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Research Article

# Community Participation in Mangrove Conservation and Ecosystem Assessment in Tanjung Rejo, Indonesia

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**Abstract:** Mangrove forests located in the intertidal zones of tropical and subtropical areas exhibit distinct characteristics and offer a range of potential advantages for human life. These mangroves should be conserved for sustainability. Therefore, the local community should participate in mangrove forest management to get the benefits directly. This study searched for to (1) identify the mangrove forest ecosystem and (2) analyze the level of participation along with the factors influencing community involvement in the management of mangrove areas. This investigation was carried out in Tanjung Rejo Village, located in the Percut Sei Tuan District of North Sumatera, Indonesia. Data collection involved conducting vegetation analysis and interviews, employing the census method with a total of 55 respondents who were affiliated with KTH (forest farmer group) Bakti Nyata and KTH Pantai Panglima. The findings indicated the presence of 10 mangrove species in Tanjung Rejo Village, which include *Avicennia alba*, *Avicennia marina*, *Bruguiera gymnorhiza*, *Bruguiera parviflora*, *Bruguiera hainesii*, *Excoecaria agallocha*, *Luminitzera racemosa*, *Rhizophora apiculata*, *Rhizophora stylosa*, and *Scyphiphora hydrophllacea*. *A. marina* emerged as the predominant species across all demographic stages, while *L. racemose* was identified as the least prevalent species among saplings and trees. The level of community participation was substantial, this was supported by the formation of several forest farmer groups in villages such as KTH Pantai Panglima and KTH Bakti Nyata. Age and education factors influenced community participation in managing mangrove areas in Tanjung Rejo Village, Percut Sei Tuan District, North Sumatra, Indonesia.

**Keywords:** Mangrove, Community, Participation, Tanjung Rejo

## Introduction

The mangrove forests in Indonesia have experienced notable decline, reducing from 4.2 million hectares in 1980 to 3.1 million hectares in 2011 and further down to 2.7 million hectares by 2020 (Basyuni *et al.*, 2022). The degradation of mangroves is mostly attributed to land conversion for many objectives, including logging, dredging, aquaculture, reclamation, industrial waste pollution, waste disposal, oil contamination and urban development (Cahyaningsih *et al.*, 2022). Mangrove ecosystems play a vital role in mitigating climate change by absorbing carbon dioxide (CO2) and providing essential services to surrounding ecosystems and communities (Mubaraq *et al.*, 2024).

Indonesia's population ranks as the fourth biggest globally, with an estimated 273 million in 2020 (Kudrna *et al.*, 2022). More than 60% of them live in coastal areas (Camila and Saraswati, 2020). One of the typical and unique forms of the natural ecosystem is the mangrove forest that occurs in coastal areas. Coastal natural resources significantly contribute to economic development (Aprilia *et al.*, 2020). This development is always accompanied by increased human population density, which lead to environmental problems in coastal areas in Indonesia, such as mangrove degradation due to excessive development (Cahyaningsih *et al.*, 2022).

Mangrove in Percut Sei Tuan District have experienced a decline in vegetation due to the conversion

of mangrove forest, such as fish ponds and tourist attractions. Sulistiyono *et al.* (2018) reported that the mangrove ecosystem in Percut Sei Tuan District has seen changes in the mangrove cover from an area of 1,140.37 ha in 2011 to 1,062.94 ha in 2016, a decrease of 77.43 ha which means the rate of deforestation that occurred was 15.49 ha/year. Deforestation of mangrove forests and the absence of replanting efforts can also cause ecosystem degradation. In order to guarantee the sustainability of mangrove in Percut Sei Tuan, it is imperative to enhance community engagement in the management of mangroves in Tanjung Rejo Village (Harefa *et al.*, 2024). Responsibility in managing mangrove area must be supported by the government and the role (participation) of all levels of society, especially communities living around the mangrove ecosystem, who are actively involved in the management and use of mangroves, to ensure sustainable development in the mangroves. Furthermore, community-driven mangrove ecosystem management is carried out by conserving mangroves with various activities that can maintain the mangrove ecosystem. Various initiatives have been carried out on a community basis led by local communities by carrying out various activities and supporting conservation activities. However, this will be maximized if supported and considered by the local government and involved in collective efforts in mangrove utilization and conservation. Expansion of community involvement is also needed to create mangrove management that can provide economic benefits to the community and environmental benefits.

Various utilization activities, including land conversion for habitation, aquaculture, agriculture and wood extraction/illegal logging, are responsible for the decline in the quality and forest cover of the mangrove ecosystem in Tanjung Rejo Village, Deli Serdang Regency. Basyuni and Sulistiyono (2018) reported that from 1990 to 2015, mangrove forests in North Sumatra experienced a decrease in primary mangrove forest area by 13,785.3 ha (from 22,513.2 ha to 8,727.9 ha) and secondary mangroves by 20,360.27 ha (from 56,128.75 ha to 35,768.48 ha). The main changes were caused by the conversion of mangroves to ponds covering 9,619.6 ha, vacant land 7,228.9 ha and swamp bushes 2,416.5 ha. The area of reforestation amounted to 701.83 ha, primarily sourced from fallow land, which accounted for 219.2 ha and swamp shrubs, contributing 211.5 ha.

Mangroves in Tanjung Rejo Village are categorized as medium density for adult trees with 1,400 stems/ha, dense saplings and seedlings with around 5,200 stems/ha and 2,000 stems /ha respectively. The biodiversity index in this mangrove area is still categorized as low (Hasibuan *et al.*, 2021).

Lack of public awareness of the condition of mangroves in Tanjung Rejo Village is one of the weak factors in the management of mangrove ecosystems in this area (Hasibuan *et al.*, 2021). To preserve the mangrove ecosystem, it is necessary to conduct research on the diversity of mangrove species as a basic material in implementing mangrove forest conservation (rehabilitation) policies and as a basis for implementing mangrove rehabilitation (planting) policies in Tanjung Rejo Village, Percut Sei Tuan District, North Sumatra.

In the process of preparing the mangrove forest area in Tanjung Rejo Village for development planning, we take into account both the direct benefits that the community derives from the mangroves and the indirect advantages that may arise. The present study aimed (1) to identify the mangrove forest status as good or damaged, (2) to analyze the level of participation along with the factors influencing community involvement in the management of mangrove areas. The results of this study may guide the optimal use of natural resources in mangroves. The study ultimately seeks to promote the sustainable utilization of mangroves, enabling the community and government of Tanjung Rejo Village to derive different advantages and both direct and indirect benefits from these ecosystems.

## Materials and Methods

### *Time and Location*

The study took place between December 2023 and January 2024 in the mangrove area of Tanjung Rejo Village, Percut Sei Tuan District, Deli Serdang Regency, North Sumatra. This research map can was depicted in Figure (1).

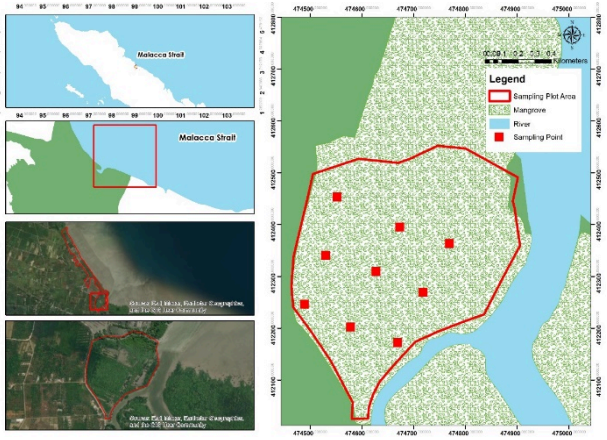


**Fig. 1:** Research location map (red rectangle) in Tanjung Rejo, North Sumatra, Indonesia

### *Vegetation Survey*

An analysis of vegetation was carried out to evaluate the density of plant life and the overall health of the mangrove ecosystem in regions defined by mangrove

forests in Tanjung Rejo Village, Percut Sei Tuan sub-District (Hasibuan *et al.* 2021).

Sample collection for vegetation data is divided into transects along the coastline that are determined deliberately according to research objectives and field conditions. Sampling and measurements at the research location used the purposive sampling method and were considered representative of mangrove stands in Tanjung Rejo Village. Transects are determined perpendicularly at the station from sea to land so that there are 3 (three) sub-stations. Each sub-station is divided into 3 (three) plots. Determination of samples for vegetation data uses the quadratic transect method, namely by skipping one or more plots in the path so that along the pioneer line there are plots at a certain distance that is the same. The distance made is 100 m for each plot. Distance of 100 m between plots. Trees, saplings and seedlings were measured using a 10x10, 5x5m and 2x2 m plot respectively (Hasibuan *et al.* 2021) as shown in Fig. (2). Species identification was carried out in the field using a mangrove identification book (Kitamura, 1997).

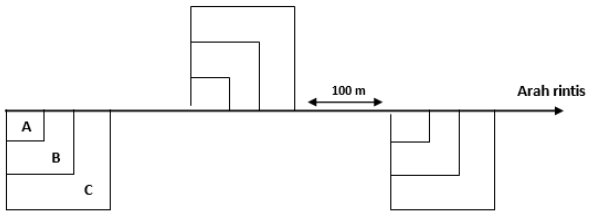


**Fig. 2:** Form of data collection plot

Information:

A = Seedling observation plot (2x2 m)

B = Sapling observation plot (5x5 m)

C = Tree observation plot (10x10 m)

The collected vegetation data is utilized to assess the Importance Value Index (IVI) and the diversity index. IVI is analyzed for seedlings, saplings and trees. The diversity index was analyzed for all species from all plots. The vegetation parameters were measured according to Parmadi *et al.* (2016) and listed as below:

1. Abundance (A) = $\frac{\text{The number of individuals of a speciess}}{\text{Sample plot area}}$
2. Relative abundance (RA) = $\frac{\text{A a species}}{\text{A total of all species}} \times 100\%$
3. Frequency (F) = $\frac{\Sigma \text{ subplot found a species}}{\Sigma \text{ all sample subplots}}$
4. Relative frequency (RF) = $\frac{\text{F a species}}{\text{Fall of species}} \times 100\%$
5. Dominancy (D) = $\frac{\text{The basal area of a species}}{\text{Sample plot area}}$
6. Relative dominancy (RD) = $\frac{\text{D a species}}{\text{D all of species}} \times 100\%$
7. Important value index (IVI), IVI = RA + RF (for seedlings and saplings), IVI = RA + RF + RD (for trees)
8. Diversity index: The calculation of diversity was performed utilizing the Shannon Wiener Index formula presented below (Ludwig and Reynolds, 1988):

$H' = -\sum_{i=1}^{s} (\rho i \ln \rho i)$

Information:

*H'* = Shannon Wiener diversity index

*Pi* = *ni* / *N*

*ni* = Number of individual types

*N* = Total number of individual types

*H'* Criterion:

1. H' ≤1: Low/little species diversity
2. 1< H' <3: Medium species diversity
3. H' >3: High species diversity

**Table 1:** Categories for measurement of community perception and level of participation

| No. | Variable | Data Collection Method | Indicator | Measurement Category (Score) |
|---|---|---|---|---|
| 1 | Perceptions about mangrove forests:<br>- Opinions regarding the mangrove forest ecosystem<br>- Opinion regarding the ecological function of mangrove forests<br>- Opinion regarding the socio-economic function of mangrove forests | Questionnaire, Interview. | Assessed based on respondents' scores regarding opinions regarding the mangrove ecosystem | a. Strongly agree (5)<br>b. Agree (4)<br>c. Neutral (3)<br>d. Disagree (2)<br>e. Strongly Disagree (1) |
| 2 | Community participation in mangrove forest management:<br>- Planning<br>- Implementation<br>- Monitoring/ Evaluation<br>- Utilization of results | Questionnaires, Interviews, Observations | Assessed based on respondents' scores for participation in managing mangrove areas | a. Always (5)<br>b. Often (4)<br>c. Sometimes (3)<br>d. Ever (2)<br>e. Never (1) |

## *Community Survey on Mangrove*

The respondents in this research were people of Tanjung Rejo Village who were members of the forest farmer group. There are only two forest farmer groups in that specially manage mangroves in this village, namely KTH Bakti Nyata which has 30 members and KTH Pantai Panglima with 25 members. The sample from this research was all KTH members, namely 55 respondents. All respondents were male because many field activities require physical activity so that women were not involved. However, for women, a separate group was formed, namely usaha mikro, kecil dan menegah, Micro,

Small, Medium Enteprises (MSMEs) to process non-timber forest products from mangroves.

We measured four types of community participation according to Margareta and Salahuddin (2021), namely participation in planning, implementation, utilizing results and monitoring and evaluation. The response for community participation were measured using a Likert Scale. Categories for measuring community perception and level of participation were displayed in Table (1).

The average score for each response was determined based on the methodology outlined by Parenri *et al.* (2021) (Table 2):

$$Interval = \frac{Highest\ score\ -\ Lowest\ score}{5}$$

$$Interval = \frac{275\ -55}{5} = 44$$

**Table 2:** Assessment scoring

| No. | Score range | Perception | Participation |
|---|---|---|---|
| 1 | 55–99 | Strongly agree | Always |
| 2 | 100–143 | Agree | Often |
| 3 | 144–187 | Disagree | Sometimes |
| 4 | 188–231 | Don't agree | Once |
| 5 | 232–275 | Strongly disagree | Never |

### *Factors Influencing Participation*

Factors influencing community participation were analyzed using a regression equation of the interaction of participation levels with demographic variables the community.

Independent Variables, consist of:

1. Age (X1)
2. Gender (X2)
3. Marital Status (X3)
4. Jobs (X4)
5. Education (X5)
6. Revenue (X6)
7. Length of Residence (X7)
8. Incentive (X8)

The Dependent Variable is defined as the level of community participation in mangrove management (Y).

The impact of the independent (demographic) variable on the dependent variable can be assessed using multiple linear regression analysis, represented by the following equation:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8$$

Information:

$Y$ = Dependent variable

$a$ = Intercept or constant

$b$ = Regression coefficient of $X$

$X$ = Independent variable

## Results and Discussion

### *Vegetation Survey*

The analysis of vegetation is employed to ascertain the distribution of different species within a specific area, utilizing direct observation in the mangrove areas of Tanjung Rejo Village, Percut Sei Tuan District, Deli Serdang Regency, North Sumatra, Indonesia. The findings indicated that 10 species of mangrove vegetation were identified at the research location (Table 3). The dominating family composition consists of members from the *Acanthaceae* and *Rhizophoraceae* families. The synthesis of all observation plots revealed a total of 5 families comprising 10 species of mangrove vegetation. 6 species at the seedling stage, 10 species at the sapling stage and 7 species at the tree stage.

The biggest total count of individuals per hectare was recorded in *A. marina*. This corresponds with the population of type *A. marina* that were often noted at the research location, as highlighted by Basyuni *et al.* (2014); Afefe *et al.* (2019), suggesting that the optimal conditions for mangroves flourishing in coastal regions involve a dominance of *Avicennia spp* in conjunction with *Rhizophora spp* in sandy or mud-mixed substrates. The extensive coverage of the *A. marina* type of mangrove across all tree levels is due to its ability to withstand high salt concentrations and thrive in sandy mud substrates. According to the findings of Ahmad Zulfani *et al.* (2022), the substrate type in Percut Sei Tuan District is identified as muddy sand, comprising a fraction of components that includes mud, coarse sand, medium sand and fine sand.

**Table 3:** Abundance (A) and Relative Abundance (RA) at the growth rate of seedlings, saplings and trees

| No. | Species | A (ind/ha) | | | RA (%) | | |
|---|---|---|---|---|---|---|---|
| | | Seedling | Sapling | Tree | Seedling | Sapling | Tree |
| 1. | *Avicennia alba* | 8.333,33 | 711,11 | 111,11 | 16,67 | 16,16 | 18,52 |
| 2. | *Avicennia marina* | 14.444,44 | 1.022,22 | 222,22 | 28,89 | 23,23 | 37,04 |
| 3. | *Bruguiera gymnorhiza* | 2.500 | 444,44 | - | 5 | 10,10 | - |
| 4. | *Bruguiera parviflora* | - | 222,22 | 22,22 | - | 5,05 | 3,70 |
| 5. | *Bruguiera hainesii* | - | 133,33 | 22,22 | - | 3,03 | 3,70 |
| 6. | *Excoecaria agallocha* | - | 177,78 | 22,22 | - | 4,04 | 3,70 |
| 7. | *Lumnitzera racemosa* | 1.111,11 | 177,78 | - | 2,22 | 4,04 | - |
| 8. | *Rhizophora apiculata* | 9.444,44 | 622,22 | 88,89 | 18,89 | 14,14 | 14,81 |
| 9. | *Rhizophora stylosa* | 14.166,67 | 755,56 | 111,11 | 28,33 | 17,17 | 18,52 |
| 10. | *Scyphiphora hydrophyllacea* | - | 133,33 | - | - | 3,03 | - |
| | Total | 50.000 | 4.400 | 600 | 100 | 100 | 100 |

The Decree of the Minister of Environment Number 201 of 2004 describes the Standard Criteria and Guidelines for Determining Mangrove Damage (Table 4), indicating that the mangrove condition in Tanjung Rejo Village was classified as infrequent, with a density of less than 1,000 individuals per hectare (600 individuals per hectare) and it was noted that eight tree species were present, predominantly *A. marina.* The total abundance in seedlings and saplings was more than 1,500 individuals/ha, more than trees. Therefore, if the growth of the seedlings and saplings can be maintained, the condition of the mangrove vegetation in Tanjung Rejo Village could inprove in the future (Basyuni *et al.*, 2014).

**Table 4:** Standard criteria for determining mangrove damage

| No. | Criteria | Density (Inv/ha) |
|---|---|---|
| 1. | Dense | >1.500 |
| 2. | Medium | 1.000-1.500 |
| 3. | Infrequent | <1.000 |

This condition was caused by pond cultivation around mangrove forests which resulted in a reduction in mangrove land and the function of mangroves (Basyuni *et al.*, 2014; Hasibuan *et al.*, 2021). Arifanti (2020) indicates that the present state of mangrove forests in Indonesia is concerning, attributed to the overexploitation of these ecosystems without regard for environmental consequences and the sustainability of coastal resources.

*A. marina* species exhibited the highest relative abundance value, showcasing a seedling growth rate of 28.89%, a sapling growth rate of 23.23% and a tree growth rate of 37.04%. The increased relative abundance of A. marina can be linked to its consistent presence in the frontal zone, which is defined by a soft muddy substrate that supports growth across seedling, sapling and tree stages (Etongo *et al.*, 2022).

To overcome the natural and sustainable regeneration rate of mangrove populations, several efforts can be made such as maintaining mangrove health, providing seedlings and reforestation. Maintaining mangrove health can be done by ensuring optimal light, appropriate water substrate conditions and cleaning undergrowth and waste from rehabilitation areas. Reforestation is carried out on damaged mangroves, improving hydrological regimes, carrying out intensive planting patterns, spaced clumps or other patterns and enriching plant species. Spatial planning can also be done to improve the mangrove ecosystem (Basyuni *et al.*, 2022).

Importance Value Index (IVI) isa metric used to measure how important a species is in a community. It's often used in ecological studies to assess the importance of plant species in a forest. The analysis results of the Importance Value Index (IVI) are presented in Table (5) *A. marina* exhibits the highest importance across all growth levels when compared to other species. As explained by Utami *et al.* (2018) regarding the contribution of important values in the community, namely the species that have the highest important value are those that have a large number of individuals, level of distribution and control over the substrate. *A. marina* has a large proportion of substrate control, resulting in the dominance of the *A. marina* species in the observed mangrove area.

Another condition that results in a higher presence of mangroves at the sapling level in the research location, as opposed to the seedling and tree levels, is that mangrove forest in Tanjung Rejo Village is designated as a rehabilitation area, where mangrove density is categorized as low. This results from human activities that disrupt the mangrove ecosystem, including the conversion of land for agricultural purposes and the creation of ponds. Dalimunthe *et al.* (2023) noted that in Tanjung Rejo Village, numerous individuals have established ponds in the vicinity of the mangrove forest. The identified ponds varied in size, including small, medium and even large specimens.

**Table 5:** The results of the calculation of the important value index for the growth rate of seedlings, Saplings and trees

| No. | Species | Important Value Index | | |
|---|---|---|---|---|
| | | Seedling (%) | Sapling (%) | Tree (%) |
| 1. | *A. alba* | 37,50 | 31,95 | 52,18 |
| 2. | *A. marina* | 58,06 | 41,65 | 97,50 |
| 3 | *B. gymnorhiza* | 9,17 | 18 | - |
| 4. | *B. parviflora* | - | 10,31 | 12,62 |
| 5. | *B. hainesii* | - | 5,66 | 11,63 |
| 6. | *E. agallocha* | - | 9,30 | 10,95 |
| 7. | *L. racemose* | 6,39 | 9,30 | - |
| 8. | *R. apiculate* | 35,56 | 35,19 | 48,70 |
| 9. | *R. stylosa* | 53,33 | 30,33 | 66,43 |
| 10. | *S. hydrophyllacea* | - | 8,29 | - |
| | Total | 200 | 300 | 300 |

The calculation of mangrove species diversity values indicates that the seedling growth rate was 1.48, while the tree growth rate was 1.67. The findings indicate that the mangrove species diversity in Tanjung Rejo Village falls within the low category, as evidenced by an H' value ranging from 0-2. The limited variety of mangrove species in the research area is a consequence of environmental conditions that can support the growth of only certain species (Hasibuan *et al.*, 2021). The occurrence of *A. marina,* succeeded by *R. stylosa,* illustrates the growth rate of seedlings and trees that prevail and distribute uniformly across the mangrove region of Tanjung Rejo Village.

The species diversity value at the sapling growth level, recorded at 2.07, falls within the medium species diversity criteria, as the H' value ranges between 2 and 3. The mangrove vegetation at the sapling growth level in Tanjung Rejo Village exhibits a diverse array of plant types that are uniformly distributed throughout the area. A community exhibits high species diversity when it

consists of numerous species without any single species dominating the ecosystem (Basyuni *et al.*, 2014). In contrast, a community demonstrates a low species diversity value when it is composed of only a limited number of species, especially if one species is predominant (Akatov *et al.*, 2018).

### *Level of Community Participation*

This study involved a total of 55 individuals from the KTH (forest farmer group) Bakti Nyata and KTH Pantai Panglima. The assessment consists of 23 questions, including 8 that focus on the extent of community involvement in planning, 8 concerning community participation in implementation, 3 that address the level of community engagement in monitoring and evaluation and 4 related to the degree of community participation in the utilization of results.

### *Community Participation Planning Stage*

The planning stage involves a set of 8 (eight) questions for community participation. The results of the scoring are presented in Table (6).

**Table 6:** Community participation in planning

| No. | Statement | Total Score | Category |
|---|---|---|---|
| 1 | Participate in the election of management of the Mangrove Forest Farmers Group | 243 | Always |
| 2 | Participate in every meeting held by the group | 244 | Always |
| 3 | Participate in determining the location of the rabak (mangrove planting place) in the mangrove area managed by KTH | 161 | Sometimes |
| 4 | Participate in determining the size of the mangrove area that will be managed by KTH | 86 | Never |
| 5 | Participate in determining the timing of activities | 111 | Ever |
| 6 | Participate in determining the sanctions/punishments given if the community commits a violation | 179 | Sometimes |
| 7 | Participate in determining the distribution of profits from the mangrove area managed by KTH | 86 | Never |
| 8 | Participate in providing ideas/suggestions in meetings related to planning activities in managed mangrove areas | 148 | Sometimes |

Based on Table (6) regarding community participation at the organizational level, it can be seen that almost all respondents always participate in the election of forest farmer group administrators and in every meeting held by the group. Then, in determining the location of rabak in the mangrove area managed by KTH, it is classified as occasional. Likewise, in determining the size of the mangrove area, most respondents never participated because not all KTH members could participate in determining the size of the mangrove area that KTH would manage. Determining the area and boundaries of KTH is at the discretion of the management and founders of KTH.

Education contributes to the development of advanced knowledge and critical thinking, enabling informed decision-making. The degree of involvement from the community in the rehabilitation of mangrove forests in Tanjung Rejo village correlates with the education level of the respondents. Likewise with the respondent's involvement in farmer groups. The more respondents who participate in farmer groups, the higher the level of participation. Various information and activities come from farmer groups, including mangrove planting activities and community service around mangrove forests.

### *Community Participation Implementation Stage*

The implementation of community participation includes a total of eight questions. The results of the scoring are presented in Table (7).

**Table 7:** Community participation in the implementation stage

| No. | Statement | Total Score | Category |
|---|---|---|---|
| 1 | Attend socialization related to mangrove area management | 166 | Sometimes |
| 2 | Participate in providing education to the community regarding the management of mangrove areas | 245 | Always |
| 3 | Participate in planting | 249 | Always |
| 4 | Participate in carrying out plant maintenance | 55 | Never |
| 5 | Participate in eradicating animals and plants that disturb mangroves | 55 | Never |
| 6 | Participate in eradicating diseases that damage mangroves | 203 | Often |
| 7 | Participate in watering dead mangrove plants | 194 | Often |
| 8 | Participate in preventing anyone who tries to damage mangrove plants | 166 | Sometimes |

Based on Table (7) regarding community participation at the implementation stage, it can be seen that respondents were always present when providing outreach regarding mangrove area management. Counseling as a learning process (non-formal education) is aimed at communities involved in mangrove management in order to develop community knowledge, so that communities can independently manage the surrounding mangrove forests and improve their families' standard of living to become more decent and prosperous (Arfan *et al.*, 2021).

Participants occasionally engage in educating the community about the management of mangrove areas. The counseling provided highlights the ecological roles and social service contributions of mangrove forests. This initiative seeks to enhance community awareness regarding the roles and advantages of mangroves. Study by Jumnongsong *et al.* (2015) indicated that mangrove

training influences community perceptions regarding participation and management of mangroves.

Respondents always participate in maintaining plants. The community maintains mangrove plants in Tanjung Rejo Village through various efforts, such as periodically checking the condition of the seeds that have been planted, replanting if the plants die, not cutting down mangroves carelessly and carrying out community service work to clean up rubbish stuck in the mangrove plants. In contrast to plant maintenance, respondents have never participated in the eradication of animals, plant pests and mangrove-destroying diseases because these eradication activities have never been carried out in areas managed by KTH. However, respondents often participate in preventing anyone who tries to damage the mangrove plants. The prevention efforts carried out by respondents were through education to the community, relatives and family about the importance of mangrove plants. Then this was also strengthened by the existence of village regulations regarding the prohibition of illegal logging carried out by the community.

Respondents often took part in embroidering dead mangroves. After planting, maintenance is carried out on the mangroves. Replanting is one way to achieve success in mangrove rehabilitation. Bakrin Sofawi *et al.*, (2017) highlight that replanting represents a critical phase, as its primary objective is to ensure the survival of the mangrove seeds that have been planted, thereby maximizing their chances of thriving. Replanting is carried out by replacing dead mangrove seeds with new mangrove seeds. The people of Tanjung Rejo Village often carry out mangrove embroidery at certain times, either in groups or individually.

### *Community Participation in Monitoring/Evaluation Stage*

Engagement of the community in the monitoring and evaluation process involves three key questions. The results of the scoring are presented in Table (8).

**Table 8:** Community participation in monitoring/ evaluation stage

| No. | Statement | Total Score | Category |
|---|---|---|---|
| 1 | Participate in monitoring and checking activities | 172 | Sometimes |
| 2 | Report to the relevant chairman or management if problems occur in the management of the mangrove area | 184 | Sometimes |
| 3 | Participate in making improvements to inappropriate activities if there are errors | 194 | Often |

Based on Table (8) regarding community participation in monitoring/evaluation, it can be seen that respondents sometimes participate in monitoring and checking activities and report to the relevant chairman or administrators if problems occur in the management of mangrove areas. The findings from the interviews indicate that supervision and checking responsibilities are exclusively assigned to designated individuals. Consequently, not all members of KTH are obligated to perform checks and supervision within an activity. Respondents often participate in making improvements to inappropriate activities if there are errors. Based on interviews with respondents, correcting non-compliant activities is a shared responsibility of KTH members, this is done after carrying out an error evaluation process.

### *Community Participation in the Results Utilization Stage*

Participation of the community in the monitoring and evaluation process involves three key questions. Table (9) presents the scoring results.

**Table 9:** Participation in the results utilization stage

| No. | Statement | Total Score | Category |
|---|---|---|---|
| 1 | Carrying out harvesting in mangrove areas managed by KTH | 216 | Often |
| 2 | Marketing the harvest | 182 | Sometimes |
| 3 | Get wood for firewood | 82 | Never |
| 4 | Taking non-timber forest products (leaves, fruit, shrimp, crabs, fish) | 172 | Sometimes |

Based on Table (9) regarding community participation in utilizing the results, harvesting in the mangrove areas managed by KTH is categorized as frequent. The collection typically involves non-timber forest products that support MSMEs in Tanjung Rejo Village, including the production of dodol from *A. marina* fruit and chips made from Jeruju leaves. However, in terms of marketing, it is still lacking because MSMEs do not yet have Food and Drug Supervisory Agency, Badan Pengawas Obat dan Makanan (BPOM) permits and labels to carry out wider marketing. Based on interviews with heads of farmer groups, BPOM permits and labels are under processed.

People do not take wood for firewood because there is a prohibition in the village that regulates illegal logging carried out by the community. Nonetheless, the findings from the field inspection indicated that logging activities were occurring in the mangrove region of Tanjung Rejo Village. The community reported frequent instances of unauthorized removal of mangrove wood by individuals from outside the village. People sometimes take non-timber forest products, leaves, fruit, shrimp, crabs and fish. The lack of public knowledge and low creativity of the people of Tanjung Rejo Village means that many people do not know that mangroves have many economic benefits and can increase people's income. Utilization of mangroves and their derivative products can be used as basic capital and opportunities for community empowerment. People can use mangroves from the leaves, stems, roots, to the fruit into products that can bring economic value.

The questions posed to participants regarding the engagement of the Tanjung Rejo Village community in mangrove forest management reveal a significant degree of achievement. Various community groups such as KTH members have begun replanting dead plants independently without any direction from the government. According to Janssen-Jansen and Van Der Veen(2017), the community is moved to participate if the participation is carried out through organizations that already exist in the community, this participation provides direct benefits to the community concerned, the direct benefits obtained from participation can fulfill the interests of the community.

Wever *et al.* (2012) analyzed participation in the utilization of local ecosystems affected by the decentralization of coastal management in Indonesia. Within their jurisdiction, local and provincial governments are responsible for (1) exploration, exploitation, conservation and management of coastal resources; (2) administrative matters; (3) zoning and spatial planning matters; (4) enforcement of regulations; 5) participation in maintaining security; and (6) participation in defense sovereignty (Mursyid *et al.*, 2021). This is different from regulations issued by governments in other Southeast Asian countries on mangrove restoration, which first emphasize management, such as in Malaysia, which highlights the urgent need for proper management and conservation to ensure the continued existence of mangrove forests in Malaysia (Islam *et al.*, 2024). Regulations in Thailand place more emphasis on mangrove rehabilitation, resulting in the emergence of corporations playing a significant role in financing mangrove rehabilitation (Kongkeaw *et al.*, 2019).

Community participation in mangrove management is still low in involvement in mangrove management because they only provide assistance in mangrove management. Different conditions are found in Gumilar (2018) research on coastal communities in Indramayu Regency who contribute to mangrove management activities not only in the form of manpower and time but also thoughts and funds (materials). Support from several parties is needed to encourage participation.

## *Factors that Influence Community Participation in Mangrove Area Management in Tanjung Rejo Village*

Community participation represents a comprehensive process that necessitates both active and passive involvement from individuals or groups who consciously and voluntarily contribute to a program or activity. This engagement spans from the planning phase through implementation, evaluation and ultimately to the utilization stage. Multiple regression analysis is utilized to assess the degree of influence and the relationship that independent variables have on the dependent variable. Previously, a classical assumption test was conducted to show that the model shows a representative and significant relationship. The test states that the data is normal, has no multicollinearity problems and no symptoms of heteroscedasticity. Following this, linear regression analysis is carried out using the F-test.

The f-test results presented in Table (10) were determined to be significant at 0.002. As a result, the significant value of 0.002 is below the threshold of 0.05, suggesting that the independent variables—Incentives, Length of Residence, Employment, Income, Education and Age together exert a meaningful influence on the dependent variable, namely the level of community participation in the management of mangrove areas.

**Table 10:** Results of T-test and regression analysis as Anova (analysis of variance)

| Model | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| 1 | Regression | 25.015 | 6 | 4.169 | 4.302 .002[b] |
| | Residual | 46.513 | 48 | .969 | |
| | Total | 71.527 | 54 | | |

Table (11) showed that the coefficient of determination obtained was 0.268 which means that the influence of independent variables (incentives, length of residence, employment, income, education and age) on community participation was 26.8%. While the remaining 73.2% is influenced by other factors outside the variable X.

Based on the output coefficients in Table (12), the tolerance value is all greater than 0.1. Then the VIF value of all variables is less than 10 which indicates that the data does not have multicollinearity problems.

A t-test analysis was then performed to evaluate the influence of each independent variable on the dependent variable. The results of the t-test analysis are displayed in Table (12).

**Table 11:** Model summary

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .591[a] | .350 | .268 | .98438 | 1.815 |

*a. Predictors: (Constant), Incentives, Length of Residence, Occupation, Income, Education, Age*

**Table 12:** Results of T-test analysis and regression analysis (Coefficients)

| Model | Unstandardized Coefficients | | Standardized Coefficients | | | | |
|---|---|---|---|---|---|---|---|
| | B | Std. Error | Beta | t | Sig. | Tolerance | VIF |
| 1 (Constant) | .347 | .915 | | .379 | .706 | | |
| Age | .488 | .212 | .480 | 2.306 | .025 | .312 | 3.203 |
| Jobs | .068 | .154 | .056 | .444 | .659 | .861 | 1.162 |
| Education | .356 | .139 | .351 | 2.555 | .014 | .718 | 1.392 |
| Income | -.113 | .373 | -.040 | -.302 | .764 | .777 | 1.287 |
| Long lived | -.138 | .209 | -.137 | -.657 | .514 | .312 | 3.208 |
| Incentive | .461 | .405 | .143 | 1.141 | .260 | .866 | 1.154 |

According to the findings presented in Table (11), a multiple linear regression equation can be formulated as follows:

$$Y = 0,347 + 0,488X_2 + 0,068X_4 + 0,356X_5 - 0,113X_6 - 0,138X_7 + 0,467X_8$$

The findings from the regression analysis presented in Table (12) indicate that the variables gender (X1) and marital status (X3) yield consistent results, revealing no variations in the responses of participants, thus rendering them unsuitable for regression analysis. The constant value (a) is measured at a positive 0.347. This condition indicates that each increment in a results in an increase of Y by 0.347, assuming the estimates X2, X4, X5, X6, X7 and X8 are held constant. The constant possesses a noteworthy value of 0.706. The observed probability value is noted to surpass the significance threshold, specifically 0.706, which exceeds 0.05. The constant has no effect on the level of community engagement in the management of mangrove areas.

The significance value for the age variable is 0.025, while for the education variable, it stands at 0.014, with both values falling below the threshold of 0.05. This suggests that both age and education influence the degree of community involvement in the management of mangrove areas. As noted by Frank *et al.* (2017), age is connected to experience, which influences an individual's perception and behavior, particularly in the context of managing mangrove forests. Increased levels of community education correlate with enhanced participation in the management of mangrove forests, as individuals become more aware of the essential environmental functions of mangroves (Daupan, 2016).

Data obtained through interviews with respondents stated that people aged 50-57 years are included in the adult category, namely 31%, which is classified as productive age. The productive age in society has a major influence on the formation of community perceptions towards a better and more positive direction (Kim *et al.*, 2017). Therefore, people of productive age are expected to participate more actively in managing mangrove forests in their residential areas.

The education level of high school graduates/equivalent is the highest level of education of respondents, which is 36%. This means that respondents are classified as having secondary education. The level of education is one indicator to measure the quality of human resources. Education is an important factor in shaping behavior in interpreting mangrove forests which then encourages people to participate in preserving mangrove forests. Purnomo *et al.* (2017) said that the level of education can influence the perception and participation of the community. Therefore, people with this level of education are expected to be more perceptive, more rational and more creative in participating in preserving mangrove forests.

Based on the interview results, it was found that most of the community is willing to participate in the preservation of mangrove forests even though they do not receive a salary because the people of Tanjung Rejo Village are aware of the importance of the mangrove ecosystem as a prevention of abrasion and erosion, to withstand storms, as a habitat and spawning ground for marine biota so that they can provide food sources for humans and other species. The results of the study by Nuraeni *et al.* (2023) stated that the community has understood that mangrove forests have many functions (multiple functions), namely as a place for ecotourism (social function), preventing erosion or flooding (ecological function), a place to earn income (economic function) and other functions.

## Conclusion

*Avicennia marina* plays a crucial role in the growth rates of seedlings, saplings and trees in comparison to other species (Basyuni *et al.*, 2014). *A. marina* significantly impacts substrate control, thereby establishing itself as the dominant species in the mangrove region of Tanjung Rejo Village. The restricted diversity of mangrove species at both the seedling and tree stages can be traced back to external pressures that result in the extinction of particular mangrove species (Basyuni *et al.*, 2014). There are many ways that people use to conserve mangroves, for example by planting mangrove seedlings in groups or individually. However, the strong waves often cause community rehabilitation efforts to be in vain because the planted seeds tend to die or be swept away by the waves. The community hopes that the government will build breakwaters or wave barriers directly in the sea, so that the seeds planted can grow well and help reduce the rate of abrasion.

Mangrove conservation strategies in Tanjung Rejo Village need to be carried out by creating partnerships between the community and the government or universities. In addition, it is also necessary to increase awareness in maintaining mangrove areas so that they remain sustainable. It is necessary to pay attention to technical instructions in managing mangrove forests in creative efforts that are carried out, namely mangrove planting techniques and mangrove rehabilitation efforts by forming institutions, the need for appropriate information selection techniques in efforts to maintain the mangrove forest ecosystem and techniques for utilizing biodiversity in mangrove forests while remaining within the corridor of maintaining the sustainability of the mangrove ecosystem.

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## Author's Contributions

**Finny Juniyanti Nasution**: Conceptualized the study, conceive and designed the analysis, collected the data and written the manuscript.

**Mohammad Basyuni**: Analyzed, interpreted data, reviewed the manuscript text, proofread and edited the final draft of the study.

**Yunasfi**: Analyzed the data and reviewed the manuscript.

**Sri Kansih Hartini, Pindi Patana, Alfian Mubaraq and Alison Kim Shan Wee**: Reviewed the draft manuscript.

## Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

### *Competing Interests*

The authors report no conflicts of interest regarding this study.

## References

A. Afefe, A., S. Abbas, M., Sh. Soliman, A., A. Khedr, A.-H., & E. Hatab, E.-B. (2019). Physical and chemical characteristics of mangrove soil under marine influence. A case study on the Mangrove Forests at Egyptian-African Red Sea Coast. *Egyptian Journal of Aquatic Biology and Fisheries*, *23*(3), 385-399. https://doi.org/10.21608/ejabf.2019.47451

Ahmad zulfani, A. zulfani, Fadhilah, A., Susetya, I. E., & Yusni, E. (2022). Distribusi dan Karakteristik Kepiting Bakau (Scylla spp.) di Kawasan Rehabilitasi Mangrove Pantai Sei Tuan Indah Kecamatan Pantai Labu Kabupaten Deli Serdang. *AQUACOASTMARINE: Journal of Aquatic and Fisheries Sciences*, *1*(2), 58-66. https://doi.org/10.32734/jafs.v1i2.8864

Akatov, V. V., Akatova, T. V., & Chefranov, S. G. (2018). Degree of Dominance and Species Richness in Plant Communities with High and Low Intensity of Interspecies Competition. *Biology Bulletin Reviews*, *8*(5), 389-400. https://doi.org/10.1134/s207908641805002x

Aprilia, D., Arifiani, K. N., Dianti, Cahyaningsih, A. P., Kusumaningrum, L., Sarno, Rahim, K. A. B. A., & Setyawan, A. D. (2022). Review: Biogeochemical process in mangrove ecosystem. *International Journal of Bonorowo Wetlands*, *10*(2), 126-141. https://doi.org/10.13057/bonorowo/w100205

Arfan, A., Maru, R., Side, S., Abidin, M. R., & Sideng, U. (2021). Mangrove Forest Management Strategy as A Sustainable Production Forest Area in Luwu District, South Sulawesi Province, Indonesia. *Journal of Physics: Conference Series*, *1752*(1), 012089. https://doi.org/10.1088/1742-6596/1752/1/012089

Arifanti, V. B. (2020). Mangrove management and climate change: a review in Indonesia. *IOP Conference Series: Earth and Environmental Science*, *487*(1), 012022. https://doi.org/10.1088/1755-1315/487/1/012022

Bakrin Sofawi, A., Rozainah, M. Z., Normaniza, O., & Roslan, H. (2017). Mangrove rehabilitation on Carey Island, Malaysia: an evaluation of replanting techniques and sediment properties. *Marine Biology Research*, *13*(4), 390-401. https://doi.org/10.1080/17451000.2016.1267365

Basyuni, M., Putri, L. A. P., Nainggolan, B., & Sihaloho, P. E. (2014). Growth and Biomass in Response to Salinity and Subsequent Fresh Water in Mangrove Seedlings Avicennia marina and Rhizophora stylosa. In *Journal of Tropical Forest Management* (Vol. 20, Issue 1, pp. 17-25). https://doi.org/10.7226/jtfm.20.1.17

Basyuni, M., Sasmito, S. D., Analuddin, K., Ulqodry, T. Z., Saragi-Sasmito, M. F., Eddy, S., & Milantara, N. (2022). Mangrove Biodiversity, Conservation and Roles for Livelihoods in Indonesia. In S. Chandra Das, Pullaiah , & E. C. Ashton (Eds.), *Mangroves: Biodiversity, livelihoods and conservation* (1st ed., pp. 397-445). Springer, Singapore. https://doi.org/10.1007/978-981-19-0519-3_16

Basyuni, M., & Sulistiyono, N. (2018). Deforestation and reforestation analysis from land-use changes in North Sumatran Mangroves, 1990-2015. *IOP Conference Series: Materials Science and Engineering*, *309*, 012018. https://doi.org/10.1088/1757-899x/309/1/012018

Cahyaningsih, A. P., Deanova, A. K., Pristiawati, C. M., Ulumuddin, Y. I., Kusumaningrum, L., & Setyawan, A. D. (2022). Review: Causes and impacts of anthropogenic activities on mangrove deforestation and degradation in Indonesia. *International Journal of Bonorowo Wetlands*, *12*(1), 12-22. https://doi.org/10.13057/bonorowo/w120102

Camila, T. R., & Saraswati, R. (2020). Vulnerability of the East Coast of Balikpapan City in East Kalimantan (Lamaru Beach - Klandasan Beach). *IOP Conference Series: Earth and Environmental Science*, *448*(1), 012128. https://doi.org/10.1088/1755-1315/448/1/012128

Dalimunthe, F. I., Yanti, D., & Albattat, A. (2023). The Potential of Mangrove Forests for Tanjung Rejo Communities, Deli Serdang District, Indonesia. *Proceedings of the 4th International Conference on Tourism, Gastronomy, and Tourist Destination (TGDIC 2023)*, 320-325. https://doi.org/10.2991/978-94-6463-296-5_44

Daupan, S. M. M. V. (2016). *Community Participation in Mangrove Forest Management in the Philippines: Management Strategies, Influences to Participation, and Socio-Economic and Environmental Impacts*.

Etongo, D., D'Offay, K., Vel, T., Murugaiyan, P., & Henriette, E. (2022). Growth Rate and Survivorship of Rhizophora mucronata, Avicennia marina and Ceriops tagal Seedlings with Freshwater and Seawater Treatment for Mangrove Propagation in Nurseries. *Applied Ecology and Environmental Research*, *20*(6), 5409-5431. https://doi.org/10.15666/aeer/2006_54095431

Frank, C., Kairo, J. G., Bosire, J. O., Mohamed, M. O. S., Dahdouh-Guebas, F., & Koedam, N. (2017). Involvement, knowledge and perception in a natural reserve under participatory management: Mida Creek, Kenya. *Ocean & Coastal Management*, *142*, 28-36. https://doi.org/10.1016/j.ocecoaman.2017.03.009

Gumilar, I. (2018). Partisipasi Masyarakat Pesisir Dalam Pelestarian Ekosistem Hutan Mangrove (Studi Kasus Di Kabupaten Indramayu Jawa Barat). *Sosiohumaniora - Jurnal Ilmu-Ilmu Sosial Dan Humaniora*, *20*(2), 145-153. https://doi.org/10.24198/sosiohumaniora.v20i2.14707

Harefa, M. S., Pratama, A., Sihombing, E. T., Ivaldo, I., Putri, N. A., Sembiring, Y. P., & Ramadani, Y. F. (2024). The Role of Local Communities in Development Mangrove Ecotourism at Paluh Getah Beach. *Journal of Social, Policy and Development Studies*, *1*(1), 29-40.

Hasibuan, I. M., Amelia, R., Bimantara, Y., Susetya, I. E., Susilowati, A., & Basyuni, M. (2021). Vegetation and macrozoobenthos diversity in the Percut Sei Tuan mangrove forest, North Sumatra, Indonesia. *Biodiversitas Journal of Biological Diversity*, *22*(12), 5600-5608. https://doi.org/10.13057/biodiv/d221245

Islam, M. A., Billah, M. M., Idris, M. H., Bhuiyan, M. K. A., & Kamal, A. H. M. (2024). Mangroves of Malaysia: a comprehensive review on ecosystem functions, services, restorations, and potential threats of climate change. *Hydrobiologia*, *851*(8), 1841-1871. https://doi.org/10.1007/s10750-023-05431-z

Janssen-Jansen, L. B., & van der Veen, M. (2017). Contracting communities: Conceptualizing Community Benefits Agreements to improve citizen involvement in urban development projects. *Environment and Planning A: Economy and Space*, *49*(1), 205-225. https://doi.org/10.1177/0308518x16664730

Jumnongsong, S., Gallardo, W. G., Ikejima, K., & Cochard, R. (2015). Factors Affecting Fishers' Perceptions of Benefits, Threats, and State, and Participation in Mangrove Management in Pak Phanang Bay, Thailand. *Journal of Coastal Research*, *31*(1), 95. https://doi.org/10.2112/jcoastres-d-12-00257.1

Kim, J., Lee, J., & Sims, O. T. (2017). The Productive Aging Concept and Social Work Students' Perceptions Toward an Older Population. *Journal of Social Service Research*, *43*(2), 149-155. https://doi.org/10.1080/01488376.2016.1202878

Kitamura, S. (1997). *Handbook of mangroves in Indonesia: Bali & Lombok*.

Kongkeaw, C., Kittitornkool, J., Vandergeest, P., & Kittiwatanawong, K. (2019). Explaining success in community based mangrove management: Four coastal communities along the Andaman Sea, Thailand. *Ocean & Coastal Management*, *178*, 104822. https://doi.org/10.1016/j.ocecoaman.2019.104822

Kudrna, G., Le, T., & Piggott, J. (2022). Macro-Demographics and Ageing in Emerging Asia: the Case of Indonesia. *Journal of Population Ageing*, *15*(1), 7-38. https://doi.org/10.1007/s12062-022-09358-6

Ludwig, J. A., & Reynolds, J. F. (1988). *Statistical Ecology: A Primer in Methods and Computing*.

Margareta, P. S., & Salahudin, S. (2022). Community Participation in Regional Development Planning: A Literature Review. *TRANSFORMASI: Jurnal Manajemen Pemerintahan*, *13*(2), 121-132. https://doi.org/10.33701/jtp.v13i2.1584

Mubaraq, A., Sembiring, M., Widiastuti, E., Fachrial, E., Utomo, B., Turjaman, M., Sidik, F., Ulumuddin, Y. I., Arifanti, V. B., Siregar, E. S., Kajita, T., Procheş, Ş., & Basyuni, M. (2024). Diversity and distribution of nitrifying bacteria play an important role in the nitrogen cycle in mangrove sediments. *Global Journal of Environmental Science and Management*, *10*(4), 2145-2162.

Mursyid, H., Daulay, M. H., Pratama, A. A., Laraswati, D., Novita, N., Malik, A., & Maryudi, A. (2021). Governance issues related to the management and conservation of mangrove ecosystems to support climate change mitigation actions in Indonesia. *Forest Policy and Economics*, *133*, 102622. https://doi.org/10.1016/j.forpol.2021.102622

Nuraeni, E., & Kusum, Y. W. C. (2023). The role of community-based tourism for mangroves conservation in Banten, Indonesia. *Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan (Journal of Natural Resources and Environmental Management)*, *13*(4), 606-612. https://doi.org/10.29244/jpsl.13.4.606-612

Parenri, N., Sukendi, S., & Nurhidayah, T. (2021). Persepsi dan partisipasi masyarakat terhadap pelestarian hutan mangrove di Kecamatan Bantan-Bengkalis. *Jurnal Zona*, *2*(1), 23-28. https://doi.org/10.52364/jz.v2i1.15

Purnomo, B., Anggoro, S., & Izzati, M. (2017). Analysis of perception and community participation in forest management at KPHP model unit VII-Hulu Sarolangun, Jambi Province. *IOP Conference Series: Earth and Environmental Science*, *70*, 012034. https://doi.org/10.1088/1755-1315/70/1/012034

Ruzanna, A. (2023). Identifikasi dan Indeks Nilai Penting Mangrove di Kuala Bubon, Kecamatan Samatiga, Kabupaten Aceh Barat. *Juvenil:Jurnal Ilmiah Kelautan Dan Perikanan*, *4*(4), 397-401. https://doi.org/10.21107/juvenil.v4i4.23008

Sulistiyono, N., Patana, P., Thoha, A. S., Amri, K., & Onrizal, O. (2018). Deteksi Deforestasi Menggunakan Citra Satelit Resolusi Tinggi Pada Lanskap Hutan Mangrove Percut Sei Tuan. *Talenta Conference Series: Agricultural and Natural Resources (ANR)*, *1*(2), 213-217. https://doi.org/10.32734/anr.v1i2.239

Utami, N. D. N., Susiloningtyas, D., & Handayani, T. (2018). Community Perception and Participation of Mangrove Ecosystem in Ngurah Rai Forest Park Bali, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *145*, 012147. https://doi.org/10.1088/1755-1315/145/1/012147

Wever, L., Glaser, M., Gorris, P., & Ferrol-Schulte, D. (2012). Decentralization and participation in integrated coastal management: Policy lessons from Brazil and Indonesia. *Ocean & Coastal Management*, *66*, 63-72. https://doi.org/10.1016/j.ocecoaman.2012.05.001