



Integrated Strategy for Addressing Deforestation within the Framework of Environmental Law Governance in Indonesia

Soediro^{1*}, Mahdi Muhammad²

¹ Faculty of Law, Universitas Muhammadiyah Purwokerto, Purwokerto, Indonesia.

² Regional Office of the Ministry of Law of Central Java, Semarang, Indonesia.

 : diro_dl66@yahoo.co.id
Corresponding Author*



Abstract

Deforestation represents a multidimensional challenge affecting environmental sustainability, biodiversity loss, social welfare, and global climate stability. Indonesia, as one of the world's largest holders of tropical forests, faces persistent tensions between economic development, land-use governance, and conservation obligations. These challenges demand integrated regulatory, institutional, and societal responses beyond conventional environmental protection frameworks. The purpose of this research is to analyze comprehensive strategies for addressing deforestation in Indonesia by examining the interaction between legal policies, institutional arrangements, community participation, technological monitoring, and economic instruments. This study aims to identify an integrated approach capable of enhancing environmental quality while balancing development objectives and sustainable forest management. This research employs normative legal research with statutory, conceptual, and policy approaches. The study analyzes environmental laws, forestry regulations, international mechanisms such as REDD+, and relevant scholarly literature. Qualitative analysis is used to evaluate how legal norms interact with institutional practices, community-based initiatives, technological tools, and economic incentives in deforestation control. The findings demonstrate that deforestation control is more effective when legal frameworks are integrated with community-based approaches, digital monitoring technologies, and economic instruments. The novelty of this research lies in its unified analytical model that moves beyond reliance on formal legal regulation alone, offering a multidimensional governance strategy that strengthens environmental protection and policy implementation in Indonesia).

Keywords: Deforestation; Environmental Governance; Integrated Strategy.

Submitted: 2026-02-11

Revised: 2026-07-30

Accepted: 2026-08-18

Published: 2026-08-31

How To Cite: Soediro, and Mahdi Muhammad. "Integrated Strategy for Addressing Deforestation Within the Framework of Environmental Law Governance in Indonesia." *BACARITA Law Journal* 7 no. 1 (2026): 1-13.
<https://doi.org/10.30598/bacarita.v7i1.24371>

Copyright © 2026 Author(s)



Creative Commons Attribution-NonCommercial 4.0 International License

INTRODUCTION

Deforestation represents a form of environmental degradation that results in biodiversity loss, increased greenhouse gas emissions, and disruption of socio-ecological balance. In Indonesia, deforestation pressures are driven by illegal logging, conversion of land for plantations, infrastructure development, and fragmented policies and governance structures that remain insufficiently integrated.¹ Empirical studies indicate that forest cover loss reduces the quality of ecosystem services, diminishes carbon sequestration capacity, and weakens climate commitments, while permit-restriction mechanisms such as concession moratoria provide only limited and variable mitigation across different landscapes, including peatlands.² These findings are important because they indicate that

¹ Republic of Indonesia Ministry of Environment and Forestry, *The State Of Indonesia ' S Forests 2022, 2022.*

² Jewel Andoh and Yohan Lee, "National REDD+ Strategy for Climate Change Mitigation: A Review and Comparison of Developing Countries," *Sustainability (Switzerland)* 10, no. 12 (2018): 1-17, <https://doi.org/10.3390/su10124781>.

“restrictive” policies alone - without enhanced incentives, coordination, and monitoring capacity - tend to generate only limited effects.

At the same time, deforestation dynamics cannot be separated from the political-economic realities of commodity production. Spatial studies in major commodity-producing regions, particularly oil palm areas, reveal strong relationships between forest clearing, land-use change, and shifting patterns of plantation expansion over time.³ Consequently, effective deforestation mitigation strategies must address both market logics and land-access dynamics simultaneously, not merely through prohibitions, but by reshaping incentive structures and closing governance gaps that allow destructive expansion to recur.

In this context, the REDD+ framework and performance-based economic instruments are relevant as efforts to bridge conservation and development interests. However, policy analyses indicate that the main challenges of REDD+ in Indonesia lie not only in emissions measurement, but also in the implementation of safeguards, transparency in benefit-sharing, and institutional capacity to channel incentives to the local level without triggering new conflicts.⁴ Studies on benefit-sharing emphasize that the design of benefit-distribution mechanisms is a critical point: ambiguity fosters distrust, inequity generates resistance, and the absence of audit mechanisms risks reducing REDD+ to a merely administrative project.

Nevertheless, strategies that rely solely on economic instruments are also insufficient. Many deforestation episodes occur due to delays in detecting and responding to on-the-ground changes. Accordingly, the literature on technology-based deforestation monitoring has expanded rapidly, encompassing the use of high-resolution satellite imagery, machine learning, and near real-time monitoring systems. Machine-learning-based classifications of deforestation drivers using Indonesian spatial data demonstrate that computational approaches can explain forest-loss causes more deeply, not merely identify locations.⁵ Experiences with near real-time monitoring systems such as DETER-R in Brazil further show that operational monitoring architectures can accelerate policy responses and enforcement when data are used as decision-making foundations rather than as periodic reports.⁶

Moreover, local governance components and community roles often determine the success of deforestation mitigation, although they are frequently treated as supplementary. When access to legal management rights and livelihood incentives is unavailable, communities are placed in vulnerable positions, either as victims of land conflicts or as actors driven toward unsustainable forest-use practices. Studies on village governance and sustainability indicate that local-level deforestation mitigation requires tangible institutional designs, internal rules, and implementation capacity, rather than mere participatory rhetoric.⁷ At the national level, forest rehabilitation and restoration agendas

³ David L.A. Gaveau et al., “Slowing Deforestation in Indonesia Follows Declining Oil Palm Expansion and Lower Oil Prices,” *PLoS ONE* 17, no. 3 March (2022): 1–19, <https://doi.org/10.1371/journal.pone.0266178>.

⁴ Sarah Agustiorini et al., “Summary Information Of Safeguard Redd + Indonesia © 2023 Ministry of Environment and Forestry of the Republic of Indonesia,” *Summary Information of Safeguard Redd+ Indonesia*, 2023.

⁵ N. I. Fawzi, V. N. Husna, and J. A. Helms, “Measuring Deforestation Using Remote Sensing and Its Implication for Conservation in Gunung Palung National Park, West Kalimantan, Indonesia,” *IOP Conference Series: Earth and Environmental Science* 149, no. 1 (2018): 1–8, <https://doi.org/10.1088/1755-1315/149/1/012038>.

⁶ Juan Doblas et al., “Deter-R: An Operational Near-Real Time Tropical Forest Disturbance Warning System Based on Sentinel-1 Time Series Analysis,” *Remote Sensing* 14, no. 15 (2022): 1–21, <https://doi.org/10.3390/rs14153658>.

⁷ Mawaddah, “Evaluasi Kebijakan Pengendalian Deforestasi Dalam Mencapai Target Pembangunan Berkelanjutan (SDGs),” *Jurnal Ilmu Sosial Dan Humaniora* 3, no. 3 (2025): 128–36.

also demand cross-sectoral policy consistency to avoid short-term project orientations and instead deliver measurable and sustainable landscape improvements.⁸ Previous studies generally show that deforestation mitigation efforts tend to focus on legal and state-policy approaches, such as forest-permit moratoria, designation of protected areas, and criminal sanctions against illegal logging. Other studies highlight the role of conservation areas and forest patrols as deforestation-control instruments. However, most of this research still views mitigation strategies sectorally and has yet to integrate the roles of local communities, digital technology, and global economic incentive mechanisms within a single, cohesive policy framework.

In this regard, several relevant studies provide important insights. Research by Anggraini et al. (2021)⁹ employs remote sensing to analyze the impacts of deforestation on climate-change variables such as land surface temperature and rainfall in Indonesia. The findings demonstrate a clear empirical relationship between deforestation and climate-change factors, while emphasizing the importance of geospatial technology for understanding these dynamics. Meanwhile, Mulyana and Moeis (2022)¹⁰ evaluate the impact of social forestry programs on business growth and deforestation rates across several major Indonesian islands. Their findings indicate that community-based interventions have not been sufficiently effective in reducing deforestation without careful planning and adequate management capacity. Conversely, a study by Zweta et al. (2025)¹¹ analyzes the implementation of REDD+ as a mitigation instrument aimed at reducing emissions from deforestation and forest degradation in Kalimantan. This study notes several positive achievements but also identifies significant challenges, such as tenure conflicts and policy ambiguity, that affect overall program effectiveness

When situated within the broader map of prior research, it becomes evident that many studies are robust but tend to focus on a single policy instrument. Evaluations of moratorium policies highlight uneven effectiveness and limited contributions to climate targets.¹² Studies on social forestry underscore the potential of community-based approaches, yet outcomes depend heavily on spatial context, institutional capacity, and local economic pressures. Meanwhile, remote-sensing-based monitoring studies demonstrate the strategic value of spatial data for deforestation detection and analysis, but often lack integration with clear policy-response protocols¹³.

The primary gap across these research streams lies not in a lack of empirical evidence, but in the limited operational integration among instruments. Accordingly, this article positions its novelty in formulating an integrated deforestation-mitigation strategy that

⁸ Micah R; Daulay, Muhammad Haidar; Wicaksono, Satrio Adi; Bisiaux, Alice; Arthalina, Erliza Cikal Fisher, "Forest Restoration and Rehabilitation in Indonesia: A Policy and Legal Review Report," no. (2023): 86, <https://euredd.efi.int/wp-content/uploads/2023/03/FRR-Indonesia-Report.pdf>.

⁹ Tania Septi Anggraini, Kalingga Titon Nur Ihsan, and Derick C.A Masse, "Pemanfaatan Teknologi Penginderaan Jauh Untuk Analisis Pengaruh Deforestasi Terhadap Perubahan Iklim Di Indonesia Tahun 2019," *Jurnal Paradigma: Jurnal Multidisipliner Mahasiswa Pascasarjana Indonesia* 2, no. 2 (2021): 29–42.

¹⁰ Mulyana Mulyana and Jossy Pranata Moeis, "Dampak Program Perhutanan Sosial Terhadap Pertumbuhan Usaha Dan Deforestasi: Bukti Empiris Dari Indonesia," *E-Jurnal Ekonomi Sumberdaya Dan Lingkungan* 11, no. 1 (2022): 1–20, <https://doi.org/10.22437/jels.v11i1.18124>.

¹¹ Zandri Helmalina Zweta et al., "Program Reducing Emission from Deforestation and Forest Degradation Sebagai Solusi Deforestasi Di Kalimantan," *JISHUM (Jurnal Ilmu Sosial Dan Humaniora)* 10, no. 4 (2025): 212–27.

¹² Groom, Palmer, and Sileci, "Carbon Emissions Reductions from Indonesia's Moratorium on Forest Concessions Are Cost-Effective yet Contribute Little to Paris Pledges," 2022.

¹³ Rizkika Darwin et al., "Challenging Norms, Protecting Forests: The Agency and Negotiation Strategies of Women Rangers in Aceh, Indonesia," *Gender Equality: International Journal of Child and Gender Studies* 11, no. 2 (2025), <https://doi.org/10.1093/acprof:oso/9780195329414.003.0007>.

combines strengthened policy and institutional coordination, community empowerment through accountable local governance, technology-based monitoring linked to response SOPs, and performance-based economic instruments such as REDD+ to correct incentive structures at the local level. Within this framework, technology is positioned as a rapid decision-making engine, economic incentives as mechanisms for behavioral change, and community participation as tangible implementation capacity.

In this framework, technology is not treated as a “reporting tool,” but as a rapid decision engine; economic incentives are not treated as “compensation,” but as mechanisms for behavioral correction; and community participation is not treated as “legitimation,” but as implementation capacity. Thus, this introduction directs the discussion toward the design of deforestation-mitigation strategies that do not stop at policy norms, but are realized through a sequence of measurable actions from early detection and policy and licensing corrections, to strengthening legal and productive management access, and to fair, performance-based financing.

METHODS OF THE RESEARCH

This study employs a normative juridical legal research method by positioning deforestation as an environmental-governance issue rooted in policy design and the legal framework for natural-resource management. A *statute approach* is used to examine legislation in the fields of forestry, environmental protection, spatial planning, and related sectoral policies to identify normative consistency, regulatory overlap, and their implications for forest-area protection. Meanwhile, a *conceptual approach* is applied to examine key concepts such as sustainable development, environmental governance, deforestation, and environmental economic instruments as analytical foundations for understanding the relationship between development policies and forest degradation in the Indonesian context. In addition, this study applies a *policy approach* to analyze the direction, objectives, and rationales of public policies for deforestation control, including permit-restriction policies, ecosystem rehabilitation and restoration, community-based forest management, monitoring-technology utilization, and economic incentive mechanisms such as REDD+. Primary legal materials in the form of legislation and government policies are examined alongside secondary legal materials comprising scientific literature and previous research findings to assess alignment between policy design and implementation outcomes at the local level. The analysis is conducted qualitatively through systematic and teleological interpretation to formulate integrative and sustainable deforestation-mitigation strategies, ensuring that the research methodology is relevant and consistent with the analytical focus of the discussion and conclusions.

RESULTS AND DISCUSSION

This discussion elaborates on deforestation dynamics and mitigation strategies through policy, governance, technological, and economic-instrument approaches. The analysis is conducted thematically and integratively to address the research questions, positioning deforestation as a complex, cross-sectoral environmental-governance issue.

A. Deforestation and Its Impacts on the Environment

Deforestation is a process that generates systemic impacts on the environment and human well-being, rather than merely an ecological phenomenon. Forest-cover loss reduces

ecosystem capacity to provide essential environmental services—such as microclimate regulation, erosion control, biodiversity conservation, and watershed protection—with cumulative effects that become apparent only in the medium to long term. In Indonesia, national studies indicate a direct correlation between deforestation and environmental-quality degradation, including hydrological changes, declining soil and water quality, and disruptions to clean-water availability.¹⁴ Sociological studies in Bima further confirm that forest degradation increases the socio-economic vulnerability of coastal communities through declining fisheries yields, flooding, erosion, and pressure on local livelihood strategies.¹⁵

Beyond ecological impacts, deforestation produces significant socio-economic consequences. Local communities lose direct economic resources and long-standing socio-cultural support systems, with heightened risks of land conflict, unequal resource access, and marginalization. From a climate perspective, reduced carbon stocks due to deforestation weaken climate-change mitigation efforts and increase emissions from land-use change, positioning the forestry sector as central to achieving sustainable development and global emission-mitigation targets.¹⁶ Accordingly, the urgency of deforestation mitigation is driven not solely by ecological conservation interests, but also by the need to maintain socio-ecological stability, reduce community vulnerability, and ensure long-term development sustainability. Understanding these multidimensional impacts forms a crucial foundation for formulating more comprehensive and long-term-oriented deforestation-mitigation strategies.

B. Drivers of Deforestation from a Policy Perspective

The drivers of deforestation reveal close interconnections among development policies, spatial governance, and economic-incentive structures regulated within the national legal framework. Normatively, Law Number 41 of 1999 on Forestry affirms forest functions as life-support systems, while Law Number 26 of 2007 on Spatial Planning mandates control of spatial utilization based on environmental carrying capacity. However, in policy practice, land conversion for commodity production, plantations, and infrastructure development is often positioned as a prerequisite for economic growth, while forest protection tends to be treated as a secondary concern. This imbalance between normative environmental-protection mandates and development-oriented policy priorities generates recurrent pressure on forested areas, particularly in regions with high land-economic value.

Moreover, policy fragmentation across sectors and governance levels creates significant implementation gaps. Although Law Number 32 of 2009 on Environmental Protection and Management requires cross-sectoral policy integration through environmental-planning instruments and the precautionary principle, forestry, spatial planning, agriculture, and investment policies often operate in parallel without adequate coordination. This condition is reinforced by decentralization dynamics under Law Number 23 of 2014 on Regional Government, which open space for disharmony between central and local policies in forest-area management. Consequently, administratively legal licensing decisions can still result

¹⁴ Dwi Syamsih, "Impacts of Deforestation on Soil Quality and Water Resources in Tropical Forest Areas of Sumatra," *Journal of Horizon* 1, no. 1 (2024): 16–22, <https://doi.org/10.62872/kvmcwq82>.

¹⁵ Anwar and Supriadi, "The Impact of Deforestation On The Social And Economic Dynamics of Bima Coastal Communities: An Environmental Sociology Study In A Disaster Prone Area," *Nusantara Hasana Journal* 1, no. 7 (2024): 132–37.

¹⁶ Ben Groom, Charles Palmer, and Lorenzo Sileci, "Carbon Emissions Reductions from Indonesia's Moratorium on Forest Concessions Are Cost-Effective yet Contribute Little to Paris Pledges," *Proceedings of the National Academy of Sciences of the United States of America* 119, no. 5 (2022), <https://doi.org/10.1073/pnas.2102613119>.

in substantial forest clearing. This phenomenon is reflected in studies on deforestation-policy governance in Indonesia, which find that overlapping policies and legal ambiguity regarding land use weaken law enforcement and reduce overall accountability in forestry governance.¹⁷

Within the context of fiscal policy and environmental economics, deforestation can be viewed as an indicator of weak environmental governance, wherein available control instruments within the legal system fail to counterbalance economic-expansion pressures driven by market incentive structures and regional fiscal performance. Although the Environmental Protection and Management Act normatively recognizes the principle of environmental-cost internalization and the state's responsibility to preserve environmental sustainability, fiscal-policy implementation—including intergovernmental transfers and forestry-revenue sharing—has not fully reflected the value of forest ecosystem services. This condition incentivizes local governments to prioritize land conversion as a source of short-term revenue, as demonstrated by forestry-fiscal analyses identifying positive relationships between regional funding allocations and deforestation rates.¹⁸ Thus, deforestation cannot be understood merely as a result of administrative violations or weak law enforcement, but rather as a consequence of policy design and regulatory frameworks that are not yet fully integrated with sustainable-development and environmental-conservation principles. Accordingly, analyses of deforestation drivers must focus on improving cross-sectoral policy frameworks through regulatory harmonization, strengthened institutional coordination between central and local governments, and reaffirmation of environmental law's preventive function in safeguarding ecological limits within development decision-making.

C. Policy Strategies for Deforestation Control

Policy strategies implemented to control deforestation exhibit varying levels of effectiveness, highly dependent on regional contexts, implementation capacity, and synergy among policy actors within the national legal framework. Normatively, Law Number 41 of 1999 on Forestry, Law Number 32 of 2009 on Environmental Protection and Management, and Law Number 26 of 2007 on Spatial Planning provide legal foundations for controlling forest-area utilization through principles of prevention, precaution, and sustainability. However, the effectiveness of these norms is largely determined by the operational policy instruments applied on the ground.

Restrictive instruments, such as moratoria on the issuance of new permits for primary natural forests and peatlands, have become key pillars of national strategies to curb deforestation over recent decades. These moratorium policies are implemented through Presidential Instructions—among them Presidential Instruction Number 5 of 2019 on the Suspension of New Permits and Improvement of Primary Natural Forest and Peatland Governance—and technical regulations within the forestry sector. The primary objective of this policy is to reduce conversion of ecologically vulnerable primary forests and peatlands that play critical roles in climate-change mitigation. However, empirical evaluations of moratorium effectiveness indicate that although the policy has succeeded in halting the issuance of new formal permits, non-formal land-use practices and functional changes

¹⁷ A F Yuza, H A Manaf, and Z Zainal, "Deforestation Policy Governance In Indonesia," *CosmoGov: Jurnal Ilmu* ... 9, no. 1 (2023): 36–49, <https://doi.org/10.24198/cosmogov.v9i1.44778>.

¹⁸ Rosaline Anggita Elsa, Eka Intan Kumala Putri, and Nuva, "Unintended Effects of Forestry Fiscal Transfers on Deforestation in Indonesia," *Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan* 15, no. 4 (2025): 647–56, <https://doi.org/10.29244/jpsl.15.4.647>.

through administrative loopholes persist, particularly due to weak law enforcement and limited institutional coordination at the local level. This condition demonstrates that the effectiveness of restrictive policies is heavily determined by monitoring capacity, synergy between central and local governments, and community involvement in oversight and violation reporting.¹⁹

In addition to restrictive instruments, ecosystem rehabilitation and restoration efforts serve as corrective approaches aimed at restoring ecological functions of landscapes degraded by deforestation. Normatively, forest rehabilitation and restoration are grounded in Law Number 41 of 1999 on Forestry and reinforced by various government regulations and sectoral policies governing forest and land rehabilitation. Ecosystem rehabilitation encompasses replanting native vegetation, soil stabilization, and restoration of ecological structures to recover carbon-storage capacity and environmental services. National policy reviews indicate that rehabilitation is effective only when accompanied by strong local institutional support, sustainable financing, and adequate monitoring and evaluation mechanisms, enabling restoration principles to be applied consistently within long-term forest-management frameworks. Rehabilitation success is also strongly influenced by harmonization between formal policies and local management practices, as well as integration with economic and social instruments to ensure implementation continuity.²⁰

Findings from Putri et al. (2025)²¹ emphasize that the effectiveness of deforestation-control policies depends more on policy integration and institutional capacity than on normative-design completeness alone. In practice, sectoral and fragmented policy approaches often yield limited or even paradoxical outcomes, wherein formal moratoria fail to fully prevent deforestation occurring through other legal channels, such as forest-area conversion for non-forestry purposes under sectoral permits. Therefore, policy-strategy evaluation must extend beyond normative assessment to include site-level implementation indicators that reflect efficiency, effectiveness, and long-term impacts of adopted policies. Accordingly, effective deforestation-control strategies require a combination of restrictive instruments, ecosystem rehabilitation/restoration, consistent law enforcement, and strong inter-institutional coordination mechanisms. Such approaches must be accompanied by policies responsive to local and global dynamics, including integration among spatial planning, economic development, and environmental protection.

D. Community-Based Approaches to Forest Management

Community-based approaches position local communities as key actors in forest management, based on the assumption that their direct involvement in decision-making and legal access to resources strengthens motivation to sustain ecosystems while improving economic well-being. Empirical studies indicate that social-forestry schemes, such as *Hutan Nagari Sungai Buluh* in Padang Pariaman, have increased community participation in conservation and ecotourism while reducing destructive forest-conversion practices.²² Such approaches are more adaptive to local conditions, as they respond to socio-economic needs,

¹⁹ Wina Arsy Septiani et al., "Effectiveness of Forest Moratorium Policy Using the EMMIE Framework Approach," *Jurnal Ilmu Administrasi Negara* 16, no. 1 (2025): 13–23.

²⁰ Nunang Lamaek May et al., "Efektivitas Program Rehabilitasi Hutan Dan Lahan Untuk Mengurangi Risiko Bencana Alam Di Indonesia," *Jurnal Geosains West Science* 2, no. 03 (2024): 133–42, <https://doi.org/10.58812/jgws.v2i03.1680>.

²¹ Farah Fadilla Putri et al., "Kebijakan Pengendalian Deforestasi Dan Restorasi Ekosistem," *Journal of MISTER* 2, no. 3 (2025): 3873–80.

²² Syofia Agustini and Arya Hadi Dharmawan, "The Contribution of Community Based Forest Management to Livelihood and Rural Economy: The Case of Hutan Nagari Sungai Buluh in Padang Pariaman," *Sodality Jurnal Sosiologi Pedesaan* 5, no. No.2 (2017).

cultural dynamics, and community ecological knowledge, thereby reinforcing linkages between ecological conservation and local economic development.

However, the effectiveness of community approaches is not automatic and depends heavily on local organizational capacity, clarity of internal rules, and policy and institutional support from central and local governments. Studies in Hutan Desa Sungai Buluh, Jambi, show that without cross-sectoral coordination, facilitation, and adequate monitoring mechanisms, community roles risk becoming symbolic or insufficiently effective in reducing deforestation.²³ Public participation also requires more equitable relationships among communities, government, and tenure institutions to ensure substantive empowerment.²⁴ Therefore, community-based approaches should be integrated within broader forest-governance systems, combined with national policies, monitoring instruments, and economic incentives to generate tangible contributions to forest conservation while meeting community socio-economic needs.

E. The Role of Technology in Deforestation Monitoring

Advances in forest-monitoring technology have transformed how deforestation is detected, analyzed, and addressed within natural-resource governance contexts. The use of high-resolution satellite imagery—including multispectral optical and radar data—along with artificial-intelligence-based analyses enables faster, more accurate, and repeated (multi-temporal) identification of forest-cover changes. Such technologies provide timely and continuous information critical for evidence-based decision-making in both policy formulation and operational field implementation.

As an illustration of technological development in Indonesia, utilization of the *Google Earth Engine* (GEE) platform has demonstrated effectiveness in multi-temporal land-cover and forest-cover monitoring using machine-learning algorithms such as *Random Forest*, which can process diverse satellite-image datasets (e.g., Landsat, Sentinel) in an integrated manner across large scales with high classification accuracy, thereby providing a robust foundation for deforestation and forest-degradation analysis.²⁵ Nevertheless, integrating monitoring technology does not automatically generate tangible policy impacts. Without clear response mechanisms and effective operational procedures—such as direct linkages between *monitoring* outputs, law enforcement, and management-strategy adjustments—generated information risks remaining merely technical archives. Accordingly, monitoring technology must be connected to responsive decision-making systems, including reporting mechanisms, inter-agency collaboration, and institutional support at national and sub-national levels. Studies on forest-cover-change monitoring in “*Taman Hutan Raya (Tahura)*” areas show that technologies such as Landsat and Sentinel via GEE not only provide forest-cover data, but also facilitate long-term trend analyses that underpin forestry-policy evaluation and site-level rehabilitation planning.²⁶ However, technological data alone do

²³ Fajri Rahman, Apriwan Apriwan, and Ade Irwandi, “Pengelolaan Hutan Berbasis Masyarakat (PHBM) Pada Hutan Lindung Gambut (HLG) Di Desa Pematang Rahim Provinsi Jambi,” *Jurnal Ilmiah Universitas Batanghari Jambi* 24, no. 2 (2024): 1007, <https://doi.org/10.33087/jiubj.v24i2.4984>.

²⁴ Slamet Rosyadi and Khairu Roojiqien Sobandi, “Relasi Kuasa Antara Perhutani Dan Masyarakat Dalam Pengelolaan Sumberdaya Hutan Di Banyumas: Kepentingan Bisnis Vs Community Empowerment,” *Komunitas* 6, no. 1 (2017): 47–56, <https://doi.org/10.15294/komunitas.v6i1.2939>.

²⁵ Ahmad Rizaldi et al., “Pemanfaatan Google Earth Engine Untuk Pemantauan Lahan Agroforestri Dalam Skema Perhutanan Sosial,” *Majalah Geografi Indonesia* 37, no. 1 (2022): 12, <https://doi.org/10.22146/mgi.73923>.

²⁶ Adhi Auliya Fikri et al., “Pemanfaatan Platform Google Earth Engine Dalam Pemantauan Perubahan Tutupan Lahan Di Taman Hutan Raya Wan Abdul Rachman,” *Journal of Forest Science Avicennia* 5, no. 1 (2022): 46–57, <https://doi.org/10.22219/avicennia.v5i1.19938>.

not automatically yield policy impacts. Without clear response mechanisms, monitoring information risks remaining technical archives. Therefore, monitoring technologies must be integrated with operational procedures linking early detection to corrective actions, whether through policy review, field enforcement, or management-strategy adjustment.

Within deforestation-mitigation strategies, technology functions as a policy- and management-effectiveness lever rather than a substitute for institutional roles. Integrating technology with responsive governance—through inter-agency collaboration, local-community involvement in participatory monitoring, and incentive mechanisms linking monitoring outcomes to economic rewards (e.g., within REDD+ schemes)—is a prerequisite for optimizing technological benefits over the long term. Thus, monitoring technologies must integrate technical, institutional, and policy dimensions to ensure measurable and sustainable impacts on deforestation-rate reduction and environmental-quality improvement, aligning with adaptive and data-driven forest-management targets.

F. Economic Incentives and Environmental Market Mechanisms

Environmental economic instruments such as REDD+ (*Reducing Emissions from Deforestation and Forest Degradation*) are designed to alter land-use incentive structures by rewarding deforestation-reduction performance. This scheme represents one of the *market-based instrument* innovations that seek to bridge forest-conservation interests and economic-development objectives through *Result-Based Payments* (RBP), whereby financial rewards are allocated to actors demonstrating emissions reductions from avoided deforestation and forest degradation. This mechanism has become part of Indonesia's national climate policy integrated into climate-change mitigation strategies and sustainable forest management²⁷, although its effectiveness is strongly influenced by benefit-sharing design and clarity of actor roles at local and national implementation levels.

Institutional arrangements and incentive-distribution governance are key factors in realizing REDD+ economic benefits. Empirical studies on payments for environmental services (PES) mechanisms within REDD+ schemes show that when economic incentives are not distributed equitably or verifiably, stakeholder trust declines and program sustainability is threatened. In Laman Satong Village, West Kalimantan, PES schemes integrated into REDD+ demonstrate potential to encourage local-community participation in forest conservation while improving community economic welfare; however, implementation requires transparent distribution systems and robust verification mechanisms to ensure measurable ecological and socio-economic impacts over time.²⁸

Furthermore, REDD+ effectiveness within environmental markets is also determined by integration between national policies and incentive mechanisms responsive to local economic dynamics. Studies of REDD+ implementation across Indonesian regions emphasize that economic incentives must be supported by clear institutional structures, stable carbon-pricing mechanisms, and fiscal policies capable of internalizing forest ecosystem-service values into land-use decisions. Without such support, environmental market mechanisms tend to function merely as policy complements rather than substitutes

²⁷ Helmalina Zweta et al., "Program Reducing Emission from Deforestation and Forest Degradation Sebagai Solusi Deforestasi Di Kalimantan."

²⁸ Cahyo Nugroho, Jatna Supriatna, and Ahmad Kusworo, "Dapatkah Pembayaran Jasa Lingkungan Mencegah Deforestasi Dan Meningkatkan Kesejahteraan Masyarakat? Pelajaran Dari Hutan Desa Laman Satong, Kabupaten Ketapang, Kalimantan Barat," *Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan (Journal of Natural Resources and Environmental Management)* 9, no. 4 (2019): 882–92, <https://doi.org/10.29244/jpsl.9.4.882-892>.

for comprehensive deforestation-control strategies²⁹. Therefore, economic incentives through REDD+ and PES schemes play strategic roles in supporting sustainable forest governance when designed transparently, equitably, and sustainably. Environmental market mechanisms function not only as fiscal tools, but also as reinforcements of linkages between ecological conservation and community welfare, thereby encouraging land-use behavioral change toward more economically, socially, and environmentally sustainable practices.

G. Case-Study Evaluation and Strategic Synthesis

Evaluations of various forest-management case studies indicate that successful deforestation mitigation rarely results from a single instrument. Best practices emerge when strong policies, participatory community-based management, precise monitoring technologies, and fair economic incentives are implemented simultaneously and reinforce one another. For example, case studies of REDD+ implementation in Kalimantan show that combinations of result-based incentives, participatory monitoring, and local-community involvement in MRV (*Monitoring, Reporting, Verification*) metrics can improve forest-area protection while safeguarding indigenous tenure rights, although challenges remain regarding tenure conflicts and inter-agency coordination.³⁰

Additionally, empirical studies of conservation-partnership programs in Meru Betiri National Park underscore the importance of synergy between local-community empowerment and formal conservation policies. Findings indicate that community empowerment within conservation-partnership frameworks not only positively affects community economic welfare, but also fosters social cohesion necessary for sustainable forest management. In this context, increased farmer incomes and active involvement in conservation-management processes indicate that community-based partnerships can function as important components of broader strategic efforts to reduce deforestation and strengthen socio-ecological sustainability.³¹

Synthesis of the preceding subsections demonstrates that integrative approaches are far better suited to addressing deforestation complexity than fragmented sectoral approaches. Cross-dimensional integration enables early detection of forest changes, rapid and coordinated policy responses, local-community empowerment, and economic-incentive alignment that drives broader land-use behavioral change. This approach proves effective when these elements are not isolated, but interconnected through coherent, accountable, and responsive governance frameworks attuned to both local and global dynamics. Accordingly, this discussion addresses the research questions by affirming that effective and sustainable deforestation-mitigation strategies must be built through synergies among public policies, community-based governance, monitoring technologies, and economic incentive mechanisms within a coordinated and adaptive framework responsive to environmental and social change. Such integrative approaches not only enhance individual instrument effectiveness, but also reduce governance-conflict risks and strengthen implementation legitimacy from local to national levels.

²⁹ Loso Judijanto, Wang Jun, and Chen Mei, "The Economics of REDD+ (Reducing Emissions from Deforestation and Forest Degradation): A Policy Analysis of Its Implementation in Indonesia," *Journal of Selvicoltura Asean* 2, no. 5 (2025): 306.

³⁰ Helmalina Zweta et al., "Program Reducing Emission from Deforestation and Forest Degradation Sebagai Solusi Deforestasi Di Kalimantan."

³¹ Zulfidda Lillah, Djuara P Lubis, and Dwi Sadono, "Efektivitas Pemberdayaan Masyarakat Sekitar Hutan Dalam Kemitraan Konservasi Taman Nasional Meru Betiri Kabupaten Jember," *Sosio Konsepsia* 14, no. 1 (2024): 1-12, <https://doi.org/10.33007/ska.v13i2.3328>.

CONCLUSION

This study concludes that deforestation mitigation as an effort to address environmental degradation requires integrative and sustainable strategies, as deforestation is driven not only by illegal activities, but also by development-policy configurations, spatial-governance arrangements, and economic-incentive structures misaligned with ecological limits. Stand-alone policy approaches – such as permit restrictions or forest rehabilitation – have proven insufficiently effective without support from local-community participation, operational monitoring-technology utilization, and fair, transparent performance-based economic instruments. Therefore, integrating policy, community governance, monitoring technology, and economic incentive mechanisms constitutes a fundamental prerequisite for building adaptive, effective deforestation-mitigation strategies capable of safeguarding long-term environmental sustainability.

REFERENCES

- Agustini, Syofia, and Arya Hadi Dharmawan. "The Contribution of Community Based Forest Management to Livelihood and Rural Economy: The Case of Hutan Nagari Sungai Buluh in Padang Pariaman." *Sodality Jurnal Sosiologi Pedesaan* Vol.5, no. No.2 (2017).
- Agustiorini, Sarah, Franky Zamzani, Dinik Indrihastuti, Aditya Perdana Putra, Teguh Imansyah Martadijaya, Suyitno, and Muhammad Fadli. "Summary Information Of Safeguard Redd + Indonesia © 2023 Ministry of Environment and Forestry of the Republic of Indonesia." *Summary Information of Safeguard Redd+ Indonesia*, 2023.
- Andoh, Jewel, and Yohan Lee. "National REDD+ Strategy for Climate Change Mitigation: A Review and Comparison of Developing Countries." *Sustainability (Switzerland)* 10, no. 12 (2018): 1–17. <https://doi.org/10.3390/su10124781>.
- Anggraini, Tania Septi, Kalingga Titon Nur Ihsan, and Derick C.A Masse. "Pemanfaatan Teknologi Penginderaan Jauh Untuk Analisis Pengaruh Deforestasi Terhadap Perubahan Iklim Di Indonesia Tahun 2019." *Jurnal Paradigma: Jurnal Multidisipliner Mahasiswa Pascasarjana Indonesia* 2, no. 2 (2021): 29–42.
- Anwar, and Supriadi. "The Impact Of Deforestation On The Social And Economic Dynamics Of Bima Coastal Communities: An Environmental Sociology Study In A Disaster Prone Area." *Nusantara Hasana Journal* 1, no. 7 (2024): 132–37.
- Darwin, Rizkika, Melly Masni, Bobby Rahman, Cut Dian Fitri, Anna Christi Suwardi, and Nabila Amira Septiana. "Challenging Norms, Protecting Forests: The Agency and Negotiation Strategies of Women Rangers in Aceh, Indonesia." *Gender Equality: International Journal of Child and Gender Studies* 11, no. 2 (2025). <https://doi.org/10.1093/acprof:oso/9780195329414.003.0007>.
- Doblas, Juan, Mariane S. Reis, Amanda P. Belluzzo, Camila B. Quadros, Douglas R.V. Moraes, Claudio A. Almeida, Luis E.P. Maurano, André F.A. Carvalho, Sidnei J.S. Sant'Anna, and Yosio E. Shimabukuro. "Deter-R: An Operational Near-Real Time Tropical Forest Disturbance Warning System Based on Sentinel-1 Time Series Analysis." *Remote Sensing* 14, no. 15 (2022): 1–21. <https://doi.org/10.3390/rs14153658>.
- Elsa, Rosaline Anggita, Eka Intan Kumala Putri, and Nuva. "Unintended Effects of Forestry

- Fiscal Transfers on Deforestation in Indonesia." *Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan* 15, no. 4 (2025): 647–56. <https://doi.org/10.29244/jpsl.15.4.647>.
- Fawzi, N. I., V. N. Husna, and J. A. Helms. "Measuring Deforestation Using Remote Sensing and Its Implication for Conservation in Gunung Palung National Park, West Kalimantan, Indonesia." *IOP Conference Series: Earth and Environmental Science* 149, no. 1 (2018): 1–8. <https://doi.org/10.1088/1755-1315/149/1/012038>.
- Fikri, Adhi Auliya, Arief Darmawan, Rudi Hilmanto, Irwan Sukri Banuwa, Ariyadi Agustiono, and Laviyanti Agustiana. "Pemanfaatan Platform Google Earth Engine Dalam Pemantauan Perubahan Tutupan Lahan Di Taman Hutan Raya Wan Abdul Rachman." *Journal of Forest Science Avicennia* 5, no. 1 (2022): 46–57. <https://doi.org/10.22219/avicennia.v5i1.19938>.
- Fisher, Micah R; Daulay, Muhammad Haidar; Wicaksono, Satrio Adi; Bisiaux, Alice; Arthalina, Erliza Cikal. "Forest Restoration and Rehabilitation in Indonesia: A Policy and Legal Review Report," no. (2023): 86. <https://euredd.efi.int/wp-content/uploads/2023/03/FRR-Indonesia-Report.pdf>.
- Gaveau, David L.A., Bruno Locatelli, Mohammad A. Salim, Husnayaen, Timer Manurung, Adrià Descals, Arild Angelsen, Erik Meijaard, and Douglas Sheil. "Slowing Deforestation in Indonesia Follows Declining Oil Palm Expansion and Lower Oil Prices." *PLoS ONE* 17, no. 3 (2022): 1–19. <https://doi.org/10.1371/journal.pone.0266178>.
- Groom, Ben, Charles Palmer, and Lorenzo Sileci. "Carbon Emissions Reductions from Indonesia's Moratorium on Forest Concessions Are Cost-Effective yet Contribute Little to Paris Pledges." *Proceedings of the National Academy of Sciences of the United States of America* 119, no. 5 (2022): 1–10. <https://doi.org/10.1073/pnas.2102613119>.
- — —. "Carbon Emissions Reductions from Indonesia's Moratorium on Forest Concessions Are Cost-Effective yet Contribute Little to Paris Pledges." *Proceedings of the National Academy of Sciences of the United States of America* 119, no. 5 (2022). <https://doi.org/10.1073/pnas.2102613119>.
- Helmalina Zweta, Zandri, Syaulia Grandis, Gayatri Natha Sandi, Hosea Manuel, and Ubaidillah Kamal. "Program Reducing Emission from Deforestation and Forest Degradation Sebagai Solusi Deforestasi Di Kalimantan." *JISHUM (Jurnal Ilmu Sosial Dan Humaniora)* 10, no. 4 (2025): 212–27.
- Judijanto, Loso, Wang Jun, and Chen Mei. "The Economics of REDD+ (Reducing Emissions from Deforestation and Forest Degradation): A Policy Analysis of Its Implementation in Indonesia." *Journal of Selvicoltura Asean* 2, no. 5 (2025): 306.
- Lillah, Zulfidda, Djuara P Lubis, and Dwi Sadono. "Efektivitas Pemberdayaan Masyarakat Sekitar Hutan Dalam Kemitraan Konservasi Taman Nasional Meru Betiri Kabupaten Jember." *Sosio Konsepsia* 14, no. 1 (2024): 1–12. <https://doi.org/10.33007/ska.v13i2.3328>.
- Mawaddah. "Evaluasi Kebijakan Pengendalian Deforestasi Dalam Mencapai Target Pembangunan Berkelanjutan (SDGs)." *Jurnal Ilmu Sosial Dan Humaniora* 3, no. 3 (2025): 128–36.

- May, Nunang Lamaek, Sutiharni Sutiharni, Rusdi Angrianto, Christian Soleman Imburi, and Evelin Anggelina Tanur. "Efektivitas Program Rehabilitasi Hutan Dan Lahan Untuk Mengurangi Risiko Bencana Alam Di Indonesia." *Jurnal Geosains West Science* 2, no. 03 (2024): 133–42. <https://doi.org/10.58812/jgws.v2i03.1680>.
- Ministry of Environment and Forestry, Republic of Indonesia. *THE STATE OF INDONESIA 'S FORESTS 2022*, 2022.
- Mulyana, Mulyana, and Jossy Pranata Moeis. "Dampak Program Perhutanan Sosial Terhadap Pertumbuhan Usaha Dan Deforestasi: Bukti Empiris Dari Indonesia." *E-Jurnal Ekonomi Sumberdaya Dan Lingkungan* 11, no. 1 (2022): 1–20. <https://doi.org/10.22437/jels.v11i1.18124>.
- Nugroho, Cahyo, Jatna Supriatna, and Ahmad Kusworo. "Dapatkah Pembayaran Jasa Lingkungan Mencegah Deforestasi Dan Meningkatkan Kesejahteraan Masyarakat? Pelajaran Dari Hutan Desa Laman Satong, Kabupaten Ketapang, Kalimantan Barat." *Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan (Journal of Natural Resources and Environmental Management)* 9, no. 4 (2019): 882–92. <https://doi.org/10.29244/jpsl.9.4.882-892>.
- Putri, Farah Fadilla, Eli Apud Saepudin, Widya Nurfitriani, and Diah Karmila. "Kebijakan Pengendalian Deforestasi Dan Restorasi Ekosistem." *Journal of MISTER* 2, no. 3 (2025): 3873–80.
- Rahman, Fajri, Apriwan Apriwan, and Ade Irwandi. "Pengelolaan Hutan Berbasis Masyarakat (PHBM) Pada Hutan Lindung Gambut (HLG) Di Desa Pematang Rahim Provinsi Jambi." *Jurnal Ilmiah Universitas Batanghari Jambi* 24, no. 2 (2024): 1007. <https://doi.org/10.33087/jiubj.v24i2.4984>.
- Rizaldi, Ahmad, Arief Darmawan, Hari Kaskoyo, and Agus Setiawan. "Pemanfaatan Google Earth Engine Untuk Pemantauan Lahan Agroforestri Dalam Skema Perhutanan Sosial." *Majalah Geografi Indonesia* 37, no. 1 (2022): 12. <https://doi.org/10.22146/mgi.73923>.
- Rosyadi, Slamet, and Khairu Roojiqien Sobandi. "Relasi Kuasa Antara Perhutani Dan Masyarakat Dalam Pengelolaan Sumberdaya Hutan Di Banyumas: Kepentingan Bisnis Vs Community Empowerment." *Komunitas* 6, no. 1 (2017): 47–56. <https://doi.org/10.15294/komunitas.v6i1.2939>.
- Septiani, Wina Arsy, Ramaditya Rahardian, Latifah Latifah, Mohamad Hilal Nu'man, and Yayan Andri. "Effectiveness of Forest Moratorium Policy Using the EMMIE Framework Approach." *Jurnal Ilmu Administrasi Negara* 16, no. 1 (2025): 13–23.
- Syamsih, Dwi. "Impacts of Deforestation on Soil Quality and Water Resources in Tropical Forest Areas of Sumatra." *Journal of Horizon* 1, no. 1 (2024): 16–22. <https://doi.org/10.62872/kvmcwq82>.
- Yuza, A F, H A Manaf, and Z Zainal. "Deforestation Policy Governance In Indonesia." *CosmoGov: Jurnal Ilmu ...* 9, no. 1 (2023): 36–49. <https://doi.org/10.24198/cosmogov.v9i1.44778>.