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Strengthening Mangrove Conservation Through Collaborative Governance: A Public Administration Perspective from Coastal Communities

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Abstract: *Mangrove conservation is essential for enhancing coastal resilience with sustainable development, particularly in areas vulnerable to environmental degradation. This study explores the many factors that influence sustainable mangrove management from both a collaborative governance and public administration perspective. Using a quantitative approach with potential analysis and the MICMAC method, data were collected through expert sampling involving stakeholders with extensive knowledge in environmental policy and coastal governance. The analysis revealed four key enabler variables—stakeholder engagement, regulatory framework, economic conditions, and environmental awareness—all of which showed high influence with low dependency, thus positioning these variables appropriately as critical elements for establishing an effective green governance system. In addition, elements such as environmental education, institutional quality, law enforcement, socio-cultural values, technological innovation, and tourism potential were considered to contribute to long-term sustainability, but with less weighting. Integration and strengthening of these planned enablers remain essential to improving mangrove conservation outcomes, as well as ensuring the long-term well-being of coastal communities. This study highlights the importance of how we should foster a collaborative multi-actor governance model. This will support sustainable coastal ecosystem management within a public administration framework.*

Keywords*: Collaborative Governance; Mangrove Conservation; Public Administration; Green Governance; Coastal Communities.*

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Introduction

Mangrove forests are one of the coastal ecosystems that have very important ecological, economic, and social roles. Ecologically, mangrove forests function as natural protectors of the coastline by holding back ocean waves and preventing coastal erosion (Naibaho et al., 2023). In addition, mangrove forests are able to absorb and store large amounts of carbon, thus contributing significantly to mitigating global climate change. Not only that, but mangrove forests are also a habitat for various types of coastal flora and fauna, as well as a breeding ground for various species of fish and other marine biota (Sofian et al., 2019). Socially and economically, the existence of mangrove forests supports the livelihoods of coastal communities, especially those who depend on the fisheries and non-timber forest product sectors (Senis, 2021).

However, despite its great benefits, the mangrove ecosystem is currently facing quite high pressure, both from human activities (anthropogenic) and from natural factors. Land conversion for ponds, settlements, and industrial activities are the main causes of mangrove forest degradation, in addition to excessive exploitation of resources and environmental pollution (Kartika & Amanah, 2018). One of the areas experiencing a real impact from this degradation is Bengkalis Regency in Riau Province. In this area, mangrove forests have experienced a significant decline in area, which not only threatens the sustainability of the ecosystem but also has a direct impact on the vulnerability of coastal areas to abrasion and a decrease in the quality of life of local communities (Nurrachmi et al., 2019).

Mangrove forest degradation in Bengkalis Regency is the result of complex interactions between human activities and increasingly intensive changes in the natural environment. Land conversion into agricultural and aquaculture areas has caused massive loss of mangrove vegetation cover, while uncontrolled illegal logging practices have exacerbated the damage to the ecosystem (Hermanto & As'ari 2023). On the other hand, increasingly severe coastal erosion due to rising sea levels and global climate change has accelerated the rate of mangrove degradation in this coastal area. This condition requires a comprehensive and collaboration-based governance strategy, which not only focuses on ecological conservation aspects but also pays attention to the socio-economic needs of the local community (Putra & Effendi, 2017).

Collaborative governance is an approach that is increasingly recognized for its effectiveness in addressing complex and multidimensional environmental problems, such as mangrove forest degradation. This approach emphasizes the importance of active participation of various stakeholders—including government agencies, local communities, non-governmental organizations, and the private sector—in the entire decision-making and policy implementation process (Effendi & Astuti, 2021). Through cross-sector collaboration, collaborative governance is able to build a sense of shared ownership of environmental issues, strengthen trust between parties, and create more contextual and sustainable solutions. The integration of collaborative governance into the public administration framework not only increases legitimacy and accountability in the implementation of environmental policies but also opens up broad participation space for the community to

contribute directly to the conservation and management of natural resources (Putra et al., 2022).

Mangrove Systems and Their Strategic Role in Coastal Resilience Mangrove systems provide essential ecological, economic, and social services. Mangroves act as natural barriers against coastal erosion, contain breeding grounds for marine biodiversity, support fisheries, and serve as one of the most carbon-rich tropical forest ecosystems, playing a critical role in mitigating climate change (Qaim et al., 2020). Mangroves also support the livelihoods of millions of people along Indonesia's coastlines. However, despite their importance, mangrove degradation is widespread due to unsustainable land conversion, aquaculture, and urbanization.

Mangrove management in Indonesia faces various governance challenges, including fragmented institutional mandates, lack of community participation, and inadequate regulatory enforcement (Yossi Oktorini et al., 2022) (Abdelzaher et al., 2023) (Zhang et al., 2024). In Bengkalis Regency, Riau Province, mangrove forest degradation is highly visible, driven by coastal erosion, illegal logging, and limited government coordination (Hanifah et al., 2023). Despite local efforts, the absence of an integrated and participatory governance framework has hampered long-term sustainability (Asmit et al., 2020).

Collaborative governance involves shared decision-making between public institutions, the private sector, and civil society. This governance is built on the principles of transparency, accountability, inclusiveness, and shared authority (C. Ansell & Gash, 2007) (CH Ansell & Gash, 2008). In the environmental context, collaborative governance is essential for solving complex problems where multiple stakeholders have overlapping interests (Emerson et al., 2011). Effective collaborative governance can enhance policy legitimacy and resource sharing, leading to more sustainable outcomes.

Public administration plays a critical role in facilitating and institutionalizing collaborative governance. Administrators act as coordinators, policy drivers, and enablers of stakeholder engagement (Hagger et al., 2022) (Arfan et al., 2021) (Z. Jiang, 2023) In a decentralized governance system like Indonesia, local governments are expected to lead the management of natural resources, including mangroves, by designing inclusive programs and involving local actors (Susanti & Pradana, 2021).

Prospective analysis is a strategic tool used to explore future scenarios and identify key variables in complex systems. MICMAC (Matrice d'Impacts) Croisés Multiplication Appliquée à un Classement (Multiplication Applied to Classification) method is widely used in policy research to map the influences and dependencies among variables (Godet, 2000). This method helps prioritize strategic actions by identifying drivers and dependent factors in a governance system (Mashur et al., 2024). This method is particularly relevant for analyzing environmental governance involving multiple stakeholders and dynamic interactions. Although many studies have explored the technical aspects of mangrove rehabilitation, limited research has addressed the governance dimension, especially from a public administration perspective using a quantitative and future-oriented approach. This study fills this gap by applying prospective analysis to understand strategic governance variables in mangrove conservation.

Method

This study used a quantitative research design using prospective analysis with the MICMAC method to identify and classify strategic variables in collaborative mangrove governance (Foli, 2022). This approach is future-oriented and seeks to understand the dynamics of influence and dependency among key factors in the system. This study was conducted in Bengkalis District, Riau Province, Indonesia, a coastal area facing significant mangrove degradation. Data were collected using expert sampling, targeting stakeholders with in-depth knowledge of mangrove governance, including government officials, community leaders, NGOs, and academics. A total of 15 experts participated in the evaluation. Primary data were collected through a structured questionnaire using an influence-dependence matrix. Experts were asked to evaluate the extent to which each variable influences or is influenced by other variables on a scale from 0 (no influence) to 3 (strong influence). The variables assessed were derived from a literature review and initial field discussions. The collected data were processed using MICMAC software. The tool generates a structural matrix and classifies variables into four categories: (1) Driver variables (high influence, low dependence), (2) Linkage variables (high influence, high dependence), (3) Dependent variables (low influence, high dependence), and (4) Autonomous variables (low influence, low dependence). The following procedures were adopted in conducting the study: Identification of relevant variables based on literature and expert input. Development of an influence-dependence matrix. Expert validation and assessment of variables. Input and analysis using MICMAC software. Interpretation of results and classification of variables. Formulation of policy implications based on strategic variables. This methodology allows the identification of the most important factors to strengthen collaborative governance and provides actionable insights for public administrations in sustainable mangrove management (Favoretto et al., 2024).

Results And Discussion

Variable Classification Results Using MICMAC Analysis

Prospective analysis using the MICMAC method produces a structural map that categorizes strategic variables based on their level of influence and dependence (Hong et al., 2024). The analysis identified four key driver variables that are highly influential but have low dependence: stakeholder engagement, regulatory framework, economic conditions, and environmental awareness. These variables form the backbone of effective green governance and are considered leverage points in strengthening mangrove conservation strategies.

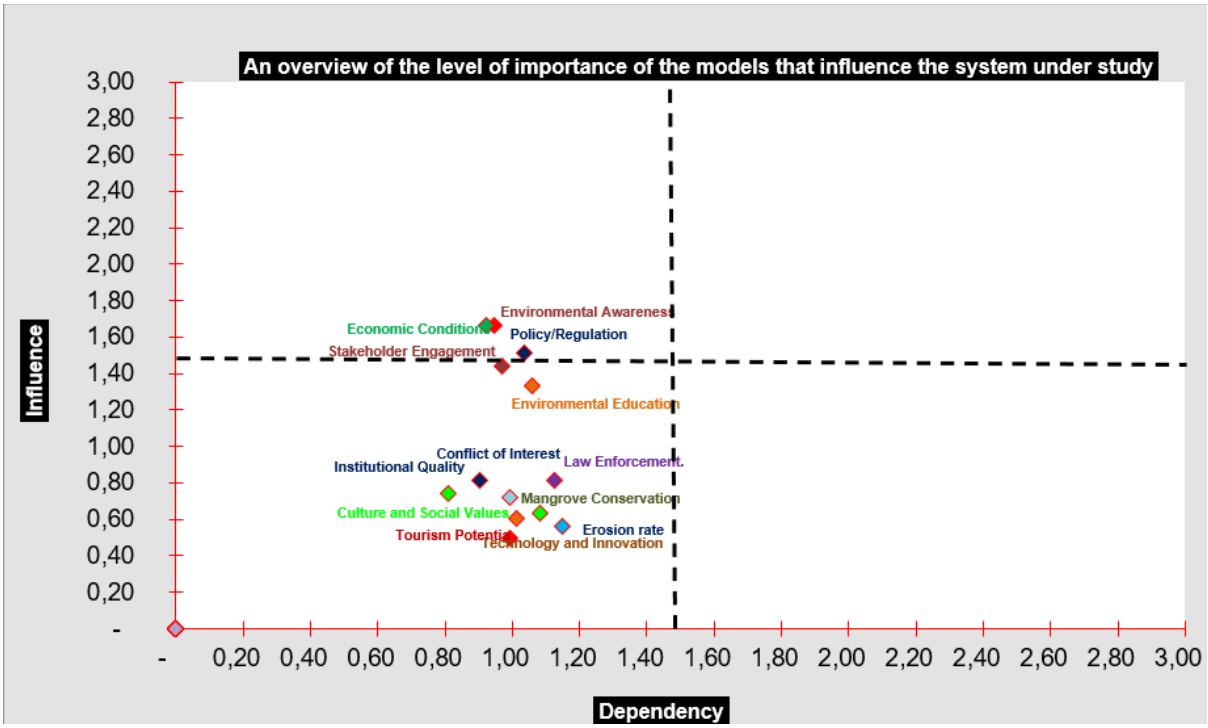

Figure 1. Variable Classification Results Using MICMAC Analysis (Source: Author, 2025)

Figure 1 illustrates the results of MICMAC (Matrice d'Impacts Analysé Croisés Multiplication Appliquée à un Classement), which was used to classify key variables influencing sustainable mangrove governance based on their level of influence and dependency. The analysis grouped the variables into four categories. Driving factors, characterized by high influence and low dependency, included *economic conditions* and *stakeholder engagement,* which shows its crucial role as a key driver of change in the system. The linkage factors, which have high influence and high dependency, consist of *environmental awareness, policies/regulations,* and *environmental education.* These factors are dynamic and highly interrelated with other variables, meaning that any change in them can trigger significant systemic shifts. Dependency factors, which have low influence but high dependency, include *conflicts of interest, institutional quality, law enforcement, mangrove conservation, abrasion, social and cultural values, tourism potential, and technology and innovation.* These variables are more likely to be influenced by other drivers and are considered outcomes rather than initiators of change. Finally, no variables were identified in the autonomous factors quadrant, which represents factors with low influence and low dependence—indicating that all selected variables are relevant and interrelated in the mangrove governance system.

Driving Factors: Economic Conditions and Stakeholder Engagement

These variables are characterized by a strong influence on the system with low dependence on other factors. This implies that economic conditions and stakeholder engagement serve as key drivers for driving change in mangrove

governance. Economic conditions determine the capacity of coastal communities to engage in sustainable practices and withstand environmentally damaging economic pressures. Stakeholder engagement reflects the level of collaboration between government, local communities, NGOs, academia, and the private sector.

These findings are in line with the theory of collaborative governance (CH Ansell & Gash, 2008), which emphasizes that the active involvement of various stakeholders is essential in managing common pool resources such as mangroves. In this context, public administration plays a facilitative role in enabling partnerships, building consensus, and coordinating cross-sectoral actions. Economic conditions are highlighted by scholars as both drivers and barriers. Improved local livelihoods and alternative sources of income can reduce pressure on mangrove resources. Conversely, poverty and economic vulnerability can drive unsustainable exploitation (G. Jiang, 2021).

Environmental awareness, especially among local communities and policymakers, plays a strategic role in creating a culture of conservation. Programs that build environmental literacy and encourage stewardship are needed to sustain engagement in mangrove protection. In addition to the main drivers, several supporting variables were identified, including environmental education, institutional quality, law enforcement, socio-cultural values, innovation and technology, and tourism potential. These variables, although not dominant, contribute to the resilience and adaptability of the governance system in the long term.

Interrelationship Factors: Environmental Awareness, Policies/Regulations, and Environmental Education

In the context of mangrove ecosystem management, the interrelationships between factors play a central role in determining the effectiveness and sustainability of various interventions undertaken. Factors such as environmental awareness, education, economic stability, stakeholder actions, and institutional frameworks do not stand alone but rather influence each other in a dynamic system. Changes in one factor can have a cascading effect on other factors. For example, increasing environmental awareness and education can encourage communities to be more actively involved in conservation activities, but this also depends heavily on the economic conditions of the community and the institutional support available. Therefore, understanding the interrelationships between these factors is essential in designing adaptive and holistic management strategies.

On the other hand, policies and regulations serve as the main instruments in shaping the behavioral framework of all actors involved, from the government and private sector to local communities. Responsive and evidence-based policies can encourage the creation of inclusive and equitable governance and strengthen coordination across sectors and levels of government. Regulations also provide a legal basis for the protection of mangrove ecosystems and can create incentives and sanctions that encourage compliance with sustainability principles. However, the effectiveness of policies is highly dependent on their implementation in the field, which in turn is influenced by

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institutional capacity, resource availability, and the level of community participation.

Because these factors are sensitive and reactive, they require an integrated policy approach. Strengthening education and awareness campaigns through public sector initiatives is essential, especially when linked to enforceable regulations. This supports the environmental governance literature that emphasizes the importance of cognitive and institutional dimensions in natural resource management (Arun Agrawal & Maria Carmen Lemos, 2007). Regulatory frameworks also rank high in terms of influence, reflecting the need for coherent and enforceable policies at the local and regional levels. Effective regulations establish an enabling environment for long-term conservation and support institutional coordination (Savari, 2022).

Dependent Factors: Conflict of Interest, Institutional Quality, Law Enforcement, Mangrove Conservation, Abrasion, Socio-Cultural Values, Tourism Potential, Technology and Innovation

Within the framework of systems analysis, dependent variables have a unique role because although their direct influence on system dynamics is relatively low, their existence is highly dependent on changes in other variables, especially driver variables and linking variables. Dependent variables often serve as the ultimate indicator of the effectiveness of interventions and policies implemented in a system. For example, institutional quality and the effectiveness of law enforcement are the result of a series of dynamics involving stakeholder engagement, institutional capacity, and regulatory clarity. When the participation of key actors in mangrove governance is inclusive and supported by consistent policies, institutional quality tends to increase. Conversely, in the context of minimal collaboration and weak legal certainty, institutions become vulnerable to stagnation or even decline.

One of the main challenges in the resource management system is the conflict of interest that often arises due to the absence of a strong governance structure and transparent and participatory decision-making mechanisms. When there is no forum that accommodates dialogue between actors with different interests—such as industry players, government, local communities, and environmental organizations—these conflicts will be difficult to resolve and can hinder conservation efforts and sustainable development. In this case, variables such as tourism potential, abrasion, and the level of technology adoption are highly dependent on the existence of appropriate policy incentives and strategic partnerships between the public and private sectors. For example, the development of mangrove ecotourism can only be effective if supported by adequate investment, regulations that encourage innovation, and the active involvement of local communities as key actors.

From a policy perspective, these dependent variables are areas that require special attention through an adaptive governance approach and ongoing support. Public administration has an important role to play in ensuring that aspects such as institutional quality, abrasion mitigation, tourism development, and technological transformation are continuously monitored and evaluated periodically. This evaluation is not only useful for measuring the effectiveness of existing policies but also as a basis for making necessary adjustments as environmental and social conditions change. Therefore,

cross-sectoral and cross-government synergy is needed so that the strengthening of these variables can run optimally. With the right policy strategy, public institutions can create a resilient and sustainable governance ecosystem while encouraging a system transformation that is more responsive to future challenges.

Autonomous Factor: Not Identified

The absence of variables in the autonomous quadrant in the MICMAC analysis indicates that all variables studied play an important role in the system and are dynamically interconnected. This indicates that no factor is truly independent or irrelevant in the context of sustainable mangrove management. All elements of the system have significant functional interrelationships, reflecting the complexity and systemic nature of environmental management challenges. Thus, a sectoral and fragmented policy approach will be less effective than a holistic approach that considers the interconnectedness of variables as a whole. Consequently, policy interventions must be designed based on an understanding of the causal relationships between factors to achieve optimal impact.

The classification of variables in the MICMAC framework provides a clear strategic direction for policy formulation and prioritization. Driver variables, such as leadership quality, institutional capacity, and environmental protection policies, should be the main focus in early interventions because of their high impact on other variables in the system. On the other hand, linkage variables, such as environmental education and community awareness, need special attention because they have strong reciprocal influences and are vulnerable to change. Meanwhile, dependent variables such as mangrove-based tourism potential and technology adoption rates are more dependent on the progress of other variables and should be managed with medium- to long-term strategies. With no autonomous variables found, it is apparent that all elements of the system have potential relevance in various scenarios, so adaptive planning needs to be applied.

The implications of these findings require government agencies to adopt an adaptive and inclusive governance approach. First, stakeholder engagement should be promoted through dialogue forums, strategic partnerships, and transparent collective decision-making in order to create a sense of shared ownership and responsibility. Second, strengthening environmental education at various levels—from formal schools to community-based programs and the mass media—is essential to building critical awareness and changing community behavior toward coastal ecosystems. Third, the formulation of integrated regulations must be able to balance environmental protection and economic development incentives. In this context, the principles of common resource management proposed by Elinor Ostrom (1990), such as collective action, institutional diversity, and locally based arrangements, are very relevant to be applied in designing a responsive, equitable, and sustainable mangrove governance system.

The Role of Public Administration in Strengthening Collaborative Mangrove Governance

Public administration plays a critical role in organizing collaboration across the various actors involved in mangrove governance. Its function goes

beyond traditional regulatory responsibilities to encompass a broader facilitative and integrative approach to ensure sustainable outcomes. Facilitating dialogue and building trust among stakeholders involves creating inclusive spaces where government agencies, local communities, academics, NGOs, and private sector actors can engage in open communication. Through public forums, participatory workshops, and multi-stakeholder platforms, public administrators act as neutral facilitators who bridge differences in interests, power, and knowledge. This process fosters mutual understanding, reduces conflict, and strengthens social capital, which is essential for collective action in managing shared environmental resources such as mangroves.

Ensuring transparency and accountability in resource management is a key aspect of good governance. Public administration institutions are responsible for establishing mechanisms that enable citizens to access information, monitor policy implementation, and hold decision-makers to account. This includes developing clear regulatory frameworks, transparent budgeting for conservation programs, and performance audits of local initiatives. Transparency not only enhances legitimacy but also encourages public compliance and trust in environmental governance.

Enabling institutional learning and adaptive policymaking means that public administration must remain responsive to changing environmental conditions, stakeholder feedback, and emerging knowledge. This involves integrating monitoring and evaluation into the policy cycle, promoting cross-sectoral learning, and supporting innovation in governance practices. Adaptive governance allows institutions to iteratively refine their strategies, ensuring that mangrove management remains effective, equitable, and resilient to socio-ecological change. By applying network governance principles, public administrators can act as boundary spanners—connecting government agencies, civil society organizations, and the private sector to co-design and implement sustainable solutions. This collaborative orientation enables a more holistic, context-sensitive, and inclusive approach to ecosystem management.

The results underscore the importance of a multi-actor governance approach in which public administration facilitates collaboration, supports policy coherence, and ensures inclusive participation. Strengthening strategic and enabling variables collectively will enhance the effectiveness of mangrove conservation initiatives and promote sustainable development in coastal areas. Improving collaborative governance of mangrove ecosystems requires a transformative shift in public administration—from a rigid command-and-control model to a more inclusive, participatory, and networked approach. This shift must be based on evidence-based policymaking, local empowerment, and institutional innovation, ensuring that mangrove governance is not only sustainable but also socially just and democratically accountable.

Coastal Communities: A Critical Component in Mangrove Conservation and Sustainable Development

Coastal communities play a critical role in mangrove ecosystem conservation, as they are direct stakeholders and direct beneficiaries of these natural resources. These communities, which often depend on resources provided by mangroves such as fish, timber, and other marine products, are at the forefront of challenges and

opportunities in sustainable environmental management (Prasetya et al., 2018). Mangrove ecosystems serve as critical buffers against coastal erosion, flooding, and storm surges, which is especially important in areas vulnerable to climate change impacts such as rising sea levels and extreme weather events. For coastal communities, mangrove conservation is not only an environmental issue but also an economic and social imperative. The loss of these ecosystems can result in the degradation of livelihoods, increased vulnerability to natural disasters, and the loss of biodiversity on which these communities depend for their well-being.

From a collaborative governance perspective, the active involvement of coastal communities is critical to implementing sustainable mangrove conservation strategies. Collaborative governance emphasizes the need for partnerships among multiple stakeholders, including government agencies, non-governmental organizations (NGOs), local businesses, and communities themselves. In the case of mangrove conservation, involving coastal community members in decision-making processes ensures that management strategies are contextually relevant and culturally appropriate. Local knowledge and traditional practices, honed over generations, can provide valuable insights into the most effective ways to protect and restore these ecosystems.

Public administration frameworks are key to supporting coastal community engagement in mangrove conservation efforts. They can facilitate the development of policies and programs that incorporate local needs and preferences while aligning them with broader national and global sustainability goals. Effective public administration helps create an environment that supports collaborative governance by establishing clear regulations, providing funding for conservation initiatives, and ensuring enforcement of laws designed to protect mangrove ecosystems.

In the context of green governance, the role of coastal communities becomes even more significant. As active participants in the decision-making process, they help ensure that policies adopted are not only environmentally sustainable but also economically and socially equitable. Green governance models that prioritize local involvement can result in more resilient and adaptive strategies for managing coastal ecosystems, encouraging greater community ownership and compliance with conservation efforts.

Ultimately, strengthening mangrove conservation through collaborative governance, with a focus on coastal communities, offers a sustainable pathway to environmental protection and socio-economic development. By recognizing and empowering these communities, governments and other stakeholders can achieve long-term and sustainable outcomes that benefit both communities and the environment. This study underscores the importance of integrating coastal communities into mangrove conservation governance structures, as their active participation is critical to ensuring the long-term health of coastal ecosystems and the resilience of the communities that depend on them.

Conclusion

This study emphasizes the critical role of collaborative governance in strengthening mangrove conservation, particularly through the active

involvement of coastal communities. The findings highlight that key driver variables, such as stakeholder engagement, regulatory framework, economic conditions, and environmental awareness, are fundamental to establishing an effective green governance system. These factors, when integrated into a participatory governance model, will create a solid foundation for the long-term sustainability of mangrove ecosystems, which is critical to the resilience of coastal communities. The role of public administration in fostering collaborative governance is critical. By facilitating partnerships across government agencies, local communities, NGOs, and the private sector, public administrators can ensure that conservation efforts are inclusive and tailored to local conditions. Public administration frameworks should also support the implementation of policies that take into account the economic, social, and cultural needs of coastal communities while also being aligned with broader environmental sustainability goals. This study emphasizes the importance of integrating local knowledge, traditional practices, and community-led initiatives into the design and implementation of mangrove conservation strategies. Coastal communities, as direct beneficiaries and stakeholders of these ecosystems, must be at the center of the decision-making process. Their active participation ensures that conservation efforts are not only environmentally effective but also socially just and economically beneficial. In conclusion, strengthening mangrove conservation through collaborative governance presents a promising pathway to achieving sustainable coastal ecosystem management. By empowering coastal communities and encouraging multi-actor collaboration, this approach can promote ecological conservation and socio-economic development. The study calls for a transformative change in governance, where inclusive, participatory, and adaptive strategies are at the heart of environmental management, ensuring the long-term well-being of coastal communities and the protection of their natural resources.

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