

APPLICATION OF COOPERATION PRINCIPLE IN ADDRESSING TRANSBOUNDARY MANGROVE LAND USE CHANGE

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Abstract

Transboundary mangrove ecosystems play a vital role in the global environment, providing essential ecological services, carbon sequestration, and coastal protection. However, rapid coastal development and resource exploitation have led to significant conversion of mangrove lands, triggering transboundary environmental degradation and resource conflicts. This study examines the application of international cooperation principles in addressing the conversion of transboundary mangrove lands. Employing a normative legal research method combined with a qualitative contextual approach, the study analyzes international legal frameworks, regional environmental agreements, and bilateral cooperation mechanisms. The findings indicate that while the principle of cooperation is well established in international environmental law such as through the obligation to prevent transboundary harm and the mandate for sustainable development its practical implementation in transboundary mangrove management remains fragmented. Considerations of national sovereignty, conflicting economic interests, and divergent regulatory standards often hinder effective joint governance and law enforcement. To address these challenges, the study emphasizes the need to strengthen institutional frameworks, harmonize regional spatial planning policies, and establish joint monitoring systems and data sharing protocols among neighboring countries. Ultimately, upholding the principle of cooperation through integrated coastal zone management and multilateral agreements is crucial for minimizing the loss of transboundary mangroves, preserving biodiversity, and achieving long term regional ecological resilience.

Keywords: coastal governance; international environmental law; land use conversion; principle of cooperation; transboundary mangroves.



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1. Introduction

Transboundary mangrove ecosystems are one of the global ecological bulwarks that play a crucial role in maintaining climate stability, mitigating coastal disasters, and ensuring the sustainability of marine biodiversity (Maskun et al., 2019). Normatively, international environmental law has established a strong legal foundation for protecting these strategically valuable coastal areas. Based on the doctrine of sovereignty limitation, a state's sovereign rights over its natural resources are limited by the legal obligation not to cause environmental damage beyond its national borders (Sakharina et al., 2020). This fundamental principle is explicitly enshrined in various international instruments, such as the 1972

Stockholm Declaration (Principle 21) and the 1992 Rio Declaration (Principle 2), and is reinforced by provisions of the United Nations Convention on the Law of the Sea (UNCLOS 1982) regarding the protection and conservation of the marine environment.

In the context of coastal border areas, these norms are implemented through the Principle of International Cooperation. This principle requires countries that share ecological boundaries not to act unilaterally, but rather to engage in close coordination based on good faith. Such cooperation is realized through obligations regarding prior notification, cross border public consultations, periodic exchanges of scientific data, and the conduct of Transboundary Environmental Impact Assessments. Furthermore, international law encourages the implementation of Integrated Coastal Zone Management and Marine Spatial Planning as holistic instruments to balance economic, ecological, and social interests across jurisdictional boundaries (Wiranti et al., 2025).

While the normative framework outlined above has been theoretically planned, empirical realities on the ground reveal a starkly different situation. In recent decades, the pace of economic growth and the expansion of coastal industries have triggered massive conversion of mangrove lands in various border regions. Mangrove ecosystems continue to be converted into large scale aquaculture areas, commercial ports, energy infrastructure, and even coastal settlements on a massive and uncontrolled scale (Asriyani & Maskun, 2024). Unilateral land conversion by one neighboring country has clearly led to the accumulation of transboundary ecological losses, such as severe coastal abrasion, sediment erosion, the loss of habitats for endemic marine species, and a drastic decline in carbon absorption and storage capacity. In addition to ecological impacts, this land conversion fuels potential conflicts over resource use and jurisdictional disputes between neighboring countries. In practice, the implementation of the principle of cooperation is often paralyzed due to a direct clash with rigid national sovereignty claims.

Countries often use the doctrine of internal sovereignty as a justification for prioritizing short term economic development agendas over regional environmental commitments. This problem is exacerbated by striking disparities in domestic regulations, inter agency sectoral rivalries within government, and differences in environmental quality standards among countries. Most existing regional environmental cooperation instruments and bilateral agreements are soft law without binding enforcement mechanisms, thus failing to impose strict sanctions for land use conversion violations in coastal border areas (Sundari et al., 2025). Although a significant body of literature on mangrove ecosystem conservation and the principles of international environmental law has been published, the majority of previous studies have had limited scopes. Existing studies generally fall into two dominant approaches, either a purely environmental science or ecological approach that focuses on quantifying the biochemical damage to mangroves, or a theoretical international law approach that examines treaty texts without linking them to the actual dynamics of land use conversion on the ground.

There is a lack of scientific studies that specifically examine the relationship between the legal implications of coastal land use conversion along border areas and the effectiveness of measures taken in response to such conversions. Most existing research has not thoroughly analyzed why international legal obligations such as the “no harm” rule and Transboundary Environmental Impact Assessment face implementation challenges when confronted with national land use regulations in coastal areas. This study aims to fill this academic gap by integrating a normative legal research approach with a contextual qualitative approach to formulate a legal harmonization framework that is precise, practical, and legally binding at the regional level.

Based on the fundamental conflict between ideal norms and factual reality, as well as the limitations of the existing literature, the main issue in this study is formulated as follows, how can the operationalization of the principle of cooperation in international environmental law be optimized to address the fragmentation of law enforcement and conflicts of national sovereignty related to cross-border mangrove land use conversion.

In line with this research question, this study aims to comprehensively analyze the effectiveness of the international legal framework, regional environmental agreements, and existing bilateral mechanisms, while also formulating strategies for institutional strengthening, harmonizing cross border coastal spatial planning policies, and promoting integrated Coastal Zone Management to minimize ecological damage and achieve long term regional environmental resilience.

2. Method

This study employs a normative legal research design with a contextual qualitative approach (Sugiyono, 2026). This design was chosen to analyze the international legal framework, evaluate the alignment of legal norms, and identify legal obstacles in the application of the principle of cooperation regarding the management of cross border mangrove land conversion. The data sources in this study focus on legal materials classified into three levels (Bahagia, 2026). Primary legal materials include legislation and international instruments, such as the United Nations Convention on the Law of the Sea (UNCLOS 1982), the Ramsar Convention 1971, the Convention on Biological Diversity (CBD 1992), the 1992 Rio Declaration, and the International Law Commission (ILC) draft article on the Prevention of Transboundary Harm. Secondary legal sources are drawn from scholarly literature. Tertiary legal sources include legal dictionaries. The primary tools in this study were the researcher, a legal inventory matrix, and a document coding sheet based on a theoretical framework. This matrix served as a control tool to categorize legal norms based on indicators of sovereignty, the obligation to prevent transboundary harm, and the mechanisms of Integrated Coastal Zone Management (ICZM).

Data collection was conducted through a systematic literature review based on digital repositories (ScienceDirect, Springer, and the UN Document Repository). The document search applied a combinatory keyword search technique, including “transboundary mangroves,” “principle of cooperation,” “international environmental law,” “coastal land conversion,” and “ICZM.” The collected documents were then validated using criteria of normative relevance and legal status differentiation. The data analysis technique used was prescriptive qualitative analysis with deductive reasoning (Devra, 2026). The analysis procedure began with a systematic and grammatical interpretation of international instruments to map out conflicts between legal norms and factual conditions. Subsequently, a critical comparative analysis was conducted to formulate legal prescriptions in the form of a model for coastal spatial planning harmonization, the strengthening of regional institutions, and protocols for border states.

3. Results and Discussion

International environmental law has, from a normative perspective, provided a sufficiently solid foundation for regulating the protection of transboundary coastal ecosystems. The main principle underpinning this governance framework is the principle of cooperation, which is bound by the doctrine of sovereignty limitation (Sakharina et al., 2020). Under this

doctrine, although a state possesses full sovereignty over natural resources within its jurisdictional boundaries, that sovereignty is not absolute and is limited by the obligation not to cause harm or pollution to areas outside its jurisdiction (the “obligation to prevent transboundary harm” or “no harm rule”).

The “no harm” principle is explicitly recognized as a rule of customary international law, codified in Principle 21 of the 1972 Stockholm Declaration and Principle 2 of the 1992 Rio Declaration. In the context of coastal and marine areas, the United Nations Convention on the Law of the Sea (UNCLOS 1982) reinforces this mandate through Article 192, which obligates every state to protect and preserve the marine environment, as well as Article 194, which requires states to take all necessary measures to prevent, reduce, and control pollution of the marine environment from any source, including land-based activities (Permatasari et al., 2026).



Figure 1. Image of Mangrove Land Use Conversion on the Riau Border
Source: (Mongabay.co.id, 2026)

The implementation of the principle of cooperation in the management of transboundary mangrove ecosystems is operationalized through four main procedural legal instruments, the obligation of prior notification, whereby a country planning large scale coastal land use conversion activities that may have transboundary impacts is required to provide advance notice to neighboring countries. Good faith consultations that foster a space for dialogue among nations to seek mitigation solutions before land use conversion projects are implemented. Analysis of transboundary environmental impacts, namely mandatory academic and legal assessments of the risks of ecological damage that may cross national borders. Periodic exchange of scientific data and information, namely transparency regarding biological conditions, mangrove cover boundaries, and coastal water quality monitoring (Naswar et al., 2023).

In addition to UNCLOS 1982, the 1971 Ramsar Convention on Wetlands (specifically Article 5) explicitly mandates that where wetlands or mangrove ecosystems straddle the jurisdictional boundaries of several countries, those countries are required to consult and coordinate in implementing conservation policies. The Convention on Biological Diversity (CBD 1992) also emphasizes a similar obligation to cooperate in Article 5. However, a

normative review shows that most of these cooperation provisions are formulated as “soft law” or procedural obligations (obligations of conduct), rather than obligations of result. Consequently, the success of these instruments depends heavily on the political will of each country.

The gap between ideal norms and on the ground realities is particularly striking in the governance of coastal border areas. Over the past two decades, the rate of mangrove land conversion and coastal pollution in various border areas has shown a significant upward trend. Unilateral coastal land conversion for industrial scale aquaculture, port reclamation, and settlements has triggered irreversible transboundary environmental damage (Maskun et al., 2022).

This situation is further exacerbated by overlapping jurisdictional authority among institutions and weak law enforcement in border areas, which industry actors often exploit to disregard environmental regulations. This disregard not only damages coastal ecosystems and reduces natural defenses against climate change, but also undermines the livelihoods of local communities that depend on marine resources. Without an integrated governance framework and inclusive cross border cooperation, environmental and social marginalization in coastal border areas will continue, while simultaneously threatening ecological stability and territorial sovereignty in the long term.

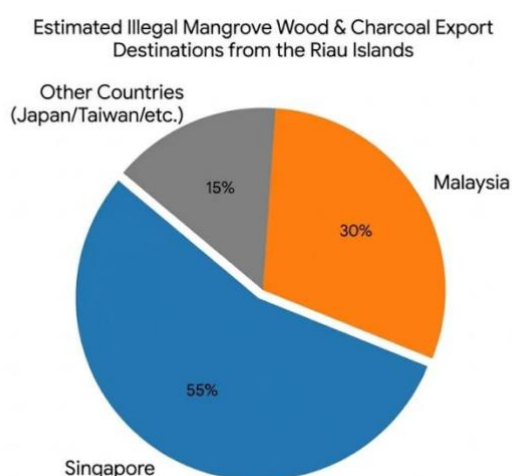


Figure 2

Source: (Directorate General of Customs and Excise (DJBC), 2021)

This graph shows the estimated proportion of illegal export destinations for mangrove products from the Riau Islands, specifically the Batam and Karimun regions. Singapore is the largest export destination, accounting for 55% of the total, with the main commodity being high quality mangrove charcoal to meet the needs of the restaurant industry and for coastal construction materials. Malaysia ranks second with a 30% share as the primary destination for the smuggling of raw timber via sea routes to the Johor region, while the remaining 15% is channeled to other international markets such as Japan, Taiwan, and the Middle East. The high demand from these two neighboring countries demonstrates that the degradation and conversion of mangrove ecosystems along Indonesia’s coastline are strongly driven by the dynamics of cross border economic supply chains in the region.

The prevalence of these illegal export activities has significant implications for both parties. For Indonesia, as the country of origin, this overexploitation causes severe damage to coastal ecosystems, eliminates natural barriers against erosion, and destroys marine habitats all of which threaten the livelihoods of local fishermen. Meanwhile, destination countries such as Singapore and Malaysia, on the one hand, benefit from the availability of cheap mangrove wood and charcoal to support their industrial and commercial sectors, on the other hand, they risk facing international scrutiny regarding the sustainability of their supply chains and their environmental commitments in the region. Furthermore, the loss of mangrove carbon sequestration functions in the Riau Islands ultimately crosses national borders and exacerbates the regional climate crisis, impacting the long term environmental stability of both parties.

To address these cross border ecological and economic losses, Indonesia and destination countries must move beyond piecemeal, single country focused law enforcement strategies. The proliferation of the illegal mangrove trade is deeply rooted in high market demand, weak border controls, and regulatory loopholes that allow illegally logged timber to enter international supply chains without strict oversight. Therefore, addressing this crisis requires a robust regional governance framework a collaboration capable of harmonizing environmental regulations, mandating supply chain transparency, and strengthening joint maritime patrols. Without coordinated bilateral policy interventions, the ongoing degradation of mangrove ecosystems will not only derail regional carbon neutrality targets but also exacerbate the socio environmental vulnerabilities of coastal communities.

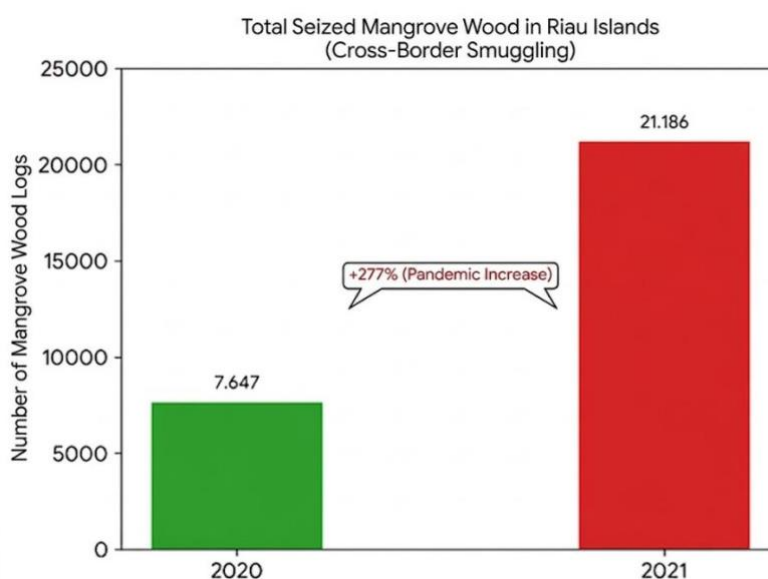


Figure 3

Source: (Directorate General of Customs and Excise (DJBC), 2021)

This graph shows the trend in enforcement actions against illegal mangrove timber smuggling in the Riau Islands, which has led to the conversion of mangrove ecosystems in coastal border areas. Based on enforcement data from the Directorate General of Customs and Excise (DJBC) in collaboration with law enforcement agencies, the number of mangrove logs successfully seized as evidence increased significantly from 7,647 logs in 2020 to 21,186 logs in 2021. This 277% surge in seized evidence indicates a rise in destructive mangrove logging

and land conversion activities during the pandemic, driven by the high economic value of raw timber on the overseas black market.

The rampant trend of smuggling, as reflected in the surge in seized evidence, has serious consequences for both sides. In Indonesia, the high volume of mangrove logging is simultaneously accelerating land clearing and the destruction of coastal ecosystems in the Riau Islands, which directly contributes to widespread coastal erosion, the loss of natural barriers against extreme waves, and a decline in local fishermen's catches. Meanwhile, for export destination countries, the high number of enforcement actions in Indonesia's border regions serves as a strong indication that oversight in the downstream segments of their domestic markets remains limited, while also underscoring the need for a strict commitment to screening out illegal commodities in order to safeguard their reputation for environmental governance at the regional level.

Table 1. Factual Evaluation of Transboundary Coastal Land Conversion and Pollution Management

Cross-Border Area	Forms of Pollution / Land Conversion	Transboundary Environmental Impact	Current Management Mechanisms	Obstacles / Law Enforcement Challenges
Malacca Strait & Singapore Strait (Indonesia–Malaysia–Singapore)	Unilateral coastal reclamation, mangrove clearing for port/industrial development, and oil spills.	Transboundary coastal erosion, changes in shipping channels, severe decline in coastal water quality, and loss of fish nursery grounds.	Tripartite Technical Expert Group and ASEAN environmental cooperation.	Conflicts of national sovereignty, fear of declining investment, and the absence of legally binding financial sanctions or compensation mechanisms.
Segara Anakan–Java Sea (Inter-Provincial Watershed / Border Area)	Massive sedimentation due to inland land conversion, domestic waste pollution, and mangrove conversion into shrimp ponds.	Extreme narrowing of the lagoon, loss of mangrove cover, and a sharp decline in traditional fishermen's catch.	Inter-agency regional cooperation and Coastal Zone Management Boards (domestic/local level).	Fragmentation of authority across jurisdictions, sectoral egos, and the lack of an legally enforceable integrated coastal spatial plan.
South China Sea / Kalimantan Border (Indonesia–Malaysia)	Uncontrolled clearing of border mangroves for oil palm plantations and coastal aquaculture.	Degradation of carbon sinks, disruption of natural border boundaries, and seawater intrusion into inland aquifers.	Heart of Borneo (HoB) Initiative and ministerial-level bilateral cooperation (Joint Commission).	Non-binding commitments (based solely on memorandums of understanding), conflicting domestic regulations, and a lack of joint monitoring.
Bay of Bengal Border (Bangladesh–India / Sundarbans)	Construction of dams/coastal embankments, mangrove land conversion, and upstream industrial pollution.	Soil salinization, extinction of endemic species, and increased vulnerability to tropical cyclones.	Joint River Commission (JRC) and MoU on Sundarbans Conservation.	Geopolitical dominance by one state, conflicts over water resource utilization, and the absence of a Transboundary Environmental Impact Assessment (TEIA).

Source: (Ministry of Environment and Forestry, 2020)

Based on the factual data in Table 1, the unilateral conversion of mangrove land has been shown to trigger a domino effect on the ecological balance of the region. When a country clears mangroves for domestic economic interests, neighboring countries that share the same coastal area suffer negative impacts such as coastal erosion, loss of marine habitat, and a decline in fish stocks.

The lack of a robust law enforcement mechanism (enforcement capacity) means that the “no-harm” rule is often ignored. Countries tend to use the pretext of internal sovereignty to allow coastal land conversion activities to continue. This failure to address the issue is exacerbated by the lack of real time and transparent data-sharing protocols, so that claims of environmental damage often become a political debate rather than being resolved through academic and legal channels (Maskun et al., 2019).

To gain a deeper understanding of the causes of fragmentation in law enforcement, it is important to compare binding international legal frameworks (“hard law”), non-binding agreements (“soft law”), and the domestic laws of neighboring countries. These differences in legal nature are the primary drivers of gaps in law enforcement.

Table 2. Comparative Juridical Characteristics of Legal Instruments in Transboundary Coastal Governance

Legal Instrument	Juridical Nature	Binding Force	Sanction & Law Enforcement Mechanisms
UNCLOS 1982 (Articles 192, 194, 207)	Hard Law (<i>Multilateral Treaty</i>)	Legally Binding for ratifying states.	Utilizes the International Court of Justice (ICJ) or the International Tribunal for the Law of the Sea (ITLOS); proceedings are complex and slow.
Ramsar Convention 1971 (Article 5)	Hard Law	Legally Binding, but formulated with flexible (open-ended) phrasing.	Montreux Record mechanism (<i>public review</i>); lacks direct financial sanctions or legal penalties.
Rio Declaration 1992 & Stockholm Declaration 1972	Soft Law (<i>Declaration of Principles</i>)	Non-Legally Binding.	No sanction mechanisms; serves purely as moral guidelines and direction for the development of new laws.
ASEAN Agreement on Conservation of Nature (1985)	Hard Law (<i>Regional</i>)	Not fully in force as it has not been ratified by all member states.	Weak; constrained by the <i>ASEAN Way</i> principle (non-intervention and absolute consensus).
Domestic Spatial & Coastal Regulations	Hard Law (<i>Domestic</i>)	Absolutely binding within national jurisdictional boundaries.	Enforced by domestic police/civil servant investigators (PPNS); lacks extraterritorial reach (<i>no extraterritoriality</i>).

Source: (Ministry of Environment and Forestry, 2020)

The results of the comparative analysis in Table 2 reveal the existence of a transboundary environmental law trilemma: legal instruments with strong binding power (hard law, such as UNCLOS) are often too general and involve highly bureaucratic dispute resolution processes that states avoid for political reasons. Instruments specifically regulating the conservation of border areas at the regional level are generally soft law or constrained by the political principle of non-intervention (such as the “ASEAN Way” doctrine in Southeast Asia). National domestic law possesses the strongest enforceability and sanctions, yet its scope of

application is rigidly limited by national borders (the principle of territoriality). These differences create legal loopholes that economic actors exploit to alter the function of coastal lands without regard for the ecological impacts on neighboring countries (Maskun et al., 2019). Without harmonization of domestic regulations among countries, transboundary environmental governance will remain fragmented.

Based on normative and factual findings, this study identifies four major obstacles that hinder the operationalization of the principle of cooperation in transboundary mangrove conservation, the doctrine of rigid national sovereignty. Claims to domestic territorial sovereignty remain the primary line of defense for countries to reject external environmental intervention. Coastal infrastructure development and aquaculture expansion are viewed as sovereign rights of the state aimed at increasing Local Revenue (PAD) or Gross Domestic Product (GDP). This mindset prioritizes short term economic interests over long term ecological responsibilities (Maskun et al., 2021).

Disparities in domestic legal and land use standards. There is a significant gap between the environmental legal standards of one country and those of its neighbors. For example, one country may designate a mangrove zone as a strictly protected area, while its neighboring country designates the same border mangrove area as a zone for aquaculture or coastal industrial development (Maskun et al., 2019). These disparities disrupt the ecological continuity of mangroves as a single ecological unit. The absence of a common institutional framework with supranational authority means that existing cooperation mechanisms are largely in the form of dialogue forums, technical committees, or joint committees that are ad hoc and consultative in nature. These bodies lack the supranational authority to make binding decisions, conduct unannounced cross border inspections, or directly impose legal sanctions on those responsible for land use conversion.

Due to limitations in protocols for scientific data exchange and joint monitoring, procedures for conducting Transboundary Environmental Impact Assessments (TEIA) are rarely implemented comprehensively. Countries still harbor concerns about sharing spatial and environmental data along their borders due to national security or industrial secrecy. Without joint monitoring based on satellite technology and the Internet of Things (IoT), land use conversion violations are difficult to detect early on (Maskun et al., 2019). Strategies for institutional strengthening and policy harmonization models (*de lege ferenda*). To address legal fragmentation and operational deadlocks in the principle of cooperation, this study formulates three prescriptive recommendations (*de lege ferenda*) as concrete solutions for integrated governance. Due to limitations in scientific data exchange protocols and joint monitoring, procedures for conducting Transboundary Environmental Impact Assessments (TEIA) are rarely implemented comprehensively. There remains reluctance among countries to share spatial and environmental data along borders due to concerns over national security or industrial secrecy. Without joint monitoring based on satellite technology and the Internet of Things (IoT), land conversion violations are difficult to detect early on (Maskun et al., 2019). Strategies for institutional strengthening and policy harmonization models (*De Lege Ferenda*). To address legal fragmentation and operational deadlocks in the prin.

First, the harmonization of cross border coastal spatial planning policies through ICZM and MSP. Countries that share border areas are required to align their marine spatial planning (MSP) and integrated coastal zone management (ICZM). Border coastlines must be viewed as a single ecological unit (ecosystem based management). This harmonization is achieved by establishing mangrove buffer zones that may not be converted to other uses by any country in

the border area. The establishment of a joint transboundary coastal authority (Yusal et al., 2025).

The harmonization of spatial planning policies and the establishment of this joint authority have implications for both countries. For Indonesia, the agreement on buffer zones and an ecosystem based approach provides legal certainty to protect border mangrove areas from the pressure of unilateral land use conversion that undermines the national environmental carrying capacity. Meanwhile, for the neighboring country, the alignment of the MSP and ICZM provides clarity on the boundaries of marine and coastal space utilization, so that development activities and industrial investments in the border region can proceed without triggering environmental sovereignty conflicts. Overall, this spatial planning integration transforms the border area which was previously vulnerable to uncoordinated exploitation into an ecological buffer zone that sustainably strengthens the resilience of both countries' territories.

Second, cooperation must not be limited to the level of an ad hoc committee. It is necessary to establish a permanent joint institution with independent authority to conduct periodic evaluations of the implementation of land use conversion permits in coastal border areas. Facilitate the objective and independent conduct of Transboundary Environmental Impact Assessments before coastal development projects begin (Maskun et al., 2022). Manage the Regional Mangrove Conservation Fund to support transboundary Payment for Ecosystem Services (PES) schemes.

The existence of these permanent institutions and regional financial mechanisms has a transformative impact on both parties. For Indonesia, the Cross Border EIA and Transboundary PES schemes ensure that any potential coastal damage resulting from border development projects can be mitigated early on, while also providing fair financial compensation for the mangrove ecosystem services they provide to the region. Meanwhile, for neighboring countries, active involvement in these institutions provides legal certainty and a more predictable investment climate, while positioning them as responsible partners in sustainable development. The management of this joint conservation fund ultimately shifts the burden of environmental protection which Indonesia previously bore alone into a collective responsibility that benefits the economic and ecological stability of both nations.

Third, the development of protocols for systematic data exchange and technology based monitoring. Border countries need to ratify a Legally Binding Agreement on real time environmental data exchange protocols (Hasbi et al., 2020). Remote sensing technologies based on satellite imagery and spatial sensing can be utilized to detect mangrove land use changes or water pollution at an early stage (early warning system) (Maskun et al., 2024). This integrated data eliminates gaps in political debate and provides strong scientific evidence for environmental law enforcement. By integrating a normative approach, harmonizing domestic regulations, and strengthening technology based institutions, the operationalization of the principle of cooperation is no longer merely a theoretical concept in international law but becomes an effective legal instrument for curbing the rate of mangrove loss, minimizing interstate conflicts, and ensuring long term regional ecological resilience.

The implementation of this technology based data exchange and monitoring protocol has significant strategic implications for both parties. For Indonesia, the availability of transparent, real time scientific evidence strengthens its bargaining position and legal sovereignty in addressing transboundary ecological violations and holding neighboring countries accountable for illegal supply chains that damage its coastal areas (Maskun et al.,

2024). Meanwhile, for neighboring countries as partners, this data integration enhances accountability in their domestic environmental governance, minimizes the risk of greenwashing in the timber supply industry, and prevents the escalation of diplomatic disputes stemming from unverified allegations of violations (Maskun et al., 2025). Ultimately, the transparency provided by this technology transforms bilateral relations from interactions marked by mutual suspicion into a robust partnership for ecological resilience.

4. Conclusion

This study concludes that although the international environmental legal framework (the principle of cooperation and the no harm rule) is normatively sound, its implementation in protecting transboundary mangrove ecosystems remains stalled due to a legal trilemma, conflicts of sovereignty, and the rampant conversion of land use and illegal practices driven by regional economic interests. Its practical and theoretical implications underscore the need for a governance transformation moving beyond mere procedural commitments toward integrated, ecosystem based coastal spatial planning (ICZM/MSP), the establishment of a permanent joint authority, and the ratification of a binding agreement for technology based spatial monitoring. However, this study has limitations because it focuses on normative qualitative analysis and factual mapping of specific border areas, and thus has not quantitatively measured the financial impacts or the effectiveness of Payment for Ecosystem Services (PES) schemes. Therefore, future research is recommended to examine the formulation of an integrated Transboundary Environmental Impact Assessment (TEIA) framework and ecological economic modeling to design sustainable regional conservation funding schemes.

References

- Maskun, Assidiq, M. F., Subair, & Nurul Ilmi, M. (2019). Environmental protection of mangrove forest: Affirmation consensus approach. *IOP Conference Series: Earth and Environmental Science*, 343(1), 012063. 1-9. <https://doi.org/10.1088/1755-1315/343/1/012063>
- Sakharina, I. K., Patittingi, F., Halim, H., Napang, M., Sumardi, J., Inggit, A. B., & Hendrapati, M. (2020). Sinking or not? An Indonesian approach to prevent the rise of sea levels due to global warming. *Journal of East Asia and International Law*, 13(1), 143–160. <http://dx.doi.org/10.14330/jeail.2020.13.1.07>
- Wiranti, Maskun, Ilmar, A., Naswar, Idris, I., & Gontha, E. (2025). Strengthening community-based fisheries governance in Indonesia's coastal areas. *BIO Web of Conferences*, 185, 06001. 1-14. <https://doi.org/10.1051/bioconf/202518506001>
- Asriyani, & Maskun. (2024). Potrait on regulation and policy to life on land. *IOP Conference Series: Earth and Environmental Science*, 1430(1), 1-14. Artikel 012002. <https://doi.org/10.1088/1755-1315/1430/1/012002>
- Sundari, A., Irwansyah, Sakharina, I. K., Irwan, M., & Inamovich, R. I. (2025). Victims of crime and environmental pollution in Indonesia: The right to restitution and legal inadequacies. *Journal of Law, Environmental and Justice*, 3(2), 476–505. <https://doi.org/10.62264/jlej.v3i2.178>
- Sugiyono. (2026). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabeta.

- Bahagia, S. N., & Wasesa, M. (2026). *Metodologi Penelitian dengan Pendekatan Sistemik Terintegrasi*. Bandung: ITB Press.
- Devra, D. D., Elfrianto, Adriani, & Nurfauzi, Y. (2026). *Metodologi Penelitian Pendidikan: Panduan Kualitatif, Kuantitatif, dan Mixed Methods untuk Mahasiswa*. Medan: Media Penerbit Indonesia.
- Sakharina, I. K., Daud, A. A., Hasrul, M., Kadarudin, & Assidiq, H. (2020). Work and lives in Makassar coastal community: Assessing the local government policy. *Hasanuddin Law Review*, 6(1), 89–99. <https://doi.org/10.20956/halrev.v6i1>
- Permatasari, M., Sakharina, I. K., & Maskun. (2026). Implementation of the Ramsar Convention on the conversion of mangrove land in coastal areas of South Sulawesi. *Proceeding of SINERGY*, 1, 384–395.
- Naswar, Maskun, Al Mukarramah, N. H. A., Angi, J. C. W., & Paliling, V. E. S. (2023). Legal protection for environment and coastal community from marine ecosystem degradation and climate change impact. *Journal of Law and Sustainable Development*, 11(9), e978. 1-16. <https://doi.org/10.55908/sdgs.v11i9.978>
- Maskun, Napang, M., Nur, S. S., Achmad, Naswar, Ilmar, A., & Assidiq, H. (2022). The legal framework for climate change on power generating policy in Indonesia. *IOP Conference Series: Earth and Environmental Science*, 1016(1), 1-6. Artikel 012045. <https://doi.org/10.1088/1755-1315/1016/1/012045>
- Maskun, Ilmar, A., Bohari, N., & Tjolli, A. (2019). Legal protection of mangrove forests: From community consensus to written law. Dalam *European Proceedings of Social and Behavioural Sciences* (Vol. 70, hlm. 236–247). Future Academy. <https://doi.org/10.15405/epsbs.2019.10.26>
- Maskun, Ilmar, A., Naswar, & Achmad. (2019). Environmental protection of mangrove forest: Affirmation consensus approach. *IOP Conference Series: Earth and Environmental Science*, 343(1), 1-9. Artikel 012063. <https://doi.org/10.1088/1755-1315/343/1/012063>
- Maskun, Assidiq, H., Naswar, Achmad, Nur, S. S., & Sumardi, J. (2021). Threats to the sustainability of biodiversity in Indonesia by the utilization of forest areas for national strategic projects: A normative review. *IOP Conference Series: Earth and Environmental Science*, 886(1), 1-8. Artikel 012071. <https://doi.org/10.1088/1755-1315/886/1/012071>
- Maskun, Ilmar, A., Bohari, N., & Tjolli, A. (2019). Legal protection of mangrove forests: From community consensus to written law. *European Proceedings of Social and Behavioural Sciences*, 70, 236–247. <https://doi.org/10.15405/epsbs.2019.10.26>
- Maskun, Ilmar, A., Naswar, & Achmad. (2019). Environmental protection of mangrove forest: Affirmation consensus approach. *IOP Conference Series: Earth and Environmental Science*, 343(1), 1-9. Artikel 012063. <https://doi.org/10.1088/1755-1315/343/1/012063>
- Yusal, M. S., Hastuti, & Syukriani, A. (2025). Prinsip ilmu lingkungan: Suatu konsep untuk multidisiplin ilmu. Tahta Media Group.
- Maskun, Khalid, R. M., Al Mukarramah, N. H., Ramli, R. N. H., Juniar, M. W., Angi, J. C. W., ... & Rani, M. N. A. (2022). Legal Analysis of Reclaimed Wastewater Management in Indonesia: Reference to Malaysia and Singapore. *Water* 2025, 17, 1416.

- S. Hasbi Sasea, E. M., Maskun (2020). Role of Local Governments in Managing Mangrove Damage: The Manokwari Case. *International Journal of Law and Public Policy (IJLAPP)*, 2(1), 17-23.
- Maskun, Kamaruddin, H., Khalid, R. M., Anugerah, M., Wiranti, & Bachril, S. N. (2024). Regulatory Challenges in Wastewater Management and its Impacts on Environmental Sustainability. *Hasanuddin Law Review*, 10(3), 322-341.
- Maskun, A Mukarramah, N. H., Paliling, V. E. S., Angi, J. C. W., Putri, N. A., Amir, M. A. A., & Assidiq, H. (2024, November). Normative review on mitigation and adaptation on climate change related disaster: a case study of sea level rise in Lae-Lae Island. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1410, No. 1, p. 012008). IOP Publishing.
- Maskun, K. V. V., Mukhlis, M. M., Normiati, & Tajudin, M. S. (2025). The dilemma of administrative sanctions in legalizing palm oil plantations in Indonesian forest areas. *Jurnal Ilmu Hukum dan Konstitusi* <http://ejournal.uinsaizu.ac.id/index.php/volksgeist>.