of climate governance. These critiques imply that long-term climate resilience depends not only on improved environmental policy but also on a reconfiguration of development priorities.

Policy discussions increasingly highlight the need for adaptive mitigation that strengthens ecosystem services, stabilizes biodiversity, and promotes economic diversification in forest-dependent landscapes. Evidence suggests that integrating ecosystem services into decision-making can improve environmental and socioeconomic outcomes simultaneously by linking conservation to long-term livelihood security and economic resilience (Nugroho et al., 2022). When ecosystem services are internalized into policy instruments and market structures, financial incentives for conservation become more durable, making forests economically competitive compared to extractive land uses. This approach supports the argument that sustainable climate governance requires valuing forests not merely based on their temporary extractive worth but in terms of their long-term ecological and economic contributions.

Another crucial dimension is the inclusion of coastal forest ecosystems such as mangroves, which significantly boost national climate mitigation efforts when integrated with land-based forest management. Mangroves store high levels of carbon in both biomass and soil, and their destruction may release emissions at rates comparable to land-based deforestation (Hilmi et al., 2021). In Indonesia, the fragmentation between terrestrial and coastal governance frameworks continues to weaken integrated carbon policy implementation. Coastal forests are frequently excluded from forest-oriented climate policies, diminishing the effectiveness of climate mitigation. This reinforces the need for a unified governance architecture that incorporates terrestrial, peat, and coastal ecosystems under one strategic climate framework.

Sustainable forest management further illustrates that ecological resilience and economic benefits are not mutually exclusive when implemented through ecosystem-based strategies. Evidence shows that when sustainable management practices dominate, timber production can remain stable without causing large-scale emissions, creating a balance between economic interests and ecological stability (Sasaki et al., 2016). However, sustaining this model requires stringent monitoring, robust legal enforcement, and long-term investment in forest stewardship. The persistence of informal markets, weak institutional oversight, and inconsistent enforcement of environmental regulations remain barriers to achieving durable sustainable management outcomes in Indonesia.

Ultimately, the climate crisis trajectory forces Indonesia to reconsider its orientation toward forests not only as economic assets but also as stabilizers of national climate security. The environmental, economic, and geopolitical consequences of continued degradation signify that Indonesia must reposition forest carbon governance as a foundation for climate resilience. Long-term mitigation requires a shift from extraction-centered development toward diversified, low-carbon economic pathways designed to strengthen community participation, ensure transparent institutional arrangements, and align environmental policies with global climate imperatives. The future of Indonesia's climate resilience depends on whether forest governance evolves to overcome systemic conflicts between conservation, commodity extraction, and climate stewardship.

CONCLUSION

Indonesia's tropical forests occupy a decisive position in the global climate system because they function simultaneously as powerful carbon sinks and major potential sources of emissions when exposed to deforestation, commodity-driven land conversion, and forest fires. The discussions indicate that conservation policies anchored in ecosystem services, community engagement, and integrated coastal and terrestrial governance provide the most durable strategy to sustain forest-based carbon sequestration, whereas extractive economic pathways reinforce emission intensification and undermine climate resiliency. The effectiveness of Indonesia's climate governance depends on resolving regulatory loopholes, strengthening land rights, institutionalizing equitable benefit-sharing, and transitioning away from development paradigms that rely on continuous ecological extraction.

Future policy direction should therefore prioritize structural reforms that embed forest conservation within national development planning, diversify local economic opportunities for forest-dependent communities, and support adaptive governance that integrates scientific data, indigenous knowledge, and transparent climate finance mechanisms. Strengthening forest carbon governance offers not only mitigation benefits but also long-term climate security, biodiversity stability, and socioeconomic resilience. Through integrated environmental and economic transformation, Indonesia can reposition its tropical forests from vulnerable carbon sources to enduring carbon sinks that support a sustainable and climate-stable future.

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