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Research Article

Effect of Silviculture Technique on Mangrove Rehabilitation Growth in Pasar Rawa and Pangkalan Batu Village, North Sumatra, Indonesia

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Abstract

Background and Objective: The high deforestation on the East Coast of North Sumatra for various uses such as oil palm plantations, shrimp ponds, fish, etc. and the decline in marine catches have encouraged rehabilitation actors to carry out planting actions in Pasar Rawa and Pangkalan Batu Villages. Therefore, this study aims to determine the results of rehabilitation actions carried out by several rehabilitation actors in the form of mangrove plant density and the percentage of growth associated with the level of farmer participation in Pasar Rawa and Pangkalan Batu Villages. **Materials and Methods:** Data collection was carried out using direct field surveys, interviews with farmer groups and vegetation analysis methods to see the dominance of growing species. The existing vegetation will be counted per square meter. Then the amount of vegetation will be compared with the standard criteria. Vegetation analysis parameters by calculating the number of plants at the seedling, sapling and tree levels. Questionnaire data were processed using the Likert Scale method with a scale of 1-3. **Results:** The level of mangrove density in Pasar Rawa and Pangkalan Batu Villages was classified as good and the dominant species were *Rhizophora apiculata* and *Rhizophora mucronata*. This shows that the rehabilitation program carried out was quite successful, although with varying success percentages. The highest growth percentage results were obtained by each local community rehabilitation actor, followed by NGO₁, NGO₂ and the government. **Conclusion:** The density level of mangrove forests in Pasar Rawa Village is 1487 ind/ha ranging from moderate (<1,500 ind/ha and in Pangkalan Batu is 1759 ind/ha which is included in the good category and the level of community participation is relatively high with a participation percentage of 87.2%.

Key words: Conservation, mangrove, sustainable, management strategy, public perception

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Mangrove forests in Indonesia are around 4,251,011 ha or 2% of the land area of Indonesia. In North Sumatra itself, the remaining mangrove area is now 54,490 ha and this number continues to decline due to high deforestation. The rate of deforestation of mangrove forests in North Sumatra is quite high considering that some of the east coast areas have rapid population growth. The population growth rate in this area is quite high, around 10% in the last 10 years¹. The increasing population also results in increasing community living needs, which has an impact on the opening of mangrove areas in this area. Mangrove felling for wood, considering the high price of mangrove charcoal, is very tempting for people to carry out felling and encroachment on wood². The distance to the center of the capital city of North Sumatra Province, which is relatively close with good accessibility (60 km which can be reached in just 1-1.5 hrs driving) also greatly supports the transportation of mangrove wood products via this route.

To reach the national road (the main road connecting the provinces of Aceh and North Sumatra), this area is only 10 km away with good road conditions. This is also very attractive for local and out-of-town investors to invest along the East Coast³. The fairly high thickness of mangroves (ranging from 10-15 km) is also attractive for investors to utilize this area for plantations, shrimp ponds and other businesses. Therefore, the pressure of mangrove deforestation, especially in the Pasar Rawa and Pangkalan Batu Village, is very high. In both village, mangroves are now being converted into oil palm plantations covering an area of 1,000 ha¹. The high unemployment rate due to rapid population growth has made labor problems easy. This is the main focus of why research on the rate of deforestation and rehabilitation efforts to return to mangrove forests must be carried out. The decline in fishermen's sea catches has raised public awareness of the benefits and functions of mangroves⁴. Various outreach and guidance provided by the government have begun to inspire the community to start rehabilitating their mangroves. Several assistance programs for mangrove seedlings and plants from both the government and non-government organizations have been ongoing for the past 5 years in Pasar Rawa and Pangkalan Batu Village. It is recorded that 2 non-government organizations and the government have carried out mangrove rehabilitation activities⁵. Until now, it has been recorded that there is a mangrove rehabilitation area in Pasar Rawa Village covering an area of 138 and 87 ha in Pangkalan Batu Village with varying results. The results of the mangrove rehabilitation

have never been measured for their level of success until now. Given the concerns about the high level of mangrove deforestation and the low speed and success of mangrove rehabilitation. This study aims to analyze the success rate of mangrove planting in the village so that it can be evaluated so that the mangrove forest is maintained.

MATERIALS AND METHODS

Study area: This research was conducted in Pasar Rawa Village and Pangkalan Batu Village, Langkat Regency. The research lasted for 6 months starting from December, 2023 to May, 2024.

Vegetation analysis method to estimate the success of mangrove rehabilitation: Measurement and observation of mangrove forest vegetation were carried out using a systematic sampling method with random start. The study began by creating 10 transect lines. Furthermore, nested plots were made measuring 10×10, 5×5 and 2×2 m, with a distance between transect lines of 1 km⁶. Observations were made at the level of saplings and seedlings. The seedlings were identified as plants with a height of ≤1.5 m, saplings had a diameter of ≤10 cm (at a height of 1.3 m) and a height of ≥1.5 m and trees had a diameter of ≥10 cm⁷.

Mangrove density (K): The estimation of mangrove density was calculated for each growth level by comparing the number of individual species with the area of the entire research plot, which was converted to hectares⁷:

$$K = \frac{ni}{A} \times 10.000$$

Where:

- K = Specific density (ind/m²)
- ni = Total number of individuals of i-th type
- A = Total area of sample observation area (m²)

Standard criteria for mangrove damage the standard criteria for mangrove damage as shown in Table 1.

Rehabilitation activities: To measure the success rate of mangrove rehabilitation, data was taken from rehabilitation actors in both village for 5 years. The data taken were who the mangrove planting actors were in both village, the plants planted and the activities carried out to assess the differences in rehabilitation results by each rehabilitation actor⁸.

Table 1: Standard criteria for mangrove damage

Criteria specific	Density (ind/ha)
Very dense	$\geq 1,500$
Medium dense	$\geq 1,000 < 1,500$
Rare dense	$< 1,000$

Questionnaire sampling: The selection of sample village was carried out intentionally by considering the objectives of the study⁹. Among them were considerations for population-based sampling from farmer groups in Pasar Rawa and Pangkalan Batu Village who were directly involved in mangrove forest conservation efforts. The study focused on members of farmer groups and communities living in Pasar Rawa and Pangkalan Batu Village, using the non-probability sampling method. Specifically, this method does not provide equal opportunities for each element or member of the population to be selected as a sample.

Questionnaire data collection method: The data collection method was carried out in three stages, namely:

- **Observation:** The target objects studied were members of farmer groups engaged in mangrove forest management around Pasar Rawa and Pangkalan Batu Village, Gebang District, Langkat Regency
- A list of questions that were systematically compiled related to the research objectives to determine respondents' understanding of the progress of mangrove rehabilitation results in each village
- Respondents' answers were measured using a Likert scale

Silvicultural method: The silvicultural methods are used by the parties involved in mangrove rehabilitation in each village. Questions compiled related to the history of planting and maintenance actions carried out by each party involved in the rehabilitation actors. In addition, secondary data was also taken from village data related to the time and amount of planting that had been carried out in each village.

Growth percentage: The percentage of plant growth was calculated after the research was conducted. In each planting area of 2019-2023, ten plots measuring 10×10 m were made¹⁰. The plants were cultivated by 4 institutions, namely the government, NGO₁, NGO₂ and the local community. Furthermore, all plants in each plot were counted and compared for the rehabilitation actors. The number of plants in each area was counted using the formula⁷:

$$\text{Growth (\%)} = \frac{\text{Number of life plants in plot}}{\text{Total number in sample plot}} \times 100$$

The calculation results were presented in a summary table of the percentage of plant growth, which showed the success of planting by each organization.

Data analysis methods: The Likert scale used in this research is also known as the Summated Ratings Method, showing the highest and lowest scores of 3 and 1, respectively, for each answer to the questions asked to respondents. The answer between the two scales is adjusted according to the available responses. For the question scale, respondents who answered "agree" were given a value of 3, doubtful was 3 and did not agree was 1.

After the data are obtained, the score is calculated to determine the percentage of respondents, as shown below⁷:

Score Interpretation:

$$TS = Re \times SL$$

Where:

TS = Total score

Re = Respondent

SL = Selected Likert score

$$x = ST \times \Sigma R$$

$$y = SR \times \Sigma R$$

Where:

ST = Likert highest score

SR = Likert lowest score

ΣR = Number of respondents

$$In (\%) = TS \times 100$$

Where:

In = Index (%)

TS = Total score

Data presentation:

$$I = \frac{100}{LT}$$

Where:

I = Interval

LT = Highest Likert score

Score interpretation criteria based on intervals:

Number 0-33% = Disagree
 Number 34-66% = Undecided
 Number 67-100% = Agree

RESULTS AND DISCUSSION

Mangrove forest analysis: The total area of mangrove forests that have now been planted and managed by farmer groups in Pasar Rawa and Pangkalan Batu Village is 138 and 87 ha, respectively. The types of plants cultivated are divided into three levels, namely seedlings, saplings and trees. Mangrove planting in both village has been carried out from 2019 to 2023. Table 2 shows the mangrove density in the form of the number of individuals per hectare (ind/ha) based on the analysis of mangrove forests in Pasar Rawa and Pangkalan Batu Village, Langkat Regency.

Seedling level: The seedling level is dominated by the *Rhizophora apiculata* species with a total of 25,873 ind/ha due to the muddy soil conditions and brackish water in the Pasar Rawa Village mangrove forest. Meanwhile, the species with the least number of seedlings is *Excoecaria agallocha* with a total of 6,493 ind/ha. The lowest number of *Excoecaria agallocha* is caused by the content of diterpenoids, triterpenoids and flavonoids, namely milky sap which is very toxic and can irritate the skin, causing the skin to blister if exposed directly¹¹. In particular, eye contact with these species can cause temporary blindness, so the level of slashing by the community is high¹².

In Pangkalan Batu Village, *Rhizophora mucronata* dominates the seedling level with a total of 34,694 ind/ha due to the wet environmental conditions of the Pangkalan Batu Village mangrove forest and is directly influenced by the ebb and flow¹³. This condition supports the formation of a stretch of the *R. mucronata* ecosystem. The species with the least number at the seedling level is *Nypa fruticans* with a number of 3,745 ind/ha.

Sapling level: At the sapling level, *R. apiculata* dominates with a number of 6,293 ind/ha. This is because in Pasar Rawa Village, *R. apiculata* has long been the most abundant rehabilitation plant considering that its propagules are abundantly available on parent trees in this village. This species was recorded at 29,933 ind/ha. Meanwhile, the species found the least was *Bruguiera hainesii* with a number of 41 ind/ha. This is due to the limited growth and distribution of its propagules in the mangrove area,

so it is not surprising that this species is categorized as a critical mangrove by the International Union for Conservation of Nature (IUCN). This type of mangrove is only found in four countries, namely Singapore, Malaysia, Indonesia and Papua New Guinea¹⁴.

The stake level in Pangkalan Batu Village is dominated by *Avicennia marina* with a total of 6,195 ind/ha because this species is recorded as a type of seedling that is also widely planted by NGO₁, NGO₂ and the government. The condition of Pangkalan Batu Village which is located directly facing the sea makes this species very adaptive to direct wave action. The species that is least found at the stake level is *N. fruticans* with a total of 1,024 ind/ha, due to its low tolerance to salt water and its ability to grow in both fresh and brackish water¹⁵.

Tree level: In Pasar Rawa Village, *R. apiculata* and *N. fruticans* dominate the tree level with a total of 340 and 289 ind/ha, respectively. This means that past planting programs greatly influence the species that dominate an area where these two species are the most widely planted as rehabilitation plants in the past. In Pangkalan Batu Village, the tree level is dominated by *R. mucronata* and *A. marina* with a total of 432 and 321 ind/ha, respectively. This was in line with past planting programs that placed these two types as the main rehabilitation plants¹⁶. Based on the standard criteria for mangrove density, the level of mangrove density in the mangrove rehabilitation area in Pasar Rawa Village is classified as moderate (<1,500 ind/ha), while in Pangkalan Batu Village it is classified as good (>1,500 ind/ha). This illustrates that the condition of the mangroves in the rehabilitation location in Pangkalan Batu Village is better than in Pasar Rawa Village¹⁷.

Species dominance: The species dominance is estimated from the value of the importance index calculated from the sum of the density+frequency values for the seedling and sapling levels and added to the dominance value for the tree level¹⁸. The high importance value indicates a higher level of species dominance in an area and characterizes the main vegetation in a forest ecosystem¹⁹. Dominance at the seedling level was shown in Table 3.

The highest seedling level dominance in Pasar Rawa and Pangkalan Batu Village is *R. apiculata* and *R. mucronata*, respectively, which is indicated by the highest importance value index. This means that it was in line with the mangrove planting program carried out by the community in the past which planted the two types above as the most widely planted types. Planting over

Table 2: Number of ind/ha found in Pasar Rawa and Pangkalan Batu Village

Species	Density (ind/ha) in Pasar Rawa			Density (ind/ha) in Pangkalan Batu		
	Seedling	Sapling	Tree	Seedling	Sapling	Tree
<i>Avicennia germinans</i>	11,293	2,297	93	29,720	4,632	147
<i>Avicennia marina</i>	16,390	3,363	229	16,293	6,195	321
<i>Bruguiera hainesii</i>	6,397	1,092	41	6,972	2,933	153
<i>Ceriops tagal</i>	0	0	0	6,735	3,453	194
<i>Excoecaria agallocha</i>	6,493	1,560	65	0	0	0
<i>Nypa fruticans</i>	2,945	5,292	289	3,745	1,024	73
<i>Rhizophora apiculata</i>	25,873	6,293	340	0	0	0
<i>Rhizophora mucronata</i>	0	0	0	34,694	5,693	432
<i>Sonneratia alba</i>	12,095	3,112	133	22,453	3,342	298
<i>Sonneratia caseolaris</i>	13,957	3,981	187	0	0	0
<i>Xylocarpus moluccensis</i>	11,982	2,943	101	14,892	4,647	141
Total	107,425	29,933	1,487	135,504	31,919	1,759

Table 3: Dominance of seedlings level in Pasar Rawa and Pangkalan Batu Village

Species	Pasar Rawa Village			Pangkalan Batu Village		
	Density (%)	Frequency (%)	Important value (%)	Density (%)	Frequency (%)	Important value (%)
<i>Avicennia germinans</i>	10.5	13.5	24	22.1	24.1	46.2
<i>Avicennia marina</i>	15.3	13	28.3	12.1	11	23.1
<i>Bruguiera hainesii</i>	6.0	2.2	8.2	5.2	5.6	10.8
<i>Ceriops tagal</i>	0	0	0	5	7.2	12.2
<i>Excoecaria agallocha</i>	6.0	6.1	12.1	0	0	0
<i>Nypa fruticans</i>	2.7	1.9	4.6	2.8	4.9	7.7
<i>Rhizophora apiculata</i>	24.1	27.7	51.8	0	0	0
<i>Rhizophora mucronata</i>	0	0	0	25.8	21	46.8
<i>Sonneratia alba</i>	11.3	9.8	21.1	16.7	17.5	34.2
<i>Sonneratia caseolaris</i>	13.0	15.7	28.7	0	0	0
<i>Xylocarpus moluccensis</i>	11.2	10.1	21.3	11.1	8.7	19.8

Table 4: Dominance of the sapling level in Pasar Rawa and Pangkalan Batu Village

Species	Pasar Rawa Village			Pangkalan Batu Village		
	Density (%)	Frequency (%)	Important value (%)	Density (%)	Frequency (%)	Important value (%)
<i>Avicennia germinans</i>	7.7	10.9	18.6	14.5	10.2	24.7
<i>Avicennia marina</i>	11.2	9	20.2	19.4	20.9	40.3
<i>Bruguiera hainesii</i>	3.6	5.3	8.9	9.2	7	16.2
<i>Ceriops tagal</i>	0	0	0	10.8	11.2	22
<i>Excoecaria agallocha</i>	5.2	6.1	11.3	0	0	0
<i>Nypa fruticans</i>	17.7	15.5	33.2	3.2	5.7	8.9
<i>Rhizophora apiculata</i>	21	19.3	40.3	0	0	0
<i>Rhizophora mucronata</i>	0	0	0	17.8	15	32.8
<i>Sonneratia alba</i>	10.4	13.3	23.7	10.5	13.5	24
<i>Sonneratia caseolaris</i>	13.3	14.7	28	0	0	0
<i>Xylocarpus moluccensis</i>	9.8	5.9	15.7	14.6	16.5	31.1

the last 5 years has resulted in a high number of mature trees of these two types, resulting in new propagules falling and growing naturally into new seedlings and saplings, as shown in Table 4.

As seen in Table 5, the plants with the highest importance at the seedling level are *R. mucronata* and *R. apiculata*. This is because the community, NGO₁, NGO₂ and the government tend to plant these types of plants because of their high adaptability to all salty water conditions.

The highest dominance at the tree level in Pasar Rawa Village is *R. apiculata* with an important value of 77.5%. This is because the cultivation carried out continuously by the government, NGO₁ and NGO₂ in this village uses this species. In addition, the adaptability of *R. apiculata* is also high so that it can grow and develop at high salinity levels. The current tends to be calm because this village is located in the interior and does not directly border the sea also supports this species to grow and develop well. However, the plant that has the

Table 5: Dominance for tree level in Pasar Rawa and Pangkalan Batu Village

Species	Pasar Rawa Village				Pangkalan Batu Village			
	Density (%)	Frequency (%)	Dominance (%)	IVI (%)	Density (%)	Frequency (%)	Dominance (%)	IVI (%)
<i>Avicennia germinans</i>	6.3	2.8	3.1	12.1	8.4	6	8.1	22.5
<i>Avicennia marina</i>	15.4	18	14	47.4	18.2	7.1	6.9	32.2
<i>Bruguiera hainesii</i>	4.4	5	2.9	12.3	8.7	8.2	4.4	21.3
<i>Ceriops tagal</i>	0	0	0	0	11	8.8	11.2	31
<i>Excoecaria agallocha</i>	2.8	4.3	1.5	8.6	0	0	0	0
<i>Nypa fruticans</i>	20	26.5	25.2	71.8	0	0	0	0
<i>Rhizophora apiculata</i>	22.9	26.8	27.8	77.5	4.2	18.6	19	41.8
<i>Rhizophora mucronata</i>	0	0	0	0	24.6	27.3	22.5	74.4
<i>Sonneratia alba</i>	8.9	3.6	11.1	23.6	16.9	19.9	16.5	53.3
<i>Sonneratia caseolaris</i>	12.6	7.4	9.5	29.5	0	0	0	0
<i>Xylocarpus moluccensis</i>	6.8	5.7	4.9	17.3	8	4.1	11.4	23.5

IVI: Important value

Table 6: Succeed growth percentage for 5 years planting in Pasar Rawa and Pangkalan Batu Village

Organization	Growth in year (%)				
	2023	2022	2021	2020	2019
Government	84	68	40	32	32
NGO ₁	88	80	64	60	56
NGO ₂	92	84	76	68	60
Local community	96	96	88	84	76

lowest density and dominance is *B. hainesii*, because of its low adaptability. Although widely planted, this species is more spoiled in extreme environmental conditions without maintenance so without careful maintenance this species often dies. In Pangkalan Batu Village, the most species is *R. mucronata* with an important value of 74.4%. In addition to being the main type of rehabilitation plant in this village, *R. mucronata* is also the type that grows most easily and adapts to all extreme environmental conditions so mangrove rehabilitation activists often use it as a rehabilitation plant. *Bruguiera hainesii* has the lowest level of dominance due to its poor adaptability.

Growth percentage: The growth percentage is calculated from sampling calculations taken from 10 plots in each rehabilitation actor. The growth percentage is only taken at the sapling and tree levels because these two growth levels already represent the adaptability of rehabilitation plants to continue to grow and develop in normal environmental conditions. Among the 4 rehabilitation actors, the growth percentage of rehabilitation plants varies, for clarity, it was shown in Table 6.

In the early years of planting, the percentage of plant growth for all rehabilitation actors was a high number, but over time, the percentage of growth decreased in rehabilitation plants planted by the government and followed by NGOs. This is due to the lack of maintenance by the government. The rehabilitation program carried out by the government is limited to planting without being followed

by maintenance actions such as insertion, fertilization and land clearing. As a result, many plants died due to environmental limiting factors such as nutrients and death by strong currents that carried garbage that hit the rehabilitation plant area, especially at the seedling level. The highest percentage of rehabilitation plant growth was shown by plants from rehabilitation by the local community. This may be due to the source of the seeds. The community does its seedling in an area close to the planting location so that the planted seeds have been acclimatized to the environmental conditions. The seeds do not experience much stress from lack of water and shocks due to transportation so the death rate of the seeds is lower. Meanwhile, the rehabilitation plants by the government, NGO₁ and NGO₂ use seeds supplied from distant areas. For the government planting program, the seeds used come from other areas in Deli Serdang Regency which are >100 km from these villages. This results in stress for the plants due to transportation and long periods of drought before the plants are planted. Likewise, seeds planted by NGOs are brought in from outside the region which causes the plants to have to undergo acclimatization first before they can grow in the planting area.

Silviculture method: The silviculture method is closely related to the percentage of plant growth produced. Rehabilitation actors who carry out maintenance actions for at least 1 year after the plants are planted have been shown to produce the highest percentage of growth.

These silviculture actions were obtained from maintenance data carried out by rehabilitation activists in both village. In addition to data from farmer groups carrying out mangrove rehabilitation, interviews with members of farmer groups were also taken as valid data to conclude the planting and maintenance actions carried out by each rehabilitation actor in both village.

The government, NGO₁ and NGO₂ planted seeds obtained from outside the village, while the local community used propagules collected from the village. This phenomenon causes seeds obtained from outside the village to become stressed due to the long journey. The government took mangrove seeds from the government's nursery located in Deli Serdang Regency (>100 km away), thus reducing the percentage of growth, while NGO₁ and NGO₂ purchased seeds from a closer location. Seeds planted by the government have a gap of about 2 weeks due to operational reasons ranging from uprooting and collection, to transportation. However, seeds obtained by NGO₁ and NGO₂ were cultivated in another village close to the planting location so that the gap was shorter, namely around 1 week. Meanwhile, the local community planted propagules in a location close to the planting location so that the plants were not stressed for planting. The NGO₁, NGO₂ and the local community often carried out insertion to cover the number of dead plants, while the government was not involved in these activities. This is what causes the wide difference in the success rate of growing plants planted by each party²⁰.

Farmer group participation

Respondent characteristics: In this study, all respondents interviewed were members of mangrove forest farmer groups in both village. The social characteristics of respondents in both village were presented in Table 7.

Age characteristics in Pasar Rawa Village had the highest interval in 31-40 years with a rate of 41.5% and 40-50 years in the Advanced Joint Group at 39.3%. Meanwhile, the lowest intervals were in Pasar Rawa and Pangkalan Batu Village, which were in the 50-60 year age range, with 12.2 and 7.1%, respectively, showing productivity between the two groups. The characteristics of gender in both groups tended to be more dominant in males, with rates of 85.4 and 100% in Pasar Rawa and Pangkalan Batu Village. The members in Pangkalan Batu are mainly male thereby contributing to improved productivity in preserving mangrove forests²¹.

The characteristics of education were equally dominated by elementary education, with a rate of 56.1 and 50% in Pasar Rawa and Pangkalan Batu Village, respectively, For junior high school, high school and non-school education, the

intervals were the same, while undergraduate education had no single member, The length of stay was predominantly over 10 years, showing that members of both village are natives²².

Economic characteristics consist of work, income and ownership, with the majority of respondents working as fishermen. This shows that there is frequent interaction between the local community and mangroves, indicating their position in preserving the mangroves ecosystem in Pasar Rawa and Pangkalan Batu Village. Income is one of the benchmarks used to determine the welfare of respondents, with higher income representing more prosperity²³ as shown in Table 8.

Age-related occupational characteristics in Pasar Rawa and Pangkalan Batu Village tend to be more dominant as fishermen, with rates of 58.5 and 75%, respectively. The lowest interval in Pasar Rawa Village is for private employees and civil servants in the Forward Together Group. This shows that most of the work of members in the two groups is very dependent on the mangrove ecosystem²⁴. Based on the results, income characteristics were dominated in the Rp1,000,000-3,000,000 interval, with rates of 46.3 and 75%, respectively. Meanwhile, the lowest interval is more than IDR 5,000,000, with 7.3 and 3.6%, showing that member, welfare based on income is still considered normal with an average salary of IDR 2,500,000²⁵.

Residential ownership characteristics in both groups were dominated by parents and siblings, with rates of 68.3 and 75%, while the lowest were in contracted houses with 2.4 and 0%, respectively. This showed that most of the members were hereditary natives of the original population in village²⁶.

Questions were asked to respondents regarding their participation in mangrove planting programs, mangrove maintenance and guarding and their involvement in outreach activities and various pieces of training conducted by rehabilitation actors in Pasar Rawa and Pangkalan Batu Village. The responses given by the members of the mangrove farmer groups were presented in Table 9.

The results of the recapitulation of community participation in mangrove forest conservation in Pasar Rawa and Pangkalan Batu Village are divided into 4 indicators, namely participation in planting, utilization of mangrove forests, preservation and extension and training activities²⁷. As seen in Table 9, the total percentage of the four indicators is 87.2%, which shows that the majority of community members agree to participate in mangrove forest conservation activities in Pasar Rawa Village. The community can help mangrove forests withstand tidal waves by participating in mangrove planting²⁸. This activity has a very

Table 7: Social characteristics of the respondents

Category	Pasar Rawa Village		Pangkalan Batu Village	
	Person	Percentage	Person	Percentage
Age (year)				
20-30	8	19.5	6	21.4
31-40	17	41.5	9	32.1
40-50	11	26.8	11	39.3
50-60	5	12.2	2	7.1
Total	41	100	28	100
Gender				
Male	35	85.4	28	100
Female	6	14.6	0	0
Total	41	100	28	100
Last education				
Elementary	23	56.1	14	50.0
Junior high	7	17.1	9	32.1
Senior high	4	9.8	2	7.1
Bachelor	0	0	0	0
No school	7	17.1	3	10.7
Total	41	100	28	100
Length of stay (year)				
1-5	3	7.3	0	0
6-10	7	17.1	5	17.9
More than 10	31	75.6	23	82.1
Total	41	100	28	100

Table 8: Economic characteristics of the respondents

Category	Pasar Rawa Village		Pangkalan Batu Village	
	Person	Percentage	Person	Percentage
Work				
Fisherman	24	58.5	21	75
Trader	8	19.5	5	17.9
Government employee	2	4.9	0	0
Private employee	1	2.4	2	7.1
Housewife	6	14.6	0	0
Amount	41	100	28	100
Income				
Less than IDR 1,000,000	3	7.3	4	14.3
IDR 1,000,000-3,000,000	19	46.3	21	75.0
IDR 3,000,000-5,000,000	16	39	2	7.1
More than IDR 5,000,000	3	7.3	1	3.6
Amount	41	100	28	100
Residential ownership				
Parent's	28	68.3	21	75
Rent	1	2.4	0	0
Own	12	29.3	7	25
Amount	41	100	28	100

Table 9: Indicator and benchmarks given by the respondent

Indicators and benchmarks	Level of approval (%)	Category
Participation in planting	96.1	Participate
Participation in mangrove forests activities	65.1	Doubtful
Participation in preservation	91.6	Participate
Participation in outreach activities and training	95.9	Participate
Average	87.2	Participate

positive impact on the community, namely employing members of farmer groups and the Pasar Rawa Village community. Related to participation in mangrove forest conservation, the local community is expected to be able to replant and supervise so that the mangrove ecosystem is not damaged²⁹. For participation in extension and training activities, most farmer group members agree that community development and socialization activities will increase awareness of the benefits of mangrove forests to facilitate adequate maintenance and preservation³⁰. Community participation in preserving mangrove forests is very important, with NGO₁ and NGO₂ providing operational and maintenance costs and seed allocation. Farmer groups and communities are also involved in planting, as individuals receive daily wages according to previous agreements.

Given the above reality, maintenance actions cannot be separated from the mangrove planting and rehabilitation program if we want high planting success. Only planting without maintenance actions has been shown to reduce the growth percentage by up to 32% (Table 7). Therefore, it is appropriate that in the future, the allocation of costs for plant maintenance for at least 1 year must be provided by the parties considering that the baby plant period is a period that is very vulnerable to plant death.

CONCLUSION

This study shows that the density level of mangrove forests in Pasar Rawa Village is 1487 ind/ha ranging from moderate (<1,500 ind/ha and in Pangkalan Batu is 1759 ind/ha which is included in the good category. The dominant plant types are *R. apiculata* and *R. mucronata*. The best growth percentage was obtained in plants that received maintenance treatment for 1 year compared to those planted without maintenance. Community participation in participating in mangrove rehabilitation activities in both village is relatively high with a participation rate of 87.2%. In the future, outreach activities must be held for the community so that the community knows that mangrove forests are very important and need to be maintained together.

SIGNIFICANCE STATEMENT

Mangrove forests are very important for coastal communities. In addition to being a wave breaker, mangrove forests are also a marine biota ecosystem. The existence of mangrove forests also increases the income of fishermen in the village. This study analyzes the level of success in rehabilitating mangroves based on silviculture techniques

carried out by farmer groups. The dominant species are *Rhizophora apiculata* and *Rhizophora mucronata*. This kind of knowledge can help the community to focus on planting these species to increase the percentage of growth in the village.

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REFERENCES

1. Wakushima, S., S. Kuraishi and N. Sakurai, 1994. Soil salinity and pH in Japanese mangrove forests and growth of cultivated mangrove plants in different soil conditions. J. Plant Res., 107: 39-46.
2. Barbier, E.B., 2016. The protective service of mangrove ecosystems: A review of valuation methods. Mar. Pollut. Bull., 109: 676-681.
3. Daraba, H.D., 2017. Effect on the level of village fund program community participation in the North Galesong District Takalar Regency [In Indonesian]. Sosiohumaniora, 19: 52-58.
4. Friess, D.A., B.S. Thompson, B. Brown, A.A. Amir and C. Cameron *et al*, 2016. Policy challenges and approaches for the conservation of mangrove forests in Southeast Asia. Conserv. Biol., 30: 933-949.
5. Nanulaitta, E.M., A.H. Tulalessy and D. Wakano, 2019. Analysis of mangrove's rapidity as one of the ecowicate indicators in the Alariano beach waters of Amahai sub-district, Maluku central district [In Indonesian]. J. Hutan Pulau-Pulau Kecil, 3: 217-266.
6. Carugati, L., B. Gatto, E. Rastelli, M.L. Martire, C. Coral, S. Greco and R. Danovaro, 2018. Impact of mangrove forests degradation on biodiversity and ecosystem functioning. Sci. Rep., Vol. 8. 10.1038/s41598-018-31683-0.
7. Ukpong, I.E., 1997. Vegetation and its relation to soil nutrient and salinity in the Calabar mangrove swamp, Nigeria. Mangroves Salt Marshes, 1: 211-218.
8. Friess, D.A., 2017. J.G. Watson, inundation classes, and their influence on paradigms in mangrove forest ecology. Wetlands, 37: 603-613.
9. Thiagarajah, J., S.K.M. Wong, D.R. Richards and D.A. Friess, 2015. Historical and contemporary cultural ecosystem service values in the rapidly urbanizing city state of Singapore. Ambio, 44: 666-677.

10. Goessens, A., B. Satyanarayana, T. van der Stocken, M.Q. Zuniga, H. Mohd-Lokman, I. Sulong and F. Dahdouh-Guebas, 2014. Is Matang Mangrove Forest in Malaysia sustainably rejuvenating after more than a century of conservation and harvesting management? *PLoS ONE*, Vol. 9. 10.1371/journal.pone.0105069.
11. López-Angarita, J., C.M. Roberts, A. Tilley, J.P. Hawkins and R.G. Cooke, 2016. Mangroves and people: Lessons from a history of use and abuse in four Latin American countries. *For. Ecol. Manage.*, 368: 151-162.
12. Krauss, K.W., K.L. McKee, C.E. Lovelock, D.R. Cahoon, N. Saintilan, R. Reef and L. Chen, 2014. How mangrove forests adjust to rising sea level. *New Phytol.*, 202: 19-34.
13. Salampessy, M.L., I.G. Febryano, E. Martin, M.E. Siahaya and R. Papilaya, 2015. Cultural capital of the communities in the mangrove conservation in the coastal areas of Ambon Dalam Bay, Moluccas, Indonesia. *Procedia Environ. Sci.*, 23: 222-229.
14. Qiptiyah, M., Halidah and M.A. Rakhman, 2018. The structure of plankton community at mangrove and coastal area in Sinjai Regency, South of Sulawesi [In Indonesian]. *J. Penelitian Sosial Ekonomi Kehutanan*, 5: 137-143.
15. Lovelock, C.E., D.R. Cahoon, D.A. Friess, G.R. Guntenspergen and K.W. Krauss *et al.*, 2015. The vulnerability of Indo-Pacific mangrove forests to sea-level rise. *Nature*, 526: 559-563.
16. Mukherjee, N., W.J. Sutherland, L. Dicks, J. Huge, N. Koedam and F. Dahdouh-Guebas, 2014. Ecosystem service valuations of mangrove ecosystems to inform decision making and future valuation exercises. *PLoS ONE*, Vol. 9. 10.1371/journal.pone.0107706.
17. Murdiyarso, D., J. Purbopuspito, J.B. Kauffman, M.W. Warren and S.D. Sasmito *et al.*, 2015. The potential of Indonesian mangrove forests for global climate change mitigation. *Nat. Clim. Change*, 5: 1089-1092.
18. Nam, V.N., S.D. Sasmito, D. Murdiyarso, J. Purbopuspito and R.A. MacKenzie, 2016. Carbon stocks in artificially and naturally regenerated mangrove ecosystems in the Mekong Delta. *Wetlands Ecol. Manage.*, 24: 231-244.
19. Utomo, B., N.H. Rizki, R. Wahyudi, M. Basyuni and A. Dalimunthe, 2024. Diversity of MPTS (multi purpose tree species) in the forest area with special purpose (KHDTK). *Asian J. Plant Sci.*, 23: 244-251.
20. Sukuryadi and H.I. Johari, 2022. Community perception and participation in mangrove ecosystem restoration effort in Lembar Village, West Lombok Regency. *J. Econ. Social Fish. Mar.*, 10: 29-40.
21. Afonso, F., P.M. Félix, P. Chainho, J.A. Heumüller, R.F. de Lima, F. Ribeiro and A.C. Brito, 2022. Community perceptions about mangrove ecosystem services and threats. *Reg. Stud. Mar. Sci.*, Vol. 49. 10.1016/j.rsma.2021.102114.
22. Kusmana, C. and Sukristijiono, 2016. Mangrove resource uses by local community in Indonesia. *J. Pengelolaan Sumberdaya Alam Lingkungan*, 6: 217-224.
23. Setiawan, A., Abdul Razak, N. Syah and S. Diliarosta, 2023. Community activity in environmental management mangrove forest in Pariaman City. *Sci. Environ. J. Postgrad.*, 6: 290-295.
24. Sholeh, S., D.I.N. Evianovita, A.Y. Mayasari and A.A. Sudewo, 2024. The role of the community in the development of mangrove forest ecotourism in Pasar Banggi, Rembang Regency. *Indones. J. Environ. Disaster*, 3: 121-132.
25. Maulidah, F.Z., J. Iskandar and B. Gunawan, 2023. The tangible and intangible benefits of mangrove forests as a factor affecting community participation in mangrove management. *J. Trop. Etnobiol.*, 6: 112-125.
26. Manalo, G.I.M., 2023. Mangrove conservation: Awareness and attitudes of the local community. *Am. J. Tourism Hospitality*, 1: 35-43.
27. Nuraeni, E. and Y.W.C. Kusum, 2023. The role of community-based tourism for mangroves conservation in Banten, Indonesia. *J. Pengelolaan Sumberdaya Alam Lingkungan*, 13: 606-612.
28. Alvareza, M. and I. Leilani, 2020. Community structure of the mangrove forest in the tourism area of Pariaman City, West Sumatra. *Biosciences*, 4: 62-72.
29. Damastuti, E., R. de Groot, A.O. Debrot and M.J. Silvius, 2022. Effectiveness of community-based mangrove management for biodiversity conservation: A case study from Central Java, Indonesia. *Trees For. People*, Vol. 7. 10.1016/j.tfp.2022.100202.
30. Aipassa, M.I., M.E. Siahaya, H.S.E.S. Aponno, Y. Ruslim and R. Kristiningrum, 2023. Participation of community in mangrove conservation in coastal area of the Valentine Strait, West Seram, Maluku, Indonesia. *Biodiversitas J. Biol. Diversity*, 24: 2467-2474.