

SOCIO-ECONOMIC PERSPECTIVES OF COASTAL COMMUNITIES ON THE CHALLENGES OF MANGROVE ECOSYSTEM REHABILITATION IN TAWIRI VILLAGE, AMBON BAY

Perspektif Sosial Ekonomi Masyarakat Pesisir Terhadap Tantangan Rehabilitasi
Ekosistem Mangrove di Desa Tawiri, Teluk Ambon

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ABSTRACT

Mangrove ecosystem rehabilitation is a key strategy for sustaining coastal environments; however, its success depends not only on biophysical conditions but also on the socio-economic characteristics of coastal communities. This study aims to analyze the challenges of mangrove rehabilitation in Tawiri Village, Ambon Bay District, from a *Social-Ecological Systems* (SES) perspective. A qualitative approach was employed using thematic analysis based on in-depth interviews, field observations, and documentation. Data were analyzed through data familiarization, coding, theme development, interpretation, and conclusion drawing, supported by source and method triangulation. The findings reveal that mangrove rehabilitation is constrained by household economic pressures, community dependence on mangrove resources, low rehabilitation success, solid waste pollution, and suboptimal governance. Nevertheless, local communities demonstrate adequate ecological knowledge, environmental awareness, and willingness to participate in rehabilitation programs when supported by sustainable and collaborative initiatives. The study highlights that effective mangrove rehabilitation requires an integrated approach encompassing ecological, social, economic, and institutional dimensions. Therefore, local governments should strengthen SES-based rehabilitation policies by promoting community participation, sustainable livelihood development, integrated coastal waste management, and multi-stakeholder collaboration to enhance mangrove ecosystem resilience and improve the well-being of coastal communities.

Keywords: coastal management, community participation, mangrove rehabilitation, *Social-Ecological Systems*, Tawiri Village.

ABSTRAK

Rehabilitasi ekosistem mangrove merupakan salah satu strategi penting dalam menjaga keberlanjutan lingkungan pesisir. Namun, keberhasilannya tidak hanya bergantung pada kondisi biofisik, tetapi juga pada karakteristik sosial ekonomi masyarakat pesisir. Penelitian ini bertujuan untuk menganalisis tantangan rehabilitasi mangrove di Desa Tawiri, Teluk Ambon,

dari perspektif Social-Ecological Systems (SES). Penelitian menggunakan pendekatan kualitatif dengan analisis tematik berdasarkan wawancara mendalam, observasi lapangan, dan dokumentasi. Data dianalisis melalui tahapan familiarisasi data, pengodean, pengembangan tema, interpretasi, dan penarikan kesimpulan yang didukung oleh triangulasi sumber dan metode. Hasil penelitian menunjukkan bahwa rehabilitasi mangrove menghadapi berbagai kendala, meliputi tekanan ekonomi rumah tangga, ketergantungan masyarakat terhadap sumber daya mangrove, rendahnya keberhasilan rehabilitasi, pencemaran sampah padat, serta tata kelola yang belum optimal. Meskipun demikian, masyarakat lokal memiliki pengetahuan ekologis yang memadai, kesadaran terhadap lingkungan, serta kemauan untuk berpartisipasi dalam program rehabilitasi apabila didukung oleh inisiatif yang berkelanjutan dan kolaboratif. Penelitian ini menegaskan bahwa keberhasilan rehabilitasi mangrove memerlukan pendekatan terpadu yang mencakup dimensi ekologis, sosial, ekonomi, dan kelembagaan. Oleh karena itu, pemerintah daerah perlu memperkuat kebijakan rehabilitasi berbasis SES melalui peningkatan partisipasi masyarakat, pengembangan mata pencaharian berkelanjutan, pengelolaan sampah pesisir secara terpadu, serta kolaborasi multipihak untuk meningkatkan ketahanan ekosistem mangrove dan kesejahteraan masyarakat pesisir.

Kata kunci: Desa Tawiri, partisipasi masyarakat, pengelolaan pesisir, rehabilitasi mangrove, *Social-Ecological Systems*.

INTRODUCTION

The mangrove ecosystem is a coastal ecosystem that has high productivity and provides various ecological and socio-economic benefits for the community. Ecologically, mangroves play a role in protecting coastlines from abrasion and wave impacts, providing habitat and nursery areas for various aquatic organisms, and contributing to climate change mitigation through their ability to absorb and store carbon. Apart from these ecological functions, mangroves also support the lives of coastal communities through fishing activities, utilization of non-timber forest products, as well as various economic activities based on ecosystem services. Therefore, the existence and sustainability of mangrove ecosystems is important, not only for environmental sustainability, but also for the welfare of people who depend on coastal resources for their livelihoods (Friess *et al.*, 2019; Worthington *et al.*, 2020).

In the midst of these various benefits, the mangrove ecosystem is still facing considerable pressure due to the development of coastal areas, changes in land function, expansion of cultivation activities, resource exploitation and environmental pollution. These various pressures can cause a reduction in the area of mangroves as well as reduce their ecological function. The impact is not only felt through a reduction in biodiversity, but can also affect fisheries productivity, coastal protection capabilities, and the capacity of ecosystems to store carbon (Goldberg *et al.*, 2014; Románach *et al.*, 2018). These conditions make mangrove rehabilitation an important effort to restore ecosystems that have experienced degradation. However, successful rehabilitation does not always show the same results in every location. This success is not only determined by biophysical conditions and planting techniques, but is also closely related to socio-economic conditions and community institutions. Limited livelihood alternatives, high dependence on coastal resources, inadequate institutional capacity, and low community involvement can be factors that hinder the long-term sustainability of rehabilitation programs (Bosire *et al.*, 2008; Friess *et al.*, 2019).

Tawiri Village, Teluk Ambon District, Maluku Province, is one of the coastal areas where the presence of mangroves plays an important role in protecting the coastline and supporting the fishing activities of the local community. However, the results of field observations show that there are a number of problems, including the low level of natural regeneration of mangroves, the low survival rate of planted seedlings, the accumulation of

household waste, and ongoing pressure due to human activities and the use of mangrove resources. These problems show that the challenges of mangrove rehabilitation in Tawiri Village are not solely related to ecological and technical aspects. Initial interactions with the community also showed that limited livelihood options and inadequate institutional support have contributed to dependence on coastal resources and limited the sustainability of community involvement in rehabilitation activities. On the other hand, the community has an understanding of the benefits of mangroves and shows a willingness to be involved in rehabilitation activities if the program implemented is able to provide economic benefits while increasing community capacity.

Many studies on mangrove rehabilitation have primarily focused on biophysical indicators, such as growth rates, plant survival, changes in vegetation cover, and ecosystem conditions. Conversely, the socioeconomic aspects that influence the success of rehabilitation have received relatively less attention, particularly in archipelagic regions and small islands like the Maluku Islands. Yet, factors such as the livelihoods of local communities, their level of dependence on coastal resources, institutional support, and community participation are crucial in determining the sustainability of mangrove ecosystem management and rehabilitation. This gap highlights the need for a more in-depth examination of the relationship between the socioeconomic conditions of local communities and the various challenges associated with mangrove rehabilitation at the local level.

Given this context, this study aims to analyze the challenges of mangrove ecosystem rehabilitation in Tawiri Village from the perspective of the coastal community's socioeconomic conditions. It is expected that this research will contribute to the body of knowledge on community-based mangrove rehabilitation by placing greater emphasis on socioeconomic and institutional dimensions. Furthermore, the findings are intended to serve as a foundation for developing mangrove management and rehabilitation strategies that are more participatory, inclusive, and sustainable—tailored to the specific conditions and needs of coastal communities in archipelagic regions.

RESEARCH MTHODS

Place and Time

This research was conducted from January to March 2026 in Tawiri Village, Teluk Ambon District, Maluku Province, Indonesia. The research site was selected using a purposive sampling method, based on the fact that the area has experienced mangrove ecosystem degradation over the last three years.

Tawiri Village is a coastal area located within the Teluk Ambon (Ambon Bay) region—a bay that plays a significant role in Maluku Province. The village covers an area of approximately 19.87 km², encompassing land, coastal zones, and marine waters that are utilized and managed by the local community.

Geographically, Tawiri Village is bordered by the following areas:

- North: Wailawa Hamlet 2
- To the south: The waters of Ambon Bay
- To the East: Riang Hamlet
- West side: Indonesian Air Force (TNI AU) area and Pattimura Airport



Figure 1. Research Location

Types of Data and Data Collection Methods

This study utilizes both primary and secondary data. Primary data refers to information collected directly by the researcher from the original source (first-hand) to specifically address the research problem (Sulung and Muspawi, 2024). Such data were obtained through questionnaires, which served as a guide for interviews with the local community. The collection of primary data was further supplemented by field documentation—specifically photographs—to record environmental conditions and activities related to the mangrove ecosystem. Sulung and Muspawi (2024) note that secondary data consists of information or data obtained indirectly from pre-existing sources collected by other parties. In this study, secondary data were gathered through a literature review of various relevant research papers and reports, focusing particularly on information regarding the extent of the mangrove ecosystem and changes in mangrove cover at the research site, based on the findings of previous studies.

Data Analysis

This study employs a qualitative approach with thematic analysis to identify, categorize, and interpret the various challenges associated with mangrove ecosystem rehabilitation, viewed through the socio-economic perspectives of coastal communities in Tawiri Village, Teluk Ambon District. Thematic analysis was selected because it enables the researcher to uncover patterns, meanings, and themes emerging from the experiences, perceptions, and viewpoints of the community regarding the issues under investigation (Braun & Clarke, 2022; Byrne, 2022).

The analytical process was conducted in a phased and iterative manner, spanning from data collection through to interpretation. The analysis follows the principles of "reflexive thematic analysis" as developed by Braun and Clarke (2022). The process began with a thorough familiarization with the data, achieved through repeated readings of interview transcripts, field observation notes, and supporting documents. This stage aimed to develop a holistic understanding of the social, economic, and environmental conditions within the study area.

The subsequent stage involved initial coding—identifying information related to community experiences, obstacles to rehabilitation, patterns of mangrove resource utilization, livelihood conditions, and socio-economic factors that could influence the success of rehabilitation efforts. Related codes were then grouped to form preliminary themes. These themes were subsequently reviewed against the entire dataset to ensure a robust connection to the empirical information gathered. Following this review, the themes were defined and named based on their underlying substance or meaning. The final stage involved interpreting these themes by linking them to relevant concepts, theories, and findings from previous research,

thereby providing a more comprehensive understanding of the challenges involved in mangrove rehabilitation.

The analysis was conducted inductively; research themes were developed based on patterns and information discovered within the field data, rather than being rigidly predetermined prior to data collection. This approach allows the researcher to understand social reality through the experiences and perspectives of the community members who served as informants. Thus, the challenge of mangrove rehabilitation is understood not merely as an ecological issue, but also as a consequence of the interplay between the economic conditions of the community, social values regarding resources, institutional arrangements, and practices related to the utilization of coastal resources. This perspective aligns with the Social-Ecological Systems (SES) approach, which views society and ecosystems as interconnected components that collectively influence the management of natural resources (Partelow *et al.*, 2023).

To enhance the credibility and trustworthiness of the research findings, triangulation of both sources and methods was employed. Source triangulation was conducted by comparing information gathered from various groups of informants, including coastal community members, community leaders, village government officials, and other stakeholders involved in mangrove rehabilitation activities. Meanwhile, method triangulation was carried out by comparing information obtained through in-depth interviews, field observations, and documentation concerning the state of the mangroves and the rehabilitation activities taking place at the research site.

In addition to triangulation, the researcher also repeatedly reviewed the interpretations throughout the analysis process. This step was intended to ensure that the themes generated accurately reflected the experiences, perspectives, and conditions shared by the informants. Employing this strategy is expected to strengthen the credibility, dependability, and confirmability of the qualitative research findings (Braun & Clarke, 2022; Nowell *et al.*, 2017).

RESULT

General Overview of the Research Site

Tawiri Village is a coastal village located in the Teluk Ambon District, Ambon City, Maluku Province, Indonesia. The village has a population of approximately 1,780 people, distributed across 328 households. In terms of population composition, men account for about 51.57%, while women make up 48.93%.

Tawiri Village possesses coastal resources that are vital to the lives of its residents, most notably its fisheries and mangrove ecosystems. The village's location, facing open sea waters, supports a variety of fish resources and serves as a base for local fishing activities. Furthermore, the mangrove ecosystems found along the village's coastline play a crucial ecological role in maintaining environmental balance and supporting the productivity of the coastal ecosystem.

Although these coastal resources provide ecological and socio-economic benefits to the community, their sustainability is under increasing pressure due to human activities and changing environmental conditions. Field observations indicate a decline in the extent of the mangrove ecosystem in Tawiri Village over time. This reduction in mangrove cover raises concerns regarding the sustainability of coastal resources and the various ecosystem services they provide—both for the current community and for future generations.



a) Remaining Mangrove Ecosystems (b) Remnants of Mangrove Rehabilitation Planting
Figure 1. Condition of the Mangrove Ecosystem

Challenges of Mangrove Rehabilitation from a Social-Ecological Systems (SES) Perspective

The research findings indicate that rehabilitation challenges do not exist in isolation; rather, they emerge from the interaction between socioeconomic pressures and ecological conditions. From a social perspective, economic pressures, community dependence on mangrove resources, patterns of land use, and a lack of alternative livelihoods can all affect the sustainability of rehabilitation efforts. Ecologically, factors such as waste pollution, habitat disturbance, low planting success rates, and the decline of ecological functions are interconnected.

The interaction between these two systems reveals a reciprocal social-ecological relationship. While communities derive benefits from mangrove ecosystem services, their utilization activities and the economic pressures they face can simultaneously increase the strain on the ecosystem. A degraded ecological state, in turn, reduces the benefits the ecosystem can provide to the community. Consequently, the challenges of mangrove rehabilitation in Tawiri Village are multidimensional and cannot be resolved solely through technical planting approaches. The following is an illustration based on the research findings.



Figure 2. Conceptual Model of Mangrove Rehabilitation Challenges from a Social-Ecological Systems (SES) Perspective

These findings point to the need for adaptive and collaborative governance, achieved through increased community participation, the utilization of local knowledge, government support, institutional strengthening, waste management, and continuous monitoring and evaluation. Integrating these various aspects is expected to foster more sustainable mangrove

rehabilitation, enhance ecological functions, strengthen coastal resilience, reduce disaster risks, and ultimately contribute to improving the well-being of the community in Tawiri Village.

DISCUSSION

Socioeconomic Characteristics of Respondents

This study involved 30 respondents selected through purposive sampling. The respondents are residents of Tawiri Village who live in the vicinity of the mangrove ecosystem and were willing to provide information via interviews. The socioeconomic characteristics analyzed include gender, educational attainment, and occupation.

In terms of gender, the majority of respondents (63.33%) are male. Regarding education, the largest group (46.67%) completed senior high school (SMA). Furthermore, 16.67% of respondents hold a junior high school (SMP) education, 16.67% hold a bachelor's degree, 13.33% hold a diploma, and 6.67% completed only primary school (SD). This diversity in educational background suggests that respondents possess varied formal educational experiences, which may influence their level of understanding and perspectives regarding the existence and management of the mangrove ecosystem.

Regarding occupation, 26.67% of the respondents are currently unemployed, while the others hold various jobs. Fishermen constitute the largest occupational group at 26.67%, followed by private-sector employees (20%), drivers (10%), civil servants (10%), and casual/temporary workers (6.67%). This occupational diversity reflects differences in livelihood characteristics and the extent to which the community relies on coastal resources. Understanding these conditions is essential for grasping the various socioeconomic challenges associated with mangrove rehabilitation in Tawiri Village.

Socio-Economic Perspectives of the Community Regarding the Challenges of Mangrove Rehabilitation

Economic Pressures as a Challenge to Mangrove Rehabilitation

Thematic analysis indicates that economic pressure is a primary challenge in the implementation of mangrove rehabilitation in Tawiri Village. Interviews reveal that meeting household economic needs often takes precedence over community participation in mangrove rehabilitation and conservation efforts. This suggests that the community's utilization of mangrove areas is not necessarily a reflection of low environmental concern, but rather a response to the necessity of sustaining household income.

Most informants noted that local livelihoods remain heavily dependent on capture fisheries and informal work linked to coastal resources. Mangrove areas provide direct economic benefits by supplying fish, crabs, shellfish, and various other aquatic organisms. A lack of livelihood alternatives outside the coastal sector compels the community to continue relying on these resources to meet their families' economic needs.

Economic pressure also influences the level of community engagement in rehabilitation activities. Mangrove planting and maintenance efforts typically occur when there is external support—such as government programs, collaborations between Pattimura University and local church communities, or other initiatives from outside entities. Once such programs or support conclude, community participation in maintenance activities tends to decline.

From the perspective of Social-Ecological Systems (SES), this situation highlights a reciprocal relationship between local livelihoods and the mangrove ecosystem. Economic dependence on coastal resources drives the utilization of the ecosystem, while any decline in ecosystem quality, in turn, diminishes the capacity of the mangroves to provide the resources and ecosystem services upon which the community relies. Consequently, mangrove rehabilitation efforts must be integrated with strategies to strengthen the livelihoods of coastal communities.

These findings align with Hamza *et al.* (2024), who demonstrate that limited income opportunities and a high degree of dependence on mangrove resources pose significant challenges for mangrove management in developing countries. Friess *et al.* (2019) also emphasizes the importance of integrating ecological restoration with the improvement of livelihoods and the strengthening of coastal governance. Consequently, economic pressure should not merely be understood as a factor that directly drives mangrove degradation, but also as an indicator of the limited livelihood options available to the community.

The implication is that mangrove rehabilitation programs in Tawiri Village must be accompanied by livelihood diversification, the development of sustainable mangrove-based enterprises, skills enhancement, and the strengthening of the local economy. Such an approach has the potential to increase community engagement while simultaneously bolstering the long-term sustainability of mangrove rehabilitation efforts.

Community Dependence on Mangrove Resources

Thematic analysis indicates that the mangrove ecosystem in Tawiri Village is not merely viewed as an area requiring conservation; it is also an integral component of the coastal community's livelihood system. According to interviews, the community utilizes the mangrove area for fishing and harvesting crabs, shellfish, and various other aquatic resources. Mangroves are also perceived as playing a role in maintaining the productivity of the coastal zone, which indirectly supports the sustainability of the community's livelihoods. This demonstrates that the relationship between the community and the mangroves encompasses ecological, economic, and social dimensions.

Long-term resource utilization has fostered a significant level of dependency on the mangrove ecosystem. Informants noted that changes in the condition of the mangroves can affect catch yields and the ease with which aquatic resources are obtained. A reduction in vegetation density or a decline in habitat quality could shrink productive aquatic areas, forcing the community to invest more time and incur higher costs to secure a similar catch. Consequently, the state of the mangrove ecosystem is closely linked to the sustainability of the community's livelihoods.

Nevertheless, dependency on mangrove resources does not automatically lead to destructive exploitation. Most informants understand the long-term benefits provided by mangroves and recognize the importance of preserving the ecosystem. The primary challenge lies in establishing a management mechanism capable of balancing utilization needs with conservation interests. In the absence of adequate regulations and oversight, ongoing exploitation could intensify pressure on the ecosystem and diminish the sustainability of its functions.

From the perspective of a Social-Ecological System (SES), this situation illustrates a reciprocal relationship between the coastal community and the mangrove ecosystem. Mangroves provide ecosystem services that support the community's livelihoods, while the community's patterns of resource use, in turn, influence the condition of the ecosystem. Therefore, effective governance is a crucial factor in maintaining this relationship, ensuring that dependence on mangroves does not evolve into pressure that leads to ecosystem degradation.

These findings align with Friess *et al.* (2019), who explain that the success of mangrove conservation and rehabilitation is heavily influenced by the relationship between local communities and the ecosystem services provided by mangroves. López-Angarita *et al.* (2018) also emphasize the importance of local rules, equitable benefit-sharing, and community participation in enhancing the effectiveness of community-based mangrove management.

In the context of Tawiri Village, the community's dependence on mangroves can actually serve as social capital to support rehabilitation efforts. Local knowledge regarding environmental changes, vegetation characteristics, and suitable locations for rehabilitation can

be leveraged to design programs that are better tailored to local conditions. Consequently, the community should be viewed not merely as resource users, but as active partners in the planning, implementation, and monitoring of mangrove rehabilitation. Integrating conservation goals with livelihood needs can strengthen community participation and enhance the sustainability of rehabilitation initiatives.

Rehabilitation Failure and the Factors Influencing It

The results of thematic analysis and field observations indicate that mangrove rehabilitation efforts in Tawiri Village have not yielded the expected outcomes. Many of the planted seedlings failed to survive into subsequent growth stages, suggesting that the rehabilitation initiatives have not yet fully restored the ecological functions of the mangrove ecosystem. Consequently, the success of such rehabilitation cannot be measured solely by the number of seedlings planted; it must also account for survival rates, the seedlings' capacity to grow and develop, and their overall contribution to ecosystem recovery.

The limited success of the rehabilitation is linked to the interplay between biophysical factors and management practices. Informants identified unsuitable planting sites as a primary obstacle—specifically, locations where substrate characteristics, tidal dynamics, and strong currents hinder seedling growth. Furthermore, selecting mangrove species that are ill-suited to the specific site conditions can also diminish the success rate. These findings underscore the necessity of assessing the ecological status of a site and ensuring that the chosen mangrove species align with the habitat's characteristics before planting begins.

Beyond biophysical factors, management aspects also contribute to the low success rate. Rehabilitation programs have tended to prioritize the act of planting, while post-planting maintenance and monitoring have not been carried out consistently. As a result, seedlings that are damaged or die are not always promptly replaced. This highlights that mangrove rehabilitation should be viewed as a long-term process rather than a one-time planting activity that concludes once the seedlings are in the ground. Ongoing monitoring, maintenance, and the adjustment of strategies based on field conditions are essential.

Another factor identified is the coordination among stakeholders. Although rehabilitation efforts have involved the government and various organizations—including a collaboration between the Faculty of Fisheries at Pattimura University and the community of Tawiri Village—there remains a lack of technical guidance and support following the initial planting phase. Suboptimal communication and coordination can hinder the community's understanding of rehabilitation techniques, seedling maintenance, and the division of responsibilities once a program concludes. Consequently, the community's sense of ownership over the rehabilitation program fails to develop fully, and the sustainability of the activities remains heavily dependent on initiatives from external parties.

These findings align with research by Lewis (2005), which emphasizes the importance of understanding hydrological conditions and habitat characteristics before undertaking restoration activities. Lee *et al.* (2019) further demonstrate that approaches focused solely on planting—without considering environmental conditions—can result in low success rates. Meanwhile, Friess *et al.* (2019) highlight the necessity of integrating biophysical suitability, adaptive governance, and sustained community engagement into mangrove rehabilitation efforts.

From the perspective of Social-Ecological Systems (SES), low rehabilitation success reflects a lack of optimal integration between ecological knowledge, community capacity, and collaborative governance. Therefore, improving the success of rehabilitation requires an adaptive approach that combines site suitability assessments, the selection of appropriate mangrove species, post-planting monitoring, community capacity building, and strengthened coordination among the government, local communities, academic institutions, and other stakeholders.

Waste Pollution as an Obstacle to Mangrove Rehabilitation

The results of field observations show that waste accumulation is one of the important environmental pressures in mangrove rehabilitation in Tawiri Village. The trash found was mostly household waste, especially plastic packaging, food containers, bottles and various types of inorganic waste carried by river flows and tidal currents. Trash can be seen around mangrove roots, sediment surfaces and intertidal areas, so it has the potential to change habitat conditions and hinder the mangrove regeneration process.

Accumulated waste can directly affect seedling growth through inhibiting root development, disrupting water circulation, and changing oxygen exchange in sediments. Litter can also inhibit the spread of propagules and reduce opportunities for natural regeneration. Based on the results of interviews, some of the accumulated rubbish did not come from the Tawiri Village community, but was carried from other areas via river flows and sea currents. The community has carried out regular cleaning, but the rubbish has piled up again in a relatively short time. This condition shows that the waste problem in Tawiri Village is a cross-regional coastal management problem that cannot be resolved only through cleaning activities at the village level.

Apart from hampering rehabilitation, continuous accumulation of waste can reduce the ecological function of mangroves by reducing the quality of habitat for fish, crabs, molluscs and other organisms that use mangroves as places to find food, shelter and breed. Declining environmental quality can ultimately affect coastal fisheries and other ecosystem services that support people's livelihoods. Garbage pollution also has the potential to reduce the function of mangroves in protecting coastlines and storing carbon if vegetation growth and ecosystem restoration processes are disrupted.

These findings are in line with Martin *et al.* (2020), who explained that mangrove ecosystems are very vulnerable to the accumulation of marine debris because their dense root structures can capture and hold water-borne material. Ivar do Sul and Costa (2014) also show that plastic pollution can have a negative impact on environmental quality, biodiversity and the restoration process of coastal ecosystems.

From the SES perspective, waste accumulation shows a relationship between human activities, waste management systems, and coastal ecosystem conditions. Therefore, mangrove rehabilitation needs to be carried out in conjunction with community-based waste management, improving waste collection facilities, environmental education, and coordination between upstream and coastal areas. Handling pollution as part of a rehabilitation strategy is important to support mangrove recovery and maintain ecosystem services that support the lives of coastal communities in Tawiri Village.

Public Participation and Expectations Regarding Mangrove Rehabilitation

Thematic analysis reveals a positive public attitude toward mangrove rehabilitation efforts in Tawiri Village. Most informants expressed a willingness to participate in conservation initiatives, provided that the programs are clearly designed, implemented sustainably, and offer tangible benefits to the community. Mangroves are viewed not only as a vital component of the coastal environment but also as a resource that supports local livelihoods. This awareness serves as an essential form of social capital for strengthening community-based rehabilitation.

Community participation extends beyond the mere planting of seedlings. Informants indicated a readiness to engage in seedling preparation, post-planting maintenance, ecosystem monitoring, and periodic waste cleanup activities. Such involvement across various stages fosters a sense of ownership and supports the long-term sustainability of rehabilitation efforts. Furthermore, local ecological knowledge provides a crucial source of information—particularly regarding environmental changes, suitable planting sites, and site-specific characteristics that influence mangrove growth. Integrating local knowledge with scientific

approaches has the potential to enhance the effectiveness of rehabilitation by tailoring it to the specific conditions of each location.

While willing to participate, community members emphasized the need for ongoing guidance, technical training, and a clear delineation of roles among the government, the community, academic institutions, and other stakeholders. They also stressed that rehabilitation programs should include regular monitoring and evaluation, rather than concluding once the planting phase is complete. Additionally, respondents expressed interest in developing income-generating activities that align with mangrove conservation principles—such as community-based ecotourism, eco-friendly aquaculture, and the sustainable utilization of non-timber mangrove products. This indicates that the community views environmental preservation and the improvement of human well-being as complementary, mutually achievable goals.

These findings are consistent with those of Friess *et al.* (2019) emphasizes that community involvement during the planning, implementation, and monitoring stages is a crucial aspect of the sustainability of mangrove rehabilitation. Locatelli *et al.* (2014) also highlight the role of local knowledge, community ownership, and participatory governance in supporting the success of restoration efforts.

From the perspective of Social-Ecological Systems (SES), community participation strengthens the relationship between social and ecological components through the exchange of knowledge, mutual learning processes, and adaptive governance. Consequently, the community's willingness to participate presents a significant opportunity to bolster mangrove rehabilitation in Tawiri Village. For this willingness to evolve into sustained engagement, rehabilitation programs must enhance community capacity, establish local institutions, provide space for community participation in decision-making, and foster ongoing collaboration among the government, academic institutions, civil society organizations, and coastal communities. Positioning the community as an active partner—rather than merely as a beneficiary—can improve ecosystem recovery while simultaneously strengthening the sustainability of mangrove management.

A Synthesis of Challenges in Mangrove Rehabilitation from a Social-Ecological Systems Perspective

The research findings indicate that the challenges of mangrove rehabilitation in Tawiri Village are multidimensional and cannot be explained solely by ecological factors. The success of rehabilitation is influenced by the interplay between ecosystem conditions, community livelihoods, economic pressures, resource utilization patterns, and institutional capacity. From the perspective of Social-Ecological Systems (SES), the mangrove ecosystem and the local community are interconnected components; thus, a change in one component can affect the others (Partelow, 2023).

The study reveals that shifts in the condition of one part of the system can impact other parts. A decline in the state of the mangroves can diminish habitat quality and the availability of coastal resources, which are essential to the community's livelihoods. Conversely, patterns of resource use and the effectiveness of community governance shape the state of the ecosystem and its capacity to maintain its ecological functions. This reciprocal relationship suggests that mangrove rehabilitation should be understood as an adaptive and ongoing process, rather than merely a technical activity of planting seedlings.

A synthesis of the findings further shows that the various challenges identified—including economic pressures, reliance on natural resources, low rehabilitation success rates, waste accumulation, and limited institutional support—are interconnected and inseparable. Consequently, interventions focused exclusively on planting seedlings are likely insufficient to achieve long-term ecosystem recovery. More effective rehabilitation requires simultaneous attention to community capacity, livelihood conditions, environmental pressures, and coordination among stakeholders.

Strengthening the community's adaptive capacity—through active participation, the integration of local ecological knowledge, and collaboration with the government and other institutions—can enhance the resilience of the social-ecological system in Tawiri Village (Folke *et al.*, 2021; Partelow, 2023). In this context, governance emerges as a critical component for the sustainability of rehabilitation efforts. Adaptive and collaborative governance can strengthen coordination, clarify the division of responsibilities, foster a sense of community ownership, and support ongoing monitoring and evaluation activities. Such arrangements are increasingly important, given that the management of coastal areas involves various stakeholders with diverse interests (Friess *et al.*, 2019; Locatelli *et al.*, 2014).

Overall, the research findings support a shift from a planting-oriented rehabilitation approach toward integrated social-ecological management. The success of rehabilitation should not be measured solely by seedling survival rates or changes in mangrove cover; rather, it should also be assessed through enhanced community capacity, institutional effectiveness, the quality of collaboration among stakeholders, and the sustainability of ecosystem functions. Integrating ecological, socio-economic, and governance aspects can provide a more robust foundation for sustainable mangrove rehabilitation, while simultaneously strengthening the resilience of the coastal community in Tawiri Village.

CONCLUSION

This study demonstrates that the challenges of mangrove rehabilitation in Tawiri Village are influenced not only by biophysical conditions but also by the socio-economic dynamics of the coastal community. Applying a Social-Ecological Systems (SES) perspective, the research identifies economic pressures, community dependence on mangrove ecosystem services, low rehabilitation success rates, waste pollution, and suboptimal coastal governance as interconnected factors that collectively influence the effectiveness and sustainability of mangrove rehabilitation efforts.

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REFERENCES

- Arifanti, V. B., Sidik, F., Mulyanto, B., Susilowati, A., Wahyuni, T., Subarno, Yulianti, Yuniarti, N., Aminah, A., Suita, E., Karlina, E., Suharti, S., Pratiwi, Turjaman, M., Hidayat, A., Rachmat, H., Hendalastuti, Imanuddin, R., Yeny, I., Darwiati, W., Sari, N., Hakim, S., Surya, Slamet, W., Yasmine, Novita, N. (2022). Challenges and Strategies for Sustainable Mangrove Management in Indonesia: A Review. *Forests*, 13(5), 695. <https://doi.org/10.3390/f13050695>.
- Bosire, J. O., Dahdouh-Guebas, F., Walton, M., Crona, B., Lewis, R. R., Field, C., Kairo, J. G., & Koedam, N. (2008). Functionality of Restored Mangroves: A Review. *Aquatic Botany*, 89(2), 251–259.
- Braun, V., & Clarke, V. (2022). *Thematic Analysis: A Practical Guide*. SAGE Publications.
- Byrne, D. (2022). A worked example of Braun and Clarke's approach to Reflexive Thematic Analysis. *Quality & Quantity*, 56(3), 1391–1412. <https://doi.org/10.1007/s11135-021-01182-y>.

- Folke, C., Polasky, S., Rockström, J., Galaz, V., Westley, F., Lamont, M., Scheffer, M., Österblom, H., Carpenter, S. R., Chapin, F. S., Seto, K. C., & at all. (2021). Our Future in the Anthropocene Biosphere. *Ambio*, 50(4), 834–869.
- Friess, D. A., Rogers, K., Lovelock, C. E., Krauss, K. W., Hamilton, S. E., Lee, S. Y., Lucas, R., Primavera, J., Rajkaran, A., & Shi, S. (2019). The State of the World's Mangrove Forests: Past, Present, and Future. *Annual Review of Environment and Resources*, 49, 1–30.
- Goldberg, L., Lagomasino, D., Thomas, N., & Fatoyinbo, T. (2020). Global Declines in Human-Driven Mangrove Loss. *Global Change Biology*, 26(10), 5844–5855.
- Hamzah, A. H. P., Suriani, C., & Prastowo, P. (2024). Tinjauan Fenomena Kerusakan Lingkungan Dampak Alih Fungsi Lahan Mangrove (Studi Kasus Desa Tapak Kuda, Kecamatan Tanjung Pura, Kabupaten Langkat, Sumatera Utara). *BIOEDUSAINS: Jurnal Pendidikan Biologi dan Sains*, 8(2), 193–206.
- Ivar do Sul, J. A., Costa, M. F., Silva-Cavalcanti, J. S., & Araújo, M. C. B. 2014. Plastic Debris Retention and Exportation by a Mangrove Forest Patch. *Marine Pollution Bulletin*, 78(1–2), 252–257. <http://dx.doi.org/10.1016/j.marpolbul.2013.11.011>.
- Lee, S. Y., Hamilton, S., Barbier, E. B., Primavera, J., & Lewis, R. R. (2019). Better Restoration Policies are Needed to Conserve Mangrove Ecosystems. *Nature Ecology & Evolution*, 3(6), 870–872.
- Lewis, R. R. (2005). Ecological Engineering for Successful Management and Restoration of Mangrove Forests. *Ecological Engineering*, 24(4), 403–418.
- Locatelli, T., Binet, T., Kairo, J. G., King, L., Madden, S., Patenaude, G., Upton, C., & Huxham, M. (2014). Turning the Tide: How Blue Carbon and Payments for Ecosystem Services (PES) Might Help Save Mangrove Forests. *Ambio*, 43(8), 981–995.
- Juliana López-Angarita, Alexander Tilley, Julie P. Hawkins, Claudia Pedraza, dan Callum M. Roberts. (2018). Land use Patterns and Influences of Protected Areas on Mangroves of the Eastern Tropical Pacific. *Biological Conservation*, 227, 82-91.
- Martin, C., Baalkhuyur, F., Valluzzi, L., Saderne, V., Cusack, M., Almahasheer, H., ... & Duarte, C. M. (2020). Exponential Increase of Plastic Burial in Mangrove Sediments as a Major Plastic Sink. *Science advances*, 6(44), eaaz5593.
- Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic Analysis: Striving to Meet the Trustworthiness Criteria. *International Journal of Qualitative Methods*, 16, 1–13.
- Partelow, S., Asif, F., Béné, C., Bush, S., Manlosa, A., Nagel, B., Schlüter, A., Chadag, V. M., Choudhury, A., Cole, S., Cottrell, R., Gelcich, S., Gentry, R., Gephart, J., Glaser, M., Johnson, T. R., Jonell, M., Krause, G., Kunzmann, A., ... & Turchini, G. (2023). Aquaculture Governance: Five Engagement Arenas for Sustainability Transformation. *Current Opinion in Environmental Sustainability*, 65, 101379. <https://doi.org/10.1016/j.cosust.2023.101379>.
- Romañach, S. S., DeAngelis, D. L., Koh, H. L., Li, Y., Teo, S., & Barizan, R. S. A. (2018). Conservation and Restoration of Mangroves: Global Status, Perspectives, and Prognosis. *Frontiers in Marine Science*, 5, 57.
- Sulung, U., & Muspawi, M. (2024). Analisis Perbandingan Efektivitas Penggunaan Data Primer dan Data Sekunder dalam Riset Ilmiah. *Journal of Edu Research*, 12(2), 145-156. [doi.org](https://doi.org/10.29303/jp.v12i2.2499).
- Worthington, T. A., zu Ermgassen, P. S. E., Friess, D. A., Krauss, K. W., Lovelock, C. E., Thorley, J., Tingey, R., Woodroffe, C. D., Bunting, P., Cormier, N., Lagomasino, D., Lucas, R., Murray, N. J., Sutherland, W. J., Spalding, M., & Duncan, C. (2020). A Global Biophysical Typology of Mangroves and its Relevance for Ecosystem Structure and Deforestation. *Scientific Reports*, 10, 14652.