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Knowledge of the Tiger Forest Farmers Group in the Pulau Laut Sebuku Forest Management Unit in the Implementation of Mangrove Rehabilitation

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ABSTRACT

This study aims to analyze the level of knowledge and perception of the Tiger Forest Farmers Group (KTH) in the Sebuku Island Forest Management Unit (KPH) regarding mangrove rehabilitation and its impact on community empowerment. The method used was a qualitative descriptive approach with data collection through surveys, in-depth interviews, and direct observation. The results of the study showed that most KTH members understand the ecological and economic benefits of mangrove ecosystems, although there were still limitations in the technical aspects of rehabilitation. The impact of mangrove rehabilitation on the community can be seen in three main aspects. Environmentally, this activity has succeeded in increasing mangrove vegetation cover, which contributes to the prevention of abrasion and the improvement of coastal habitats. Socially, mangrove rehabilitation strengthened community solidarity through participation in mangrove planting and management activities. From an economic perspective, this program opened up mangrove-based business opportunities, such as ecotourism and mangrove-based processed products, although the economic benefits were not yet evenly distributed. To improve the effectiveness of mangrove rehabilitation, community empowerment strategies are needed through technical capacity building, mangrove-based economic diversification, and institutional strengthening and collaboration with the government and the private sector. A participatory approach that involves the community in every stage of rehabilitation is a key to the success of this program.

Keywords: rehabilitation, mangroves, ecotourism, Sabuku Island Forest Management Unit

INTRODUCTION

The existence of mangrove forests on the coast plays a role as a natural barrier against sea waves, abrasion and storm attacks (Fikri *et al*., 2023). Furthermore, mangroves are an ecosystem that is very efficient in storing carbon (blue carbon)—even higher than almost all other terrestrial forests. (Bimrah *et al*. 2022). In addition, as a complex ecosystem, mangroves provide habitat, breeding grounds, and nurseries for various species of fish and marine organisms. These facilities are crucial for the sustainability of fisheries and marine biodiversity (Wahyudi, 2022). Mangrove forests are also a source of life and livelihood for communities. Mangroves provide direct and indirect economic benefits, such as providing raw materials (wood, shellfish, crabs), providing

livelihoods through fisheries and tourism, and providing potential for food and traditional medicine products. Therefore, mangroves contribute to food security and the local economy of coastal communities (Fikri *et al.* 2023). In general, mangrove forests are not just coastal plants, but important multifunctional ecosystems because they protect coastlines from erosion and disasters, store large amounts of carbon for climate mitigation, serve as important habitats for marine biota, support the socio-economic life of coastal communities, and provide ecological services that support environmental balance. All of these functions demonstrate why mangroves deserve to be preserved and managed sustainably amidst the threat of damage due to development and exploitation of coastal resources (Bimrah *et al*. 2022).

However, this area also faces serious pressure from the conversion of land into environmentally unfriendly shrimp farms. Intensive farming activities that do not take into account the carrying capacity of the ecosystem have caused damage to mangroves and exacerbated the risk of coastal disasters. Therefore, a holistic approach is needed that includes conservation, sustainable use, and community capacity building. Mangrove rehabilitation and reforestation efforts need to be carried out in a planned manner, including through environmental education, community involvement, and institutional support from the government and research institutions (Mustofa *et al.* 2019).

The objectives of this study are (1) to explore the knowledge of forest farmer groups in the implementation of mangrove rehabilitation to support community empowerment, (2) to analyze the impact of mangrove rehabilitation on community empowerment, and (3) to formulate mangrove rehabilitation activities that can support community empowerment.

MATERIALS & METHODS

This research was conducted in the Mangrove Forest Area of Pulau Laut Tengah Subdistrict, Kotabaru Regency, Pantai Baru Village (Figure 1). The time required for this research was from July to September 2024, with activities including proposal preparation, data collection, data analysis, and report writing.

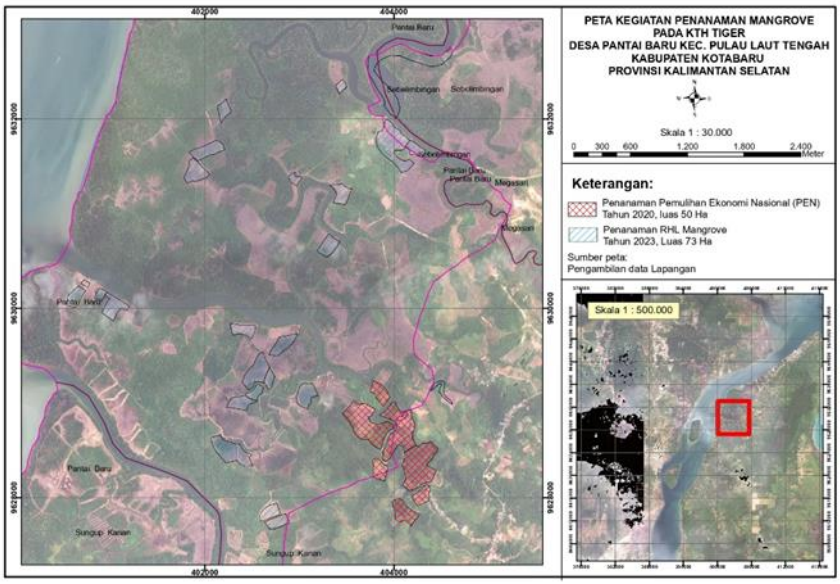

Figure 1. Location of Research

Materials and Equipment

The materials used in this study consist of vegetation, litter, and soil found within the research plots. The equipment used in this study includes (1) GPS (Global Positioning System), used to determine coordinate

positions, (2) stationery, used to record research results, (3) camera, used for documentation, and (4) laptop, used for on-site data processing.

Research Procedures

Data Collection Methods

Primary Data

Primary data were obtained through in-depth interviews with 15 respondents consisting of the head of the Tiger Farmers Group, members of the Tiger Farmers Group, and the Pantai Baru Village Government. The interview technique used was snowball sampling, which was a sampling technique in which initial respondents provide recommendations for subsequent potential respondents who were related to the research topic. This technique allows researchers to reach individuals who possess relevant information but are difficult to identify at the initial stage (Noy, 2008).

Secondary Data

Secondary data were obtained through a literature review of credible sources, such as the Pantai Baru Village Profile and scientific publications relevant to this study. The research procedure involved conducting interviews with 15 respondents, including the head of the Tiger Farmers Group, members of the Tiger Farmers Group, and the Pantai Baru Village Government. Meanwhile, secondary data were obtained from literature reviews such as the Pantai Baru Village Profile and scientific journals. This study is descriptive in nature and uses a qualitative approach. A descriptive method is a method used to examine the status of a group of people, an object, a condition, a system of thought, or an event. The purpose of this descriptive research is to produce a systematic, factual, and accurate description, depiction, or representation of facts and the relationships among the phenomena being investigated.

The exploration of the mangrove forest area in Pulau Laut Tengah Subdistrict, Kotabaru Regency, Pantai Baru Village, was conducted based on data obtained through direct interviews with key informants. To achieve a level of understanding of social phenomena in accordance with the actors' own perspectives, a reliable data collection method is required. Therefore, the relevance of the in-depth interview method is emphasized.

Data Analysis

1. Exploring the Knowledge of Forest Farmer Groups in Implementing Mangrove Rehabilitation to Support Community Empowerment

To achieve this objective, data analysis was conducted qualitatively using a semi-inductive approach. Data were obtained through in-depth interviews, focus group discussions (FGDs), and participatory observation of members of the Forest Farmer Group (KTH) involved in mangrove rehabilitation activities. The analytical techniques used were open coding and axial coding, which aim to identify and link categories such as local technical knowledge, implementation experience, and community ecological understanding. This process resulted in major themes that reflect the level of community knowledge and local wisdom in protecting and restoring mangrove ecosystems. The analysis was carried out in a gradual and reflective manner, as recommended in the Grounded Theory approach by Strauss and Corbin (1998), and with reference to the exploratory framework proposed by Creswell (2013).

2. Analyzing the Impact of Mangrove Rehabilitation in Supporting Community Empowerment

Data analysis for this objective focused on assessing the social, economic, and ecological impacts perceived by the community following the implementation of mangrove rehabilitation. Data were collected through community interviews, documentation of rehabilitation programs, and observations of changes in environmental and social conditions. The analytical techniques used included content

analysis and matrix analysis, by comparing indicators before and after the activities, such as income levels, involvement in conservation activities, and increased access to coastal resources. To enrich the analysis, a narrative approach was employed to capture how the community interprets and gives meaning to the changes that occurred. Data source triangulation was also conducted to ensure the validity of the findings. This analysis supports the identification of the extent to which mangrove rehabilitation contributes to tangible community empowerment processes.

3. Formulating Mangrove Rehabilitation Activities that Can Support Community Empowerment

In addressing the third objective, the analysis was conducted synthetically based on the findings from the first and second objectives. The formulation of rehabilitation activities was designed using a participatory approach that integrates input from local communities, government, and other stakeholders. Data were analyzed to develop recommendations for activities that not only improve the condition of mangrove ecosystems but also enhance community capacity and roles in coastal resource management. This approach ensures that the formulated rehabilitation activities are not merely technical in nature, but are oriented toward sustainable social and economic strengthening of the community.

RESULT AND DISCUSSION

A. Knowledge of Forest Farmer Groups in the Implementation of Mangrove Rehabilitation

1. Mangrove Planting Patterns and the Application of Silvofishery in Rehabilitation Activities

KTH Tiger in Pulau Laut Sabuku shows that although ecological benefits have begun to be felt—such as reduced coastal abrasion at several shoreline points—the economic benefits from mangrove utilization remain limited. Based on interviews with members of KTH Tiger, only about 30% of members have utilized mangrove products, primarily in the form of aquaculture ponds. Utilization in the form of ecotourism is still not optimal due to limitations in infrastructure and a lack of promotional support from local government. Mangrove-based ecotourism in KTH Tiger still requires capacity building and improved market access so that economic benefits can be distributed more evenly.

Mangrove rehabilitation activities in Pantai Baru Village employ an intensive planting pattern with a spacing of 1 × 1 meter, following standard rehabilitation techniques to maximize vegetation density in areas with high abrasion. This method is consistent with the principles of successful planting on open land with severe degradation. In addition to conventional planting, a silvofishery approach has also been introduced, namely a mangrove forest management system combined with fisheries cultivation (fish/shrimp) between planting rows. This method aims to provide direct economic benefits to the community without damaging the mangrove ecosystem. According to the Director General Regulation of PDASHL No. P.1/PDASHL/SET/KUM.1/2/2019, silvofishery is recommended for areas with high socio-economic pressure, such as Kotabaru.

2. The Role of KTH Tiger as a Conservation Partner in Accordance with Government Regulation No. 9 of 2021

Based on Government Regulation No. 9 of 2021 on the Management of Conservation Areas, community groups such as KTH Tiger can serve as conservation partners if they meet certain requirements, including having an organizational structure, articles of association/bylaws (AD/ART), a list of permanent members, and legal recognition from the relevant authorities. KTH Tiger already has a legitimate institutional structure, and through mangrove rehabilitation activities, it has indirectly performed the function of a conservation partner, particularly in areas adjacent to or

included within conservation areas (CA). Further formal strengthening is needed so that KTH can be officially recognized as a conservation partner and gain access to funding, training, and additional capacity-building activities.

Mangrove forests provide a wide range of ecological, economic, and social benefits for coastal communities. Ecologically, mangroves function as natural protection against coastal abrasion, seawater intrusion, and storm impacts. In addition, mangroves act as natural filters that absorb pollutants and waste before they reach the sea. Research conducted by Weaver & Stehno (2024) stated that mangrove restoration—acts as natural protection for the coastline against waves and erosion, with root systems that are effective in absorbing wave energy and stabilizing coastal sediments, thereby increasing coastal resistance to abrasion. Furthermore, a study by Septiansa *et al.* (2025) found that mangrove ecotourism contributes significantly to the community's household income, even accounting for tens of percent of their total annual income.

3. Flora and Fauna in the Mangrove Forest

Mangrove management by KTH Tiger is dominated by several plant species that have special adaptations to extreme environmental conditions. The main species commonly found are *Rhizophora* spp., *Avicennia* spp., *Sonneratia* spp., and *Bruguiera* spp.

Unique adaptations possessed by mangrove plants include stilt roots in *Rhizophora* spp., which function to resist waves and provide stability in muddy substrates, as well as pneumatophores in *Avicennia* spp., which help absorb oxygen from the air. According to Alwidakdo *et al.* (2014), environmental factors that influence mangrove growth in a location are coastal physiography (topography), tides (length, duration, range), waves and currents, climate (light, rainfall, temperature, wind), salinity, dissolved oxygen, soil, and nutrients. Furthermore, it is said that if flooded all the time, the dominant species is *Rhizophora mucronata*, and Bruguiera and Xylocarpus species are sometimes present.

At KTH Tiger, the diversity of flora found in the mangrove area that has successfully grown and developed through the rehabilitation program is largely associated with mangrove stands dominated by *Rhizophora apiculata* and *Bruguiera gymnorrhiza*. This is consistent with the study showing that *Rhizophora apiculata* and *Bruguiera gymnorrhiza* are mangrove species that exhibit relatively high tolerance to environmental stresses such as salinity fluctuations, tidal inundation, and muddy substrates, which explains their frequent use in mangrove restoration programs (Kathiresan & Bingham, 2001; Jayatissa & Wickramasinghe, 2011). However, field research indicated that the success of mangrove rehabilitation in this area is still constrained by the availability of seedlings and suboptimal maintenance techniques. Compared with previous studies, improvements are needed in selecting mangrove species based on local conditions to achieve higher rehabilitation success rates. The following is a graph of fauna distribution in KTH Tiger.

Mangrove forests support high biodiversity and serve as habitats for various species of fish, mollusks, crustaceans, birds, and mammals. Several fish species, such as milkfish (*Chanos chanos*) and snapper (*Lutjanus* spp.), use mangrove ecosystems as spawning grounds and nursery areas before migrating to the open sea. Mud crabs (*Scylla serrata*), shrimp, and oysters are also commonly found in mangrove forests and have high economic value for surrounding communities. Among birds, species such as the brahminy kite (*Haliastur indus*), egrets (*Egretta* spp.), and kingfishers (*Alcedo* spp.) are frequently found around mangrove forests, using these areas for feeding and breeding.

Mangrove rehabilitation that increases mangrove forest density can significantly enhance mud crab (*Scylla* spp.) populations

because mangrove structure and environmental conditions strongly influence crab abundance (Ulfa *et al*., 2018). Another study stated that healthy mangrove ecosystems function as important nursery habitats for marine organisms, significantly increasing fish abundance and diversity compared with areas where mangroves are degraded or removed (Aburto-Oropeza *et al*., 2008).

At KTH Tiger, survey results indicate that populations of mud crabs and small fish have begun to increase around rehabilitated areas, although the numbers are still lower than those reported in studies from Sulawesi and East Kalimantan. Some local fishers reported increased fish catches around mangrove forests, but there has been no quantitative study measuring the magnitude of this increase. Compared with previous research, the ecological benefits for fauna at KTH Tiger are becoming visible but still require further monitoring to ensure long-term impacts on biodiversity and the fisheries sector.

Based on education-level data obtained from interviews with members of the KTH Tiger Forest Farmer Group in Kotabaru, it can be concluded that the majority of members have relatively high educational attainment. No members were recorded as having no formal education or only elementary school education. Most members—eight individuals—have senior high school/vocational school (SMA/SMK) education, indicating a sufficient knowledge base to engage in natural resource management and KTH-related activities. In addition, four members have junior high school (SMP) education, which, although lower than SMA/SMK, still provides basic skills to support their activities in KTH management. The remaining three members hold undergraduate (S1) degrees, indicating the presence of more technical and structured contributions to KTH program management, including planning, supervision, and analysis. This diversity in educational background reflects the potential for collaboration between practical experience and theoretical knowledge to enhance the effectiveness and sustainability of KTH Tiger activities.

The implementation of mangrove rehabilitation is not without challenges. The main constraints faced by KTH include limited knowledge, a lack of facilities such as seedlings and planting tools, and ecosystem degradation caused by human activities such as illegal logging and land conversion. To address these issues, community empowerment strategies are needed through capacity building, including training in mangrove planting techniques and product management. Economic diversification is also necessary by developing mangrove-derived products such as natural-dye batik, chips, and mangrove honey. In addition, strengthening KTH institutions is crucial so they can access funding, partners, and the technology needed.

Based on interviews with members of the KTH Tiger Forest Farmer Group in Kotabaru, the occupations of KTH members are highly diverse and mutually supportive in efforts toward sustainable natural resource management. Most members—nine individuals—work as farmers. They focus on forest-based agriculture, including environmentally friendly and sustainable farming practices and the management of productive plants that support biodiversity. In addition, two members who work as fishers play an important role in sustainable fisheries management, particularly in waters around river basins or mangrove ecosystems. Two other members who are civil servants (PNS) are involved in planning, supervision, and implementation of government programs related to natural resource management and forest conservation, serving as a link to government agencies. Meanwhile, two honorary staff members contribute to KTH operational activities, such as monitoring, recording, and field reporting. Overall, the diversity of professions within KTH Tiger in Kotabaru reflects harmonious collaboration among different professions

that support the achievement of sustainable natural resource management goals and improved community welfare.

Most KTH members consider mangrove rehabilitation activities successful if damaged ecosystems can be restored—for example, through increased mangrove vegetation cover in rehabilitated areas—and if tangible benefits such as increased community income and reduced abrasion risk can be realized. Nevertheless, evaluation of program implementation is still necessary to ensure that rehabilitation activities proceed according to established objectives.

An exploration of farmers' group perceptions was conducted to understand their views on the mangrove rehabilitation program in Pantai Baru Village. Based on interviews with 10 respondents, the majority (eight respondents) understand the important role of mangroves in maintaining coastal ecosystems, such as preventing abrasion, seawater intrusion, and providing habitats for marine biota. The head of the Tiger Farmers Group stated that mangrove rehabilitation is a strategic step to protect the environment while supporting the sustainability of local natural resources. However, some group members (four respondents) expressed limited knowledge regarding mangrove planting and maintenance techniques, including site selection and protecting seedlings from pests. The Pantai Baru Village Government also emphasized the importance of technical training for communities to improve the success of rehabilitation programs.

Several previous studies support these findings. Serang *et al.* (2024) reports that hands-on training in mangrove planting techniques (e.g., seedling handling, planting densities, and site preparation) increased participant knowledge and engagement, contributing to significant plant survival in the field. Maulidah & Iskandar (2023) highlights that recognition of both ecological (e.g., biodiversity support) and socio-economic benefits of mangroves is a critical motivational factor shaping community engagement and participation in mangrove management. Serang *et al.* (2025) stated that in the rehabilitation program, targeted training and extension (penyuluhan) activities significantly increased community knowledge and active participation, with over 90% involvement, demonstrating how training influences community support in mangrove conservation contexts. Walton *et al.* (2006) found that community-led mangrove replanting can have significant direct economic benefits for coastal communities, including from fisheries, tourism, and timber. Those fishers who perceived greater direct benefits from mangroves (such as nursery and fisheries support) were more willing to value and protect restored mangrove areas. Syawaludin & Kurniawan (2024) on mangrove restoration underscore that combining local knowledge with scientific practices through a training enhances long-term success and community engagement in mangrove conservation.

The success of mangrove rehabilitation programs in Pantai Baru Village requires synergy among community capacity building, continuous technical training, and participatory approaches involving all stakeholders. These perceptions indicate high awareness of mangrove benefits but need to be followed up with in-depth technical training. By directly involving communities through participatory approaches, mangrove rehabilitation programs can be more effective in increasing community knowledge while ensuring sustainability. In addition, strong collaboration among farmer groups, communities, and government serves as important social capital to support mangrove rehabilitation as a sustainable conservation effort.

B. Impact of Mangrove Rehabilitation on Community Empowerment

The impact of mangrove rehabilitation on community empowerment was analyzed through respondents' perceptions of social, economic, and environmental aspects.

Socially, six respondents stated that the program has increased community awareness of the importance of protecting mangrove ecosystems. In addition, joint activities such as mangrove planting have strengthened relationships among members of the forest farmer group, fostering a sense of togetherness and mutual cooperation. From an economic perspective, seven respondents noted the potential for increased community income through the development of mangrove-based ecotourism, such as boat tours and environmental education. However, only three respondents experienced direct benefits in the form of increased fish catches, indicating that economic impacts have not been evenly felt. From an environmental standpoint, all respondents agreed that mangrove rehabilitation has produced significant positive impacts. For example, restored mangrove ecosystems provide habitats for crabs and small fish while also reducing coastal abrasion. Interview results indicate that the impacts of mangrove rehabilitation on community empowerment are complex and require strengthening, particularly in the economic aspect. By maximizing mangrove potential through community-based empowerment, more inclusive impacts can be achieved.

Mangrove rehabilitation in Pantai Baru Village, Pulau Laut Sebuku Subdistrict, has had both direct and indirect impacts on the social, economic, and environmental conditions of the community. Economically, mangrove rehabilitation has contributed to increased household income through mangrove resources such as fish, crabs, and honey. In Pantai Baru Village, members of the Tiger Forest Farmer Group (KTH Tiger) reported average monthly income increases of IDR500,000–1,000,000 after mangrove rehabilitation began to show results. The reality is supported by several statements of researchers such as mangrove ecosystems play a crucial role in supporting coastal livelihoods through fisheries and other ecosystem-based activities. Studies have shown that fish catches can be up to 70% higher in areas with intact mangroves compared with areas where mangroves are degraded (Das, 2017). In many coastal communities, mangrove products contribute substantially to household economies; for example, approximately 43% of household income in some villages is derived from mangrove resources, with more than 70% of that income originating from mangrove-related fisheries (Aye et al., 2019), while specific fisheries such as mud crab harvesting may contribute around 44% of fisher household income in Indonesian mangrove areas (Damastuti & De Groot, 2017).

Social impacts are also evident in increased community participation in rehabilitation programs. Most KTH members were involved in mangrove planting and mangrove forest product management, fostering community solidarity. This aligns with findings by Ebeler *et al.* (2025) highlighted that restoration activities contribute not only to livelihoods but also to social cohesion and community well-being, as collective action around conservation brings people together and builds relationships. However, in Pantai Baru village, social challenges remain, particularly a lack of trust among some community members regarding the sustainability of the program.

Environmentally, mangrove rehabilitation has successfully reduced abrasion risk and increased local biodiversity. Research by McIvor *et al*. (2012) showed that mangrove presence reduced wave height 13–66% within the first 100 m of mangrove forest and up to 50–99% after 500 m, demonstrating their strong role in reducing coastal abrasion. This is consistent with findings in Pantai Baru village, where residents reported reduced tidal flooding over the past two years following rehabilitation efforts. In addition, mangroves provide habitats for important species such as water birds and mud crabs, which serve as indicators of ecosystem recovery.

Although mangrove rehabilitation outcomes in Pantai Baru Village show positive impacts similar to previous studies, local challenges such as sustainable funding and continuous community training still need to be addressed. By learning from successful programs in other regions that involve intensive support from government and NGOs, the Pantai Baru program can become more effective in creating sustainable long-term impacts.

C. Formulation of Mangrove Rehabilitation Activities Supporting Community Empowerment

Based on interview results and analysis, several activities can be formulated to improve the effectiveness of mangrove rehabilitation while supporting community empowerment. First, training and technical capacity building should be provided for farmer groups, particularly in effective mangrove planting and maintenance techniques. This training can include appropriate site selection methods, seedling management, and pest control. Second, the development of mangrove-based local economies is essential. Activities such as mangrove ecotourism, mangrove-based processed products (e.g., mangrove syrup or mangrove batik), and increased fish catches through habitat protection can enhance community income. Third, participatory monitoring and evaluation activities should be conducted regularly, involving farmer groups in monitoring mangrove growth to ensure success. Fourth, collaboration among village governments, farmer groups, and the private sector is needed to support funding and implementation. Such cooperation not only enhances program sustainability but also opens new opportunities for innovation in community empowerment. With these strategies, mangrove rehabilitation programs in Pantai Baru Village can be implemented sustainably and provide tangible ecological, social, and economic benefits to local communities.

D. Mangrove Rehabilitation Activities for Community Empowerment

Mangrove rehabilitation in Pantai Baru Village, Pulau Laut Sebuku Subdistrict, has had a significant impact on the economic, social, and environmental conditions of the community. Economically, increased community income is evident through mangrove resources such as crabs and fish. The following table presents interview score results using a Likert scale.

Based on the table above, interview results show varied levels of knowledge among the KTH Tiger community. Aburto-Oropeza *et al.* (2008) stated that mangrove ecosystems support fisheries productivity by functioning as nursery habitats for many fish species, thereby contributing directly to the livelihoods of coastal communities. However, in some cases, although mangroves provide significant ecosystem services and economic benefits, local communities often face constraints such as limited financial resources and institutional support, which affect equitable benefit distribution (Barbier, 2016). In addition, research by Fatimatuzzahroh *et al.* (2017) shows that the success of mangrove rehabilitation is also influenced by the level of community participation; the more actively farmer groups are involved in mangrove management, the greater the benefits they obtain. Unlike previous studies that focused more on ecological impacts, the findings of this study indicate that empowerment through training of planting mangrove in Jayakarsa Village has made a real contribution that can help restore the surrounding community not only for the village but also for us on earth (Kabalu *et al*., 2022).

A total of 73.34% of respondents stated that they agreed or strongly agreed, 20% were neutral, and 6.67% disagreed. The average score obtained was 3.93, indicating that most respondents agreed that mangrove rehabilitation provides benefits to the community. However, the presence of neutral and disagreeing groups indicates that not all community members experience the benefits evenly. These findings align with Hutchison *et al.* (2014) stated that habitat

function reviews establish that better mangrove ecosystem health supports greater yields of commercially valuable fish and crustacean species, which in turn supports household income. In addition, Haidawati *et al.* (2021) who researched on mangrove ecotourism development in Bintan, Indonesia showed that mangrove-based ecotourism can change social interactions, perceptions, and patterns of community cooperation, beyond economic effects. The present study shows a similar trend, where participation in mangrove rehabilitation increases solidarity among forest farmer groups in collectively managing resources. However, unlike Haidawati *et al*. (2021), the present study found that some community members still doubt the sustainability of the economic impacts of mangrove rehabilitation, as reflected by the 20% neutral and 6.67% disagreeing respondents.

A new finding of this study indicates that there are still community groups that have not yet experienced direct benefits from mangrove rehabilitation, in contrast to previous studies that largely highlighted positive impacts without examining benefit distribution. Therefore, mangrove rehabilitation must be accompanied by empowerment strategies based on technical training and market access so that benefits can be more widely felt. Damastuti & de Groot (2017) examined community-based mangrove management (CBMM) in four villages in Central Java, Indonesia, and concludes that sustainable rehabilitation and resource use depend on long-term maintenance, community governance, and participatory management systems rather than planting alone. It highlights how community institutions and strategies influence ecosystem sustainability and livelihood support. In addition, Arifanti *et al*. (2022) emphasized that local economic pressures and lack of institutional and economic support systems, implying that without enabling economic structures (e.g., markets, value chains), communities struggle to maintain sustainable benefits from mangrove programs. Thus, the main recommendation of the present study is to strengthen forest farmer group institutions, enabling them to access broader markets and receive support from government and the private sector. This study contributes new insights into mangrove rehabilitation, particularly regarding inequality in the distribution of economic benefits. Without appropriate empowerment strategies, the benefits of mangrove rehabilitation may be unevenly distributed. Therefore, this study recommends a more inclusive approach, emphasizing technical training, strengthened market access, and collaboration with multiple stakeholders to ensure broader and more sustainable benefits for coastal communities.

Social impacts are also significant, with increased community participation in rehabilitation activities such as mangrove planting and maintenance. Community solidarity has been strengthened, similar to findings by Haidawati *et al*. (2021), who reported increased social interaction through rehabilitation programs. Nevertheless, Pantai Baru Village still faces challenges related to limited advanced training and technical support, which, if addressed, could further enhance program effectiveness.

From an environmental perspective, mangrove rehabilitation in Pantai Baru Village has successfully reduced abrasion and tidal flooding risks and increased local biodiversity, including the reappearance of water bird species and mud crabs. These results are consistent with McIvor *et al.* (2012) who showed that mangrove forests significantly reduce wave energy and coastal erosion. In addition, the development of mangrove ecotourism in Pantai Baru Village has strong potential to increase community income while serving as a conservation strategy. This aligns with the statement that mangrove ecotourism can provide economic benefits for local communities while promoting conservation and environmental awareness when managed through community-based approaches (Saefullah *et al*., 2023). By

learning from previous studies, Pantai Baru Village can strengthen its mangrove rehabilitation program through value-added product development, intensive training, and mangrove-based ecotourism development. Collaboration among communities, government, and the private sector is key to ensuring the sustainability of these activities and achieving long-term benefits.

CONCLUSION

1. Mangrove rehabilitation in Pantai Baru Village has increased the knowledge and awareness of forest farmer groups regarding the importance of mangrove ecosystems for environmental sustainability and community welfare. These activities have strengthened their understanding of mangrove planting techniques, ecological benefits, and potential economic opportunities. However, more targeted technical training is still needed to expand the capacity of forest farmer groups to manage mangrove ecosystems independently and sustainably.
2. The impacts of mangrove rehabilitation are evident in improvements in environmental quality, such as reduced coastal abrasion and improved coastal habitats, which support fisheries activities and biodiversity conservation. Economically, the program has opened opportunities for developing mangrove-based enterprises, such as ecotourism and processed mangrove products, although the benefits have not yet been evenly experienced by all community members. Socially, community solidarity has increased through participation in rehabilitation programs; however, limitations in funding and technical support remain key challenges that need to be addressed.
3. To support community empowerment, mangrove rehabilitation activities should focus on participatory approaches that actively involve local communities from planning through implementation and program evaluation. Relevant technical training—such as mangrove resource cultivation and processing of mangrove-derived products—needs to be intensified. Strengthening forest farmer group institutions is also essential to ensure program sustainability, supported by collaboration among government, the private sector, and communities. In addition, diversification of mangrove-based products—such as food products, handicrafts, and ecotourism—can provide added economic value for local communities.

Recommendations

The following strategic recommendations are proposed to optimize the mangrove rehabilitation program in Pantai Baru Village:

1. Sustainable Mangrove Ecosystem Management and Rehabilitation Strategy

Enhance environmental awareness and literacy by improving community understanding of the importance of mangrove ecosystems through education programs, environmental campaigns, and active involvement of local communities in conservation activities. This step aims to foster collective behavior that supports the sustainable protection of coastal resources.

2. Mangrove Ecosystem–Based Economic Diversification

Develop environmentally friendly alternative livelihoods, such as mangrove-based ecotourism, sustainable fisheries cultivation, and the utilization of non-timber forest products (NTFPs) from mangrove areas. This strategy aims to reduce exploitation pressure on natural resources while increasing the economic resilience of coastal communities.

3. Institutional Strengthening and Multistakeholder Partnerships

Improve the capacity of local institutions such as Forest Farmer Groups (KTH), cooperatives, and Village Forest Management Institutions, while building collaboration among communities, government agencies, the private sector, and research institutions. This collaborative

approach is essential to integrate conservation with socio-economic development.

4. Enhanced Policy and Financing Support

Encourage the formulation and implementation of policies that support integrated mangrove management, as well as access to diverse funding sources, including environmental grants, corporate social responsibility (CSR) programs, and performance-based incentives. Regulatory and financial support are key drivers of successful rehabilitation programs.

5. Regular and Participatory Monitoring and Evaluation

Design data-driven monitoring and evaluation systems that actively involve communities to ensure the effectiveness of rehabilitation and conservation programs. Continuous monitoring enables early identification of challenges and opportunities for improvement in mangrove management.

Declaration by Authors

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