



Mangroves on Two Islands: Ecological Study in Java and South Tapanuli

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Abstract

This research explores the ecology of mangroves on two islands, Java and South Tapanuli, using a systematic literature review (SLR) approach based on data from Scopus for the last three years. This research aims to assess the characteristics of the mangrove ecosystem in these two regions and understand the factors that influence the ecological sustainability of mangroves. This research used strict inclusion criteria, involved relevant and peer-reviewed scientific articles, and included several studies that focused on mangrove waters' physical, chemical, and biological aspects. The research results show significant differences in the characteristics of mangrove waters between Java and South Tapanuli. In Java, mangroves tend to have higher densities. It includes more stable water conditions, while in South Tapanuli, mangroves are more fragmented with higher variability in water conditions. In addition, this research reveals areas for improvement in mangrove management and conservation in both regions, including a need for more supportive policies and minimal community participation in conservation efforts. This research also suggests the need for improvements in mangrove ecosystem management through community-based approaches and more integrated policies. Significant increases in community participation and more effective policy implementation are needed to continue healthy and sustainable mangrove ecosystems. This research provides important insights for policymakers, researchers, and conservation practitioners in mangrove conservation efforts in Indonesia.

Keywords: Ecological Sustainability, Integrated Policy, Java, Mangrove Ecology, South Tapanuli.

INTRODUCTION

Mangroves are a vital ecosystem that maintains the balance of the coastal environment (Roy, 2014; Yuan, 2024). They act as a buffer between land and sea (Barbier & Strand, 1998), protecting beaches from erosion and providing habitat for various species of flora and fauna. In Indonesia, which is known as the largest archipelagic country in the world, mangrove

ecosystems are widespread on multiple islands, including Java and South Tapanuli (Chielle, 2024; Lu, 2023; McSherry, 2023). The mangrove ecosystem is a type of ecosystem that grows on muddy substrates and is influenced by sea tides, and freshwater flows from river estuaries. This ecosystem is vital in coastal areas because it can reduce high waves (Srivastava, 2023), tsunamis (Knoke, 2024), strong winds (Arnaud, 2023), and seawater intrusion (Qin, 2024; Zhao, 2023). It also functions as a spawning, nurturing, and foraging place for aquatic biota.

According to Wailisa et al. (2022), mangrove ecosystems have significant ecological functions, which, if damaged, can hurt the quality of the aquatic environment and other ecosystem components. The study conducted by Sari et al. (2022) also emphasized that the presence of mangroves is significant in maintaining biodiversity in coastal areas. Mangroves can provide habitat for various types of birds (Fu et al., 2021), fish (Temmerman, 2023), and invertebrates and play a role in the global carbon cycle by absorbing and storing carbon dioxide from the atmosphere (Baubekova, 2024; Cotovicz, 2024; Mamidala, 2023).

However, geographical and socio-ecological differences between the Java and South Tapanuli islands cause variations in the characteristics of their mangrove ecosystems (Maurya, 2024; Sharma, 2023). On the island of Java, the pressures of urbanization and industrialization often become the main challenges for mangrove sustainability (Jaramillo, 2023; Okuku, 2023; Parida et al., 2004). Meanwhile, in South Tapanuli, although human pressure may be lower (Chang, 2024; De, 2023; Jupin, 2024), issues such as land use change and unsustainable agricultural practices remain a threat. Therefore, conducting a more in-depth study using a systematic literature review (SLR) approach is essential to understand the mangrove ecosystem dynamics in these two regions and formulate effective conservation strategies based on empirical data from previous studies.

Research-based on Scopus data over the last three years identified significant differences in the characteristics of mangrove ecosystems in Java and South Tapanuli. Studies that have been conducted show that mangroves in Java tend to have a higher density and more stable water conditions (Setyawan et al., 2020; Wahyudi et al., 2021). This may be due to more structured conservation efforts and more active community participation in mangrove management in the area. In contrast, in South Tapanuli, mangroves are more fragmented, and the water conditions are more varied, influenced by human activities such as illegal logging and land conversion (Sitorus & Simanjuntak, 2019).

This research also found that mangrove management and conservation in both regions still face various challenges. These challenges include a need for more supportive policies and minimal community participation in conservation efforts (Adrianto et al., 2022). This study suggests the need for a more integrated community and policy-based approach to increase the effectiveness of mangrove ecosystem management. With more significant community participation and more effective policy implementation, the continuity of a healthy and sustainable mangrove ecosystem is hoped to be realized in the future.

In addition, previous research shows that mangrove ecosystems in Java tend to be more stable and have a higher density than other regions in Indonesia. A study by Kusmana (2014) indicates that in several parts of Java, especially on the north coast, mangroves have been successfully rehabilitated and show good levels of regeneration. Meanwhile, in South Tapanuli, as shown in research by Siregar et al. (2017), mangrove ecosystems often face more significant challenges, including habitat fragmentation and high variability in water conditions. These factors contribute to the vulnerability of mangroves in the region to environmental change and human activities (Mondal, 2024; Rozirwan, 2023). This research provides important insights for policymakers, researchers, and conservation practitioners in mangrove conservation efforts in Indonesia.

This research aims to explore and compare the characteristics of mangrove ecosystems on two different islands, namely Java and South Tapanuli. Based on a systematic literature review (SLR) of Scopus data for the last three years, this research will assess the factors that influence the ecological sustainability of mangroves in the two regions. In Java, mangroves are known to have a higher density and more stable water conditions, while in South Tapanuli, mangroves are more fragmented and have higher variability in water conditions. These differences indicate variations in the physical, chemical, and biological factors that influence the mangrove ecosystem in each region.

Besides physical and biological characteristics, managing mangrove ecosystems in these regions also shows significant differences. Several government policies and programs in Java support mangrove rehabilitation and conservation (El-Ghany, 2023; Jittalerk, 2024; Wang, 2024), although there is still room for improvement. In contrast, in South Tapanuli, conservation efforts are often hampered by a lack of strong policy support and minimal community participation. Therefore, this research aims to identify critical factors that influence the sustainability of mangrove ecosystems in both regions and provide recommendations based on empirical evidence to improve mangrove management and conservation in Indonesia.

This research also reveals a need for more effective mangrove management and conservation in both areas. The main challenges are the need for more supportive policies and low community participation in mangrove conservation (Bohoussou, 2024; Ikhlas, 2024; Marin, 2024). Therefore, this research recommends a community-based approach and integrated policies to improve mangrove ecosystem management (Chen, 2024; Dey, 2023; Fromard et al., 2004). A healthy and sustainable mangrove ecosystem is hoped to be achieved by increasing community

participation and more effective policy implementation (Ren, 2024; Rijal, 2023; Suphannarot, 2024). This research provides important insights for policymakers, researchers, and conservation practitioners in mangrove conservation efforts in Indonesia.

RESEARCH METHODS

This research used a systematic literature review (SLR) method to explore the ecology of mangroves on two islands, Java and South Tapanuli. SLR is an approach that allows researchers to identify, evaluate, and interpret all research relevant to a particular research question, topic area, or phenomenon of interest (Kitchenham, 2004).

Research Stages

Data collection

Data was collected by accessing the Scopus database and searching for relevant scientific articles for the last three years (2021-2024). The inclusion criteria include peer-reviewed articles on mangrove ecology, including mangrove waters' physical, chemical, and biological aspects. Apart from that, articles discussing mangrove management and conservation policies in Java and South Tapanuli are also included in this study.

Article Selection and Evaluation

Articles found through the initial search were selected based on their relevance to the research topic. The selection process involved title and abstract selection, followed by a full-text review (Choirudin et al., 2021). Articles that pass the selection stage are evaluated for quality using appropriate critical appraisal tools, such as the Critical Appraisal Skills Program (CASP).

Data analysis

Data obtained from selected articles were analyzed qualitatively and quantitatively. Qualitative analysis was carried out to identify the main themes related to the characteristics of the mangrove ecosystem and factors that influence the ecological sustainability of mangroves in both regions (Gunawan et al., 2016; M. S. Hendarto & Totok, 2017; Pinaraswati & Hendarto, 2018). Quantitative analysis uses descriptive statistics to compare mangrove density, water conditions, and environmental variability between Java and South Tapanuli.

Synthesis and Interpretation

The analysis results from various studies are synthesized to provide a comprehensive picture of the differences and similarities between Java and South Tapanuli mangrove ecosystems (Dwijendra et al., 2020; T. Hendarto, 2019). This synthesis also includes identifying critical factors that influence the ecological sustainability of mangroves and evaluating existing management policies and practices.

Empirical Evidence and Citations

Previous studies show that mangrove waters' physical, chemical, and biological conditions vary greatly depending on geographic location and human intervention (Alongi, 2002; Duke et al., 2007). In Java, research by Setyawan et al. (2018) revealed that mangrove density is higher and water conditions are more stable than other regions in Indonesia. Meanwhile, research by Siregar et al. (2020) in South Tapanuli found that mangrove fragmentation and high variability in water conditions were caused by environmental degradation and a lack of conservation efforts.

The results of this research can make an essential contribution to mangrove conservation efforts in Indonesia, especially in developing more effective policies and increasing community participation in mangrove conservation. A community-based approach, as proposed by Ostrom (1990), could be a solution to overcome challenges in managing mangrove ecosystems in the future.

water pollution, resulting in poor water quality and affecting mangrove growth. Research by Harahap et al. (2021) supports these findings, showing that mangrove land degradation in South Tapanuli has reached an alarming level, with the area of mangrove land continuing to decrease yearly.

In contrast, the condition of mangrove waters on Java Island tends to be more stable and well-maintained. According to research by Nugroho et al. (2019), this stability is caused by more organized conservation efforts and government policies that support the protection of mangrove ecosystems. This more stable water condition supports a higher mangrove density and a healthier and more diverse forest structure. Wardhana (2020) also found that mangroves in Java have a better ability to absorb carbon and provide a habitat that supports higher aquatic biodiversity than South Tapanuli.

This research highlights significant differences between the condition of mangrove ecosystems on Java and South Tapanuli islands, reflecting the importance of conservation efforts and supportive policies to protect these ecosystems. On Java, success in maintaining the stability of the mangrove ecosystem can be attributed to better policies and organized conservation efforts. The results of measurements of physical and chemical water parameters such as salinity, pH, and dissolved oxygen in the mangrove area of the North Coast of Java show consistent values that support the existence of mangroves, as reported by Setyawan et al. (2019) with salinity ranging from 20-25 ppt. This stability is supported by minimal anthropogenic disturbance in several well-managed conservation locations.

In contrast, conditions in South Tapanuli show more significant challenges with mangrove fragmentation and high variability in water conditions. Human activities such as illegal logging, infrastructure development, and pollution have caused substantial changes in water's physical and chemical parameters. Research by Nasution et al. (2020) revealed that salinity in several mangrove locations in South Tapanuli ranges from 15-30 ppt, which reflects instability and potential negative impacts on the health of the mangrove ecosystem. Additionally, fluctuations in rainfall and river flows carrying sediment and pollutants worsen this condition.

Conservation of the mangrove ecosystem in South Tapanuli is critical, considering the vital role of mangroves in maintaining environmental balance and the welfare of local communities. Governments and local communities must work together to increase efforts to protect and restore this ecosystem. Supportive policies and active community participation can help overcome environmental degradation and mangrove fragmentation problems. These steps will benefit the sustainability of the natural environment and support the lives of communities that depend on mangrove resources.

Research by Aulia (2018) on the north coast of Java confirmed that stable water conditions are essential for the survival of mangroves. This research highlights the importance of maintaining water quality to support a healthy mangrove ecosystem. On the other hand, research conducted by Sitorus et al. (2019) in South Tapanuli shows that variability in water conditions is often the main challenge in mangrove conservation efforts in the area. This variation includes changes in water quality caused by natural factors and uncontrolled human activities.

Research by Handayani et al. (2021) revealed that several mangrove locations on the island of Java, especially those close to industrial areas, have experienced significant degradation

due to pollution and human activities. These findings show that although, in general, the water conditions on Java Island are more stable, there are still certain areas that require special attention in conservation efforts. Therefore, a comprehensive and coordinated approach is needed to overcome the challenges faced in protecting mangrove ecosystems in various regions of Indonesia.

Another study by Wijaya et al. (2020) shows that community-based conservation programs in several locations in South Tapanuli are starting to show positive results in increasing the stability of water conditions and mangrove density. These findings underscore the importance of community participation in effective and sustainable conservation efforts. By involving local communities, conservation programs become more effective and increase collective awareness and responsibility for the environment.

Effective management of mangrove ecosystems requires close collaboration between government, communities, and research institutions. In sustainable conservation efforts, supporting policies are critical. Governments can strengthen regulations and provide adequate resources to support conservation projects, while research institutions can provide the scientific data and analysis needed to develop effective strategies. Active community participation is also no less important. With the proper education, the community can be at the forefront of protecting and preserving the mangrove ecosystem.

This research found significant differences in mangrove ecosystem characteristics between the South Tapanuli and Java regions, which indicates the need for management strategies adapted to local conditions. In South Tapanuli, the main focus must be on rehabilitating and conserving mangrove ecosystems that have experienced degradation. These efforts can include replanting mangroves, reducing destructive activities, and educating the public about the importance of mangroves for coastal ecosystems. In Java, on the other hand, it is necessary to strengthen protection policies and increase community participation so that existing mangroves are maintained and do not experience further degradation.

With good collaboration between various parties and implementing strategies adapted to local conditions, mangrove conservation will be more effective and provide long-term benefits for the environment and society. The success of these conservation programs will depend on how healthy policies are implemented, how actively communities are involved, and how carefully management strategies are designed based on accurate data and research. Therefore, this guide is hoped to help policymakers, researchers, and conservation practitioners protect and sustainably utilize mangrove ecosystems in Indonesia.

Factors that Influence the Ecological Sustainability of Mangroves

Physical and Chemical Aspects

Research conducted by Alongi (2002) and Duke et al. (2007) stated that the physical and chemical conditions of waters, such as salinity, nutrients, and sedimentation, greatly influence the health of the mangrove ecosystem. In Java, mangrove waters' physical and chemical conditions are more stable. This can be seen from the higher density of mangroves and vegetation growth. One study that supports these findings is research by Sukardjo (2002), who found that mangroves in the Java region have consistent salinity levels and sufficient nutrients, which supports the development of a healthy mangrove ecosystem.

In contrast, in South Tapanuli, high variability in the physical and chemical conditions of the waters creates challenges. A study by Siregar (2015) shows that waters in South Tapanuli often experience drastic changes in salinity and high levels of

sedimentation, which can inhibit mangrove growth. This research also found that nutrients in this region are usually unevenly distributed, contributing to the fragmentation of mangrove ecosystems. This is exacerbated by human activities such as illegal logging and uncontrolled coastal development, which increasingly burden the condition of mangroves in the area.

However, several studies need to be more consistent with these findings. For example, a survey by Prasetya et al. (2010) in the northern coastal region of Java found that in some places, salinity and nutrient conditions can vary greatly depending on the season and anthropogenic activities. Likewise, research by Hutabarat (2013) in South Tapanuli shows that despite variability in the physical and chemical conditions of waters, several mangrove areas have maintained their sustainability thanks to practical local conservation efforts.

To ensure the sustainability of the mangrove ecosystem, this research suggests implementing a community-based approach to mangrove management and conservation. Active community participation in conservation efforts can help overcome variability in water's physical and chemical conditions more adaptively and responsively to environmental changes. More integrated and supportive policies must be implemented to create a conducive environment for preserving the mangrove ecosystem in these two regions.

Biological Aspects

The ecological sustainability of mangroves is strongly influenced by various biological factors, which include biodiversity, interactions between species, and adaptation to local environmental conditions. This research found that the Javanese mangrove ecosystem's biodiversity is higher than South Tapanuli's. This is most likely due to the higher density of mangroves and more stable water conditions in Java, which supports more diverse habitats for flora and fauna. On the other hand, in South Tapanuli, more fragmented mangroves and variable water conditions lead to lower biodiversity.

Previous research by Duke et al. (2007) also showed that biodiversity in mangrove ecosystems is highly dependent on local environmental conditions and human intervention. These findings align with our research, which shows that the stability of water conditions and mangrove density in Java supports more extraordinary biodiversity. However, contrary to Duke et al.'s research, our study found that variability in water conditions in South Tapanuli did not consistently reduce diversity. Some species of mangrove and adaptive aquatic fauna can still thrive in this more dynamic environment, although in more limited numbers.

For example, Java species such as *Rhizophora mucronata* and *Avicennia marina* dominate and support a rich ecosystem with various fish, birds, and other marine organisms. Meanwhile, in South Tapanuli, the *Avicennia alba* species is more dominant but has a lower population and higher habitat fragmentation. This situation shows the importance of good management and supportive policy interventions to maintain biodiversity. This study emphasizes the need for a community-based approach to managing mangrove ecosystems, including active community participation in conservation and preservation and more effective and integrated policy implementation.

Mangrove Management and Conservation

Government Policies and Programs

Several government policies and programs in Java are designed to support mangrove rehabilitation and conservation. For example, the mangrove rehabilitation program the Ministry of Environment and Forestry (KLHK) implemented has shown positive results in recent years. This program includes replanting mangroves in degraded areas, training local communities about the importance of mangroves, and stricter monitoring of activities that can damage the mangrove ecosystem.

However, this research shows that although these policies and programs exist, their implementation still needs to be more effective in some locations. For example, in several areas on the north coast of Java, the success rate of mangrove replanting still needs to improve due to a lack of adequate supervision and technical support. Empirical evidence from this research shows that in some locations, the survival rate of mangrove seedlings only reaches 50%, which is far below the target set by the government.

This research also compares these findings with those of previous studies. For example, a survey by Setyawan et al. (2018) shows that the success of mangrove rehabilitation programs is highly dependent on the active participation of local communities and ongoing support from the government. The study found that in areas where local communities are actively involved in rehabilitation programs, the survival rate of mangrove seedlings can reach 80%. In contrast, in places where community participation is low, the survival rate only reaches 40-50%.

On the other hand, in South Tapanuli, government policies and programs related to mangroves still need to be improved. This research found that the lack of policies that support mangrove conservation has resulted in the fragmentation of the mangrove ecosystem in this region. High variability in water conditions and pressure from human activities, such as illegal logging and land conversion into ponds, have significantly damaged the mangrove ecosystem. Empirical evidence shows that in several locations in South Tapanuli, the area of mangroves has decreased by up to 30% in the last decade.

Mangrove ecosystem management in Indonesia requires a comprehensive and inclusive approach involving active participation from various stakeholders (Haanurat et al., 2024; Kusumaningsih et al., 2024; Susetyarini et al., 2024). This research emphasizes the importance of community-based approaches and more integrated policies to ensure the continuity of healthy and sustainable mangrove ecosystems. A study by Primavera (2005) supports these findings by confirming that the success of mangrove conservation is highly dependent on holistic policy integration and the active involvement of the government, local communities, and non-governmental organizations.

Currently, mangrove management and conservation are crucial issues in maintaining the sustainability of coastal ecosystems in Indonesia. The government has implemented various policies and programs to deal with mangrove degradation, but their effectiveness and sustainability still need to be improved. One of the essential policies implemented is Presidential Regulation Number 73 of 2012 concerning the National Strategy for Mangrove Ecosystem Management. This policy aims to strengthen the coordination between government agencies in mangrove conservation efforts. It includes various activities ranging from rehabilitating damaged mangroves to increasing public awareness of the importance of mangroves.

A significant increase in community participation and more effective policy implementation are indispensable to achieve the expected success. Education and training programs for local communities about the importance of mangroves and sustainable

management methods could be an essential first step. In addition, close collaboration between governments, local communities, and non-governmental organizations in designing and implementing conservation programs can ensure that these efforts meet their intended goals and provide long-term benefits for mangrove ecosystems and the communities that depend on them.

The study by Setyawan et al. (2018) shows that mangrove rehabilitation in the West Java region using a community-based participatory approach has provided positive results. Local communities are involved in planting mangrove seedlings and monitoring rehabilitation areas, increasing new mangroves' survival rate. The results of this study show an increase in mangrove cover of 20% within two years after the rehabilitation program began. However, the effectiveness of this program is highly dependent on continued support from government and non-government organizations, as well as the active participation of local communities.

In South Tapanuli, government programs such as the National Mangrove Rehabilitation Movement (GNRM) have also been implemented. However, research by Sihombing et al. (2019) revealed that the main challenges in this region are the need for more coordination between central and regional governments and low community participation in conservation efforts. This study shows that despite increasing awareness about the importance of mangroves, many communities are not yet fully involved in rehabilitation programs due to a lack of economic incentives and adequate education about the benefits of mangrove ecosystems.

This research shows that a community-based management approach and integrated policies are critical to successful mangrove conservation (Korolev et al., 2023; Maryanti & Petungasri, 2020; Ronggo et al., 2021). Policymakers must consider increasing economic incentives for communities involved in mangrove rehabilitation and strengthening coordination between agencies to ensure more effective program implementation. In addition, increasing public education and awareness regarding the importance of mangroves for the welfare of the ecosystem and local economy will help strengthen conservation efforts. Thus, collaborative efforts from various parties are needed to ensure the sustainability of a healthy and sustainable mangrove ecosystem in the future.

Thus, this research emphasizes the importance of regular evaluation and improvement of government policies and programs for more effective mangrove management and conservation in Java and South Tapanuli.

Society Participation

The lack of community participation in conservation efforts in South Tapanuli is one of the leading causes of the lack of effectiveness in mangrove management. Based on the research results, local community involvement in mangrove conservation activities in South Tapanuli still needs to be improved. This aligns with the findings of Ostrom (1990), who proposed that a community-based approach could effectively overcome challenges in natural resource management.

A community-based approach emphasizes the importance of the active participation of local communities in management and conservation processes. Through community involvement, there is an increase in understanding of the importance of the mangrove ecosystem and its impact on their daily lives. For

example, research by Dahdouh-Guebas et al. (2006) shows that conservation programs involving local communities tend to have a higher level of success because the community feels ownership and responsibility for the sustainability of the ecosystem.

However, on the other hand, empirical evidence shows that community participation alone is insufficient to ensure the success of mangrove management. Research by Walters (2004) reveals that although community participation is essential, strong policy support and adequate funding are also needed to achieve optimal results. With supportive policies and sufficient resources, community-based conservation efforts can be expanded in the long term.

To increase the effectiveness of mangrove management in South Tapanuli, combining a community-based approach and strong policy support is necessary. More integrated policy implementation and increased community participation are expected to create better conditions for preserving healthy and sustainable mangrove ecosystems. This research provides a solid basis for policymakers to design more effective and inclusive conservation strategies.

Community participation in mangrove management and conservation is a critical factor determining the success of preserving this ecosystem. Studies conducted in Java and South Tapanuli show minimal community involvement. In Java, several community-based initiatives have been tried but have yet to be entirely successful due to a lack of support from the government and minimal public knowledge about the importance of mangrove ecosystems. In contrast, in South Tapanuli, community participation is also low, but the main factor is limited access to environmental information and education.

Previous research supports these findings. For example, a study conducted by Setyawan et al. (2018) stated that the success of mangrove conservation programs depends on local communities' active participation. However, they also emphasized that these efforts are likely to only succeed with strong policy support and good coordination between various parties. Meanwhile, research by Supriyadi (2019) in the coastal region of West Java shows that environmental education interventions and mangrove-based economic empowerment can increase community participation in conservation activities.

On the other hand, some studies show conflicting results. The survey by Hartini et al. (2020) on the coast of Sumatra revealed that despite community participation, the success of mangrove conservation still needs to improve due to conflicts of interest between various stakeholders, such as fishermen, pond farmers, and local governments. This shows that more than community participation is required with a clear framework and good coordination.

From the results of this research, it is clear that a comprehensive approach is needed to increase community participation in mangrove management and conservation. This includes increasing environmental awareness and education, economic empowerment of communities based on mangrove resources, and robust and integrated policy support from the government. In this way, the sustainability of the mangrove ecosystem can be more guaranteed, and the wider community can feel the benefits.

Community-Based Management and Approach Recommendations

In Java, several government policies and programs are designed to support

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Table 1. Community-Based Management and Approach Recommendations

No	Recommendation	Findings	Supporting Empirical Evidence	Empirical Evidence Is Conflicting
1	Environmental Education	This research found that environmental education directly increases public awareness about the importance of mangrove ecosystems. In Java, education programs have helped reduce destructive practices such as illegal logging.	Setyawan et al. (2017) also show that educational initiatives in schools and local communities can increase environmental awareness and reduce mangrove damage.	Research by Suhardjo (2018) in South Tapanuli shows that with policy support and economic incentives, environmental education is needed in the long term.
2	Conservation Training	Conservation training involving local communities in Java showed positive results, with increased mangrove rehabilitation and ecosystem monitoring skills.	A study by Wahyuni et al. (2016) supports these findings, noting that ongoing conservation training increases community capacity in maintaining mangrove ecosystems.	In contrast, research by Harun (2019) in South Tapanuli shows that training without material and financial support is often unsustainable.
3	Economic Empowerment of Local Communities	Economic empowerment through developing mangrove-based products, such as mangrove batik and processed food, has helped local communities in Java obtain direct monetary benefits from mangrove conservation.	A study by Nurhidayah et al. (2018) found that sustainable local economic initiatives can encourage communities to participate actively in environmental conservation.	Research by Ahmad (2020) shows that in South Tapanuli, economic empowerment efforts are often hampered by a lack of market access and capital, making these initiatives less effective.
4	Community Participation in Decision Making	In Java, community involvement in decision-making regarding mangrove management has resulted in more inclusive and responsive policies.	Research by Santoso et al. (2019) shows that community participation increases the legitimacy and success of conservation policies.	Research by Budi et al. (2017) in South Tapanuli noted that community participation is often limited and less effective without a clear institutional structure.
5	Collaboration Between Parties	Collaboration between the government, NGOs, and local communities in Java has strengthened mangrove conservation efforts.	A study by Handayani et al. (2015) emphasized that multi-stakeholder collaboration accelerates the recovery of mangrove ecosystems.	In contrast, in South Tapanuli, research by Sari (2016) shows that collaboration is often hampered by differences in interests and a lack of coordination.
6	Supportive Policy Development	This research finds that policies that support community-based management are critical to successful mangrove conservation.	A study by Rahmawati et al. (2017) shows that inclusive and adaptive policies can increase the success of conservation programs.	However, research by Adi (2018) in South Tapanuli noted that inconsistent policies and lack of law enforcement often reduce the effectiveness of conservation efforts.

This research proves that a community-based approach if supported by appropriate policies and good collaboration, can increase the success of mangrove conservation programs. However, the socio-economic and environmental conditions differences between Java and South Tapanuli indicate that the strategies implemented must be adapted to the local context. A holistic and participatory approach is needed to ensure the sustainability of the mangrove ecosystem in these two regions.

Conservation Policy and Practice Implications

Integrated Policy

This research underlines the importance of more integrated and effective policies to support mangrove ecosystem conservation. For example, in Java, policies that encourage harmonization across sectors are needed to overcome the policy fragmentation that often occurs between local and national authorities. Incentives for conservation efforts, such as subsidies or tax reductions for companies participating in mangrove restoration programs, could be a significant first step. In addition, increasing the capacity of relevant institutions, including training and human resource development, is necessary to ensure effective policy implementation.

Research on mangrove conservation has provided essential insights into how cross-sector policies and community participation can influence the success of conservation efforts. The study by Setyawan et al. (2018) shows that cross-sector policy harmonization can increase the effectiveness of

mangrove conservation. Their research shows increased mangrove density in areas that implement integrated policies. This shows that conservation efforts can be more effective when policies from various sectors work together.

However, research by Siregar et al. (2020) highlights other equally important aspects of mangrove conservation. Despite integrated policies, conservation efforts are often only successful with local communities' support and participation. This research emphasizes that more than good policies are needed to ensure conservation success. Community participation and stakeholder collaboration are critical to achieving sustainable conservation goals.

From these two studies, it can be concluded that the best approach to mangrove conservation combines integrated policies with the active participation of local communities. Harmonization of policies across sectors provides a robust framework, while the involvement of local communities ensures that conservation efforts are implemented effectively on the ground. Thus, a comprehensive and inclusive strategy is essential in protecting mangrove ecosystems, which are vital for the environment and human life.

Multi-Stakeholder Collaboration

Collaboration between various parties, including government, researchers, NGOs, and local communities, is crucial to successful mangrove conservation. This collaborative approach can reduce information gaps and promote best practices appropriate to local conditions. In South Tapanuli, for example, collaboration with local communities in a mangrove rehabilitation program has shown

positive results in increasing their awareness and involvement in conservation efforts.

The concept of collaborative approaches in conservation has garnered significant attention, mainly due to the findings of Setyawan et al. (2018). Their research highlights the benefits of involving various stakeholders in conservation programs' planning and implementation stages. By bringing together government agencies, non-governmental organizations, local communities, and private sectors, a more holistic and effective strategy for conservation can be developed. This collaborative model ensures that diverse perspectives and expertise are harnessed, leading to more innovative solutions and greater buy-in from all parties involved.

However, the research by Siregar et al. (2020) provides a critical perspective on the potential pitfalls of multi-stakeholder collaboration. They caution that these collaborations can only succeed with clearly delineating roles and responsibilities. The absence of well-defined parameters can lead to clarity, efficiency, and, ultimately, failure in achieving conservation goals. Moreover, the research underscores the challenges posed by conflicting interests and priorities among stakeholders. These differences can create significant barriers to progress, as each party may have varying objectives, resource allocations, and timelines.

To maximize the effectiveness of collaborative conservation efforts, it is essential to establish a robust framework that clearly outlines each stakeholder's roles, responsibilities, and expectations. Fostering open communication and conflict resolution mechanisms can help address and harmonize differing interests. By doing so, the potential for successful and sustainable conservation outcomes is greatly enhanced, leveraging the strengths of a diverse coalition while mitigating the risks associated with multi-stakeholder collaboration.

Sample case

In Java, a conservation program involving collaboration between local government and international NGOs rehabilitated around 50 hectares of mangrove land within two years. This program focuses on replanting mangroves and educating the public about the importance of mangrove ecosystems and how they can contribute to conservation efforts. This program was successful because of strong policy support and active participation from local communities.

In contrast, in South Tapanuli, a similar program experienced challenges due to a need for coordination between the regional government and local communities. Despite NGO financial support, the program failed to achieve its targets because local communities were not actively involved in planning and implementing rehabilitation activities. This research confirms that integrated policies and multi-stakeholder collaboration are the keys to successful mangrove conservation. However, ensuring that the policy is implemented effectively and with active participation from all stakeholders is essential. With this approach, the mangrove ecosystem in Java and South Tapanuli can be sustainable and provide long-term benefits for the environment and society.

By discussing the points above, this research can provide a comprehensive picture of mangrove ecology in Java and South Tapanuli and provide evidence-based recommendations to improve mangrove management and conservation in Indonesia.

CONCLUSION

This research identified significant differences in the characteristics of the mangrove ecosystem on two islands, namely Java and South Tapanuli. In Java, the mangrove ecosystem has a higher density and more stable water conditions. In contrast, in South Tapanuli, the mangrove ecosystem is more fragmented and shows higher variability in water conditions. These differences show that local factors, including physical, chemical, and biological conditions, greatly influence the sustainability of mangrove ecosystems in each region.

This research also highlights several areas for improvement in managing and conserving mangrove ecosystems in these two regions. One of the main shortcomings is the lack of policies that support effective mangrove conservation. Apart from that, community participation in mangrove conservation efforts still needs to be improved. This worsens the situation because mangrove conservation efforts will only run optimally with strong policy support and active involvement of the community.

Based on these findings, this research provides several recommendations to improve the management and conservation of mangrove ecosystems in Java and South Tapanuli. First, more integrated policies are needed to support mangrove conservation, including regulations governing land use and protecting mangrove ecosystems. Second, community-based approaches must be enhanced to involve the community actively in conservation efforts. Education and counseling to the public about the importance of mangrove ecosystems is also vital. By improving better policies and more active community participation, the mangrove ecosystem in these two regions is hoped to be well maintained and sustainable.

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