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Correlation Between Participation Variables and Forest Health Parameters in Mangrove Forest Management

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ABSTRACT

Currently, mangrove forests are experiencing a lot of damage and land degradation, which impacts the forest's health condition. One of the consequences is community activities. This study aims to determine the relationship between community participation based on management stages and the health status of mangrove forests in Margasari Village, East Lampung Regency. The methods in this study are through a quantitative approach, which includes: the calculation of community participation scores using the Likert scale method, assessment of forest health status using Forest Health Monitoring (FHM) techniques, and spearman rank correlation analysis. The results showed that the people of Margasari Village actively participated (high category) in managing mangrove forests. The health of mangrove forests in Margasari has an average score of 5.04 (moderate). Mangrove forests must be followed up, especially in pest and disease maintenance and monitoring activities. Thus, there is a significant real relationship between community participation variables based on the management stages to the health status of mangrove forests. The actual relationship is in the variables of the planning stage, implementation stage, maintenance stage, and evaluation of the tree crown condition parameters with a consecutive correlation coefficient value of 0.418, 0.410, and 0.482 (medium correlation).

1. INTRODUCTION

Currently, the forest is experiencing a decrease in land cover, which hurts the overall ecosystem and environmental conditions due to changes in land use [1, 2]. Forests in extreme areas such as mountains and coasts experience stress conditions strained by severe climatic changes, changes in water availability, fungi, and insects [3]. Mangrove forests experience various disturbance conditions based on intrinsic space and time. Mangroves are found along coastlines in tropical areas that support ecosystem services, production in fisheries, and nutrient cycles [4, 5], as well as roles in ecological and economic aspects [6]. Mangrove forests show a very high level of ecological stability. The meaning of stability refers to the consistency of environmental conditions, the role of the community, and the response of the community or ecosystem to disturbances [7].

Mangrove forests are productive coastal ecosystems that provide the benefits of environmental goods and services for the community [8], as well as a habitat for flora and fauna [9]. These ecosystems require intensive and sustainable management, and the contribution of local institutions or communities is needed in managing mangrove resources [10]. The role of a community or institution is the implication of social relations that describe community relations in an activity to reduce social unrest arising from their actions which can impact coastal ecosystem degradation and marginalization of local communities [11]. Most people in developing countries rely heavily on forests for livelihood, but there is a lack of alternative means to support their livelihoods [9].

Local community participation in forest governance through decentralization is one of the keys to sustainable use of forests through increased local knowledge, stronger accountability, and related perceptions of forest management rules [12]. The participation of local communities is one of the keys to success in forest management [13]. Successful management of mangrove forests can be seen from one of the indicators of its success, namely the health condition of the forest. Forest health is a reference in determining whether management in mangrove forest areas has gone well or not [14] towards suppressing the rate of deforestation due to land clearing [15].

Conflicts between communities over forest use affect the dynamics of forest management [9]. The dynamics of regulation and policy implementation affect community preferences for forests. Basically, mangrove forest management is carried out by communities that are members of community groups. Like the case study in the Margasari mangrove forest, forest management is carried out by forest farmer groups (KTH). This is important to know the social causality of the community, namely participation in ecological conditions or forest health conditions. This is very important to know so that it can be used as a reference in making decisions on mangrove forest management. So this study was conducted to determine the relationship between the level of community participation in the condition of mangrove forests in Margasari Village, Labuhan Maringgai District, East Lampung Regency.

2. METHOD

2.1 Tools, materials and research location

The tools and materials used in this study are compass, GPS, roll meter, tape meter, binocular, magic card, calculator, questionnaire guide, and SPSS Statistical 20 software. This research was conducted in the mangrove forest of Margasari Village, Labuhan Maringgai District, East Lampung Regency, Lampung Province, Indonesia. The location of cluster-plot observations of forest health can be seen in Figure 1.

2.2 Determination and data collection

The data approach used is quantitative analysis with case study methods. Data collection is done by giving questionnaires to the community and observation directly in the field. Questionnaire instruments are used to determine the level of community participation in mangrove forest management. Determination of respondents using the formula Slovin with an estimated error of 15% [16]. The total population at the research location was 154 people who were included in several community groups, so the number of samples used in this study was 35 respondents.

The questionnaire was given to respondents to determine the level of participation of each respondent in the management of the Margasari mangrove forest. Community participation in the management of mangrove forests is seen from four variables, namely management at the planning stage, implementation stage, utilization stage, and maintenance and evaluation stage. The form of questions and questionnaire instruments provided are as shown in Table 1.

While observations are directly carried out to obtain data on forest health conditions using ecological indicators. The study [14] was conducted using forest health monitoring (FHM) methods based on vitality indicators (tree damage and tree crown conditions) and site quality indicators (pH). Determination of the pH value using lab analysis. While determining the condition of tree damage using the following formula [17]:

$$\text{TLI} = [\text{IK } 1] + [\text{IK } 2] + [\text{IK } 3] \quad (1)$$

$$\text{PLI} = \frac{\sum \text{TLI}}{\sum \text{Tree in plot}} \quad (2)$$

$$\text{CLI} = \frac{\sum \text{PLI}}{\sum \text{Plot}} \quad (3)$$

where,

CLI= Cluster-plot-level damage index;
PLI= Plot level damage index;
TLI= Tree-level damage index;
IK 1, 2, 3= Damage index to 1, 2 and 3.

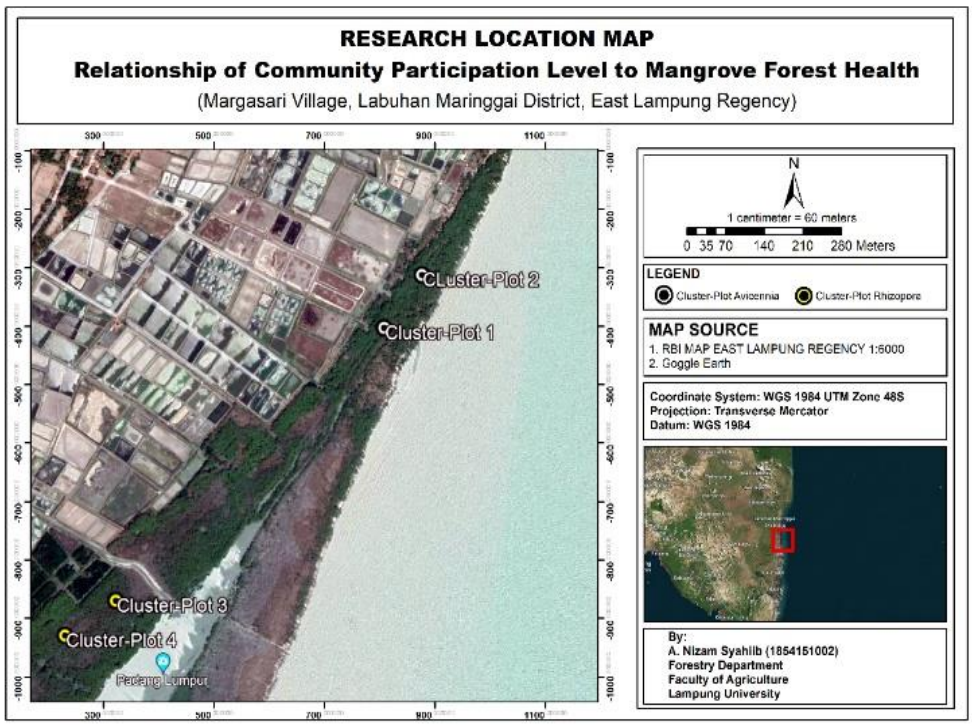

Figure 1. Observational cluster-plot determination map

Table 1. Questionnaire question design

Management Stages		Statement Form
Planning	1)	I participated in activities in planning/decision making in the context of mangrove forest management
Implementation	1)	I participated in mangrove planting activities
	2)	I participated in the rehabilitation activities for damaged mangrove land
Utilization	1)	I receive benefits/results from mangrove forest management
	2)	I obtain and receive results from the use of mangrove forests in the form of money
Maintenance and Evaluation	1)	I participated in mangrove maintenance activities and evaluated the rehabilitation results
	2)	I participated in monitoring and evaluation activities after the mangrove forest management activities

The observation plot plots are 4 clusters based on a management perspective. The determination of these clusters is based on mangrove tree types and dominant crown strata. The plot-cluster design can be seen in Figure 2.

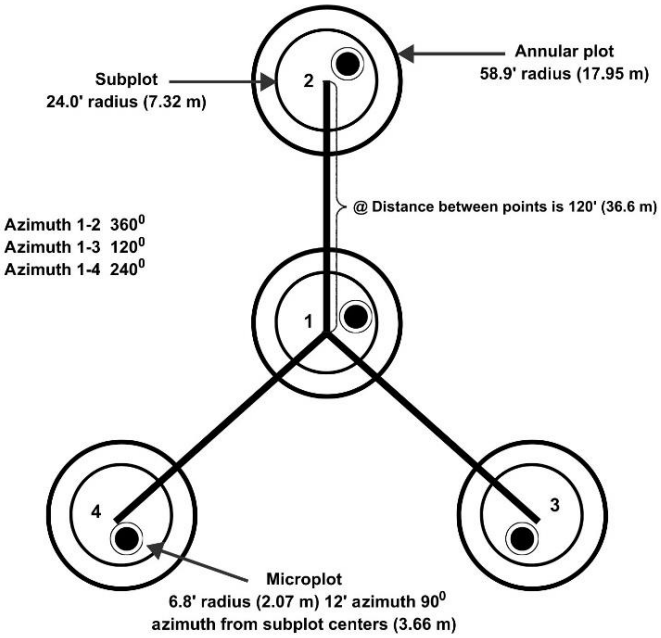

Figure 2. FHM cluster-plot design

FHM is a forest health monitoring technique that is the current status, changes, and trends of forest ecosystems based on the measurement of forest ecological indicators [18]. Figure 2 above is a form of a special measurement plot in monitoring forest health conditions. In one cluster plot (CL) there are 4 sample measurement plots, where in 1 set of sample measurement plots there are three types of plots, namely annular plots, sub plots, and microplots. The three types of sample measurement plots affect the type of growth phase of the observed stand. In the annular plot, observations are made of tree phase stands, in the sub plot, pole phase, and in the micro plot, namely the sapling and seedling phases.

2.3 Data analysis

Analysis of the level of community participation is seen based on the results of calculations and scores for each parameter using the Likert Scale formula. After the score is calculated, categorization is carried out. The categories used are low participation, medium participation, and high participation [19]. Calculation of indicator values and mangrove forest health parameters is based on the FHM technique [20]. Tree damage is calculated by measuring the level of damage; crown condition is calculated based on Live Crown Ratio (LCR), Crown Density (Cden), Foliage Transparency (FT), Crown Diameter (Crown Diameter Width and Crown Diameter at 90º), and Dieback (CDB); and site quality based on soil pH values [21]. The final value of the forest health parameters is in quantitative form which will be analyzed statistically with the participation score value.

Then, the data collected in the analysis to find out the relationship between participation rates to the health of mangrove forests Margasari Village using correlation coefficient analysis with Rank Spearman. According to Thirumalai et al. [22], the Pearson coefficient is the covariance between two variables affected by their standard deviation. Analysis of correlation coefficient tests is used to determine the relationship between community participation and forest health values. This correlation determines the positive or negative relationship between two analytical variables. The observation variable consists of variable X, namely the level of community participation based on the management stage, and variable Y, namely the value of forest health. According to Thirumalai et al. [22], as for the formula that can be used, as follows:

$$rs = 1 - \frac{6\sum D^2}{n(n^2-1)} \quad (4)$$

where,

rs= Spearman Rank correlation coefficient;
D= ranking difference between variables X and Y;
n= number of cases or samples sorted.

Relationship category determination can use coefficient intervals (Table 2). Once it is known how strong the relationship is, to know whether or not a significant relationship is done by looking at the value of sig., with the approach when sig. <0.05, then there is a significant relationship if the value is sig. >0.05, then there is no significant relationship.

Table 2. Relationship strength guidelines

Correlation Coefficient	The Power of Relationships
0.000–0.199	Very Low/Weak Correlation
0.200–0.399	Low Correlation
0.400–0.599	Medium Correlation
0.600–0.799	Strong Correlation
0.800–1.000	Very Strong Correlation

Hypothesis used:

H0: There is a significant relationship between the level of community participation and forest health values.

H1: There is no significant relationship between the participation level variable and forest health values.

3. RESULT AND DISCUSSION

One of the coastal areas with potential for its ecosystem is the District of Labuhan Maringgai East Lampung Regency. Margasari Village is one of the villages where most of the area is a mangrove forest ecosystem. One of the functions and uses of mangrove forests for local communities is as a source of livelihood to support the social and economic life of the community by utilizing and managing the results in mangrove forests. In 2005, the area owned by mangrove forests Margasari Village, Labuhan Maringgai District, East Lampung regency was 700 ha with various species of flora and fauna existing [23]. The potential seeded in this area is the beauty of the landscape in the form of mangroves in the vast expanse of the Margasari coastal area. The types of mangroves found in this village include white api-api (*Avicennia marina*), bakau (*Rhizophora apiculata*), jeruju (*Acanthus ilicifolius*), and red pidada (*Sonneratia caseolaris*). Avicennia and Rhizophora vegetation are very dominant in this location [24]. The arrangement of vegetation affects its functions [25] and benefits [26]. Related, the area's management is carried out

directly by the local government by issuing a decree addressed to community groups to conduct intensive care and management of mangroves in Margasari Village.

3.1 Participation rate based on management stages

A community-based forest management program (PHBM) is a forest area management program that is applied in mangrove forests Margasari Village Labuhan Maringgai District of East Lampung Regency. This is the main essence in applying the PHBM program to see how the involvement or participation of the community directly or indirectly in managing mangrove forests is based on the stages of management. According to Alfandi et al. [27], increasing community participation is important and very useful in sustainable mangrove forest management. The management stage consists of planning, implementation, utilization, maintenance, and evaluation stages. The success of mangrove forest management stages can be seen based on community participation (Table 3).

The concept of planning in reflection of participation as management development is a combination of two bodies, namely participation as an ideological approach, a special ethos for community development, and as a plan or formula that is prepared in a policy framework related to natural resources and development activities that will be carried out in a certain zone [28] and as various plans in the implementation of ecotourism based on ecology [21]. Based on Table 3, the level of community participation is at a high interval with a percentage of 54.29%. This is because the community is aware that good planning is needed in carrying out forest management. The characteristics of the community support public awareness. Understanding the characteristics or preferences of the community is the first step to be able to develop programs in mangrove forest management activities [29], so that policies or activity projects will respond to it in reality and adjust to the social and economic conditions of the community [28].

Good Forest Governance is a concept of implementing mangrove forest management that leads to environmental aspects. Indicators of implementation are the activeness and frequency of community participation in activities such as mangrove planting, be it initiatives on individuals, NGO activities, or the government. Based on Table 3, the community plays an active role in implementing mangrove forest management, with the number of respondents in the high category percentage of 54.29%. However, from all respondents, there are still people who are less active in participating. The high level of community implementation in mangrove forest management activities is caused by the intensity or frequency of the community in carrying out management activities such as repair and seeding properly and correctly. This is also related to management, ownership, and restrictions on land use [30].

The utilization of forest products is a form of interaction between communities to meet economic needs [31]. In addition to producing timber and non-timber forest products, the mangrove forest in Margasari Village is expected to provide social benefits such as providing clean water, recreation, and benefits for biodiversity [20, 30], so it is necessary to have a policy that regulates the utilization of the products in the forest mangrove forest [32]. Based on Table 2, the community is still relatively low in utilizing forest products in the mangrove forest of Margasari Village, with a percentage of 54.29 in the medium category. This is because there is still a lack of understanding and assistance to the community in utilizing forest product management which is influenced by education level [33]. Different from the opinion [12] that the level of education has nothing to do with the level of community participation in the protection and use of forest resources. According to Salampessy et al. [34], people assume that all products or natural resources can be utilized and passed down from generation to generation. Therefore, the optimization of mangrove forest products has a positive impact on the community.

The last stage in mangrove forest management is maintenance and evaluation activities. Evaluation activities are a systematic assessment process, attributes, appreciation, problem recognition, and solutions to problems found in the implementation process. This stage becomes a reference in decision-making [28]. Based on Table 3, these results show a significant difference between one category and another. The community has been active in carrying out maintenance and evaluation activities. To optimize this, it is necessary to involve various parties in the monitoring and evaluation process to provide progress on specific aspects of the mangrove forest management plan [35].

Determination of community participation levels based on management stages includes the stages of planning, implementation, utilization, maintenance and evaluation. The participation rate of the mangrove forest community of Margasari Village based on the stages of management can be seen in Table 4.

Table 3. Participation rate based on management stages

Stage	Number of Respondents			Average Category	Percentage Average Category (%)
	Low	Medium	High		
Planning	5	11	19	High	54.29
Implementation	2	14	19	High	54.29
Utilization	1	19	15	Medium	54.29
Maintenance and Evaluation	4	11	20	High	57.14

Table 4. Community participation rate based on management stages

Score Interval	Category	Number of Respondents	Percentage (%)
7-11	Low	4	11.43
12-16	Medium	13	37.14
17-21	High	18	51.43
Sum		35	100

Based on Table 4, it can be concluded that the participation of the Margasari Village community in mangrove forest management is high. The community, especially the management community, actively participates in mangrove forest management activities. People know their responsibility is to care for and maintain the mangrove forest ecosystem around their residences. Community participation is key to the success of community-based forest management programs. Some factors that can affect the level of participation are gender, age, and place of residence (length of residence) [36]. Community involvement and participation in the development of mangrove forest ecotourism Margasari Village becomes the main formula in conservation efforts based on the field of conservation and forest management [14, 37]. According to Dög et al. [38], it is not only the surrounding community that must play an active role in forest management, but external parties have a role in this.

Overlapping utilization and management of mangroves is a form of illustration that stakeholder coordination is still lacking [9]. This can affect the level of community participation in mangrove forest management. The dynamics of regulations and policies affect the conflict of community interests in conservation efforts [35]. The orientation of forestry development is currently shifting towards a better direction, namely oriented towards the management of forest resource ecosystems based on community empowerment [30]. This is what makes it important that regulations and stakeholder coordination influence community participation.

3.2 Forest health

The function of mangrove forest vegetation is to produce organic matter [39] as an indicator of forest health so that forest functions can run well [20]. There need to be activities carried out by the community that leads to forest health conditions, namely monitoring the health of mangrove forests [40], to obtain ideal data to support sustainable mangrove forest management [14]. This study used vitality and site quality indicators to determine forest health values (Table 5).

Table 5. Value of ecological parameters measurement of forest health conditions

Cluster-Plot FHM	VCR	CLI	pH Soil
1	2.2721	2.5634	6.6
2	2.2224	2.0652	6.2
3	2.1766	3.2269	7.1
4	2.2126	3.0235	7.3

Based on Table 5, the highest value of tree damage is in cluster plot 3 and the value of crown condition is in cluster plot 1. The greater the value of forest damage, the worse the health condition of the forest, but conversely with the condition of the tree crown, the greater the value, the better the health condition. According to Safe'i et al. [17] and Maulana at al. [21], the condition of damage to a tree can be caused by several factors, namely biotic factors, and abiotic factors, and can be seen from the physical condition of the tree in tree organs that experience abnormalities or the discovery of disruptive organisms. Damage to mangrove trees will affect the growth and development of these trees and can inhibit the physiological function of trees optimally to reduce the mangrove forest's productivity [41]. Old trees with small vitality values and large tree diameters are likely to be threatened with extinction so that they can determine their condition and suitability in a forest area, especially mangrove forests [3].

The site's quality is an indicator of forest health related to the conditions in which vegetation grows, especially in mangrove forests [40]. According to research by Dewi et al. [42], fertile soil will affect the optimization of tree productivity and vitality. Based on Table 5, the pH results indicate that the site quality of mangrove vegetation in Margasari Village is acidic. The right site quality (normal pH) supports the growth of mangrove vegetation. The pH value is related to vegetation's physical, chemical, and biological properties [43], affects the accumulation of carbon and nitrogen [44], and involves the process of increasing soil water retention capacity [45].

The health of mangrove forests is most influenced and dominated by the condition of mangrove vegetation stands. This can be triggered by several external factors. One phenomenon that is currently being hotly discussed is climate change [21]. Climate change is a phenomenon that causes several impacts of damage in various sectors, one of which is the forestry sector. This condition is what causes the condition of the level of health and damage to mangrove stands in the Margasari Mangrove Forest. Mangrove forests are an example of stands that contribute greatly to climate change, so that the two are interrelated. If the mangrove forest is damaged, the potential for climate change or weather anomalies is greater. Conversely, if the impact of climate change on coastal ecosystems is the large ebb and flow of sea water, this will have an impact on damage to mangrove stands [14].

3.3 Community participation relationship to forest health

Significant relationship or not shows the relationship of each observation indicator in the community and mangrove forests in Margasari Village. The results of the Spearman rank analysis can be seen in Table 6.

Table 6. Community participation rate relationship to forest health status

Forest Health / Participation Rate	Condition of Tree Damage		Condition of Tree Crown		Site Quality (Soil pH)	
	Correlation Coefficient	Sig.	Correlation Coefficient	Sig.	Correlation Coefficient	Sig.
Planning	-0.356	0.036*	0.418	0.012*	-0.300	0.800
Implementation	-0.191	0.271	0.410	0.014*	-0.292	0.089
Utilization	-0.207	0.233	0.207	0.233	-0.180	0.301
Maintenance and Evaluation	-0.277	0.107	0.482	0.003*	-0.172	0.323

Table 6 shows no strong relationship between the indicators. Only the utilization stage did not have a significant relationship with the condition of the tree canopy. Based on the table above, the sig. value marked with an asterisk indicates that there is a relationship between community participation (planning, implementation, maintenance and

evaluation) and forest health (tree damage and canopy condition). This is in accordance with the field results described by respondents that they still lack understanding and skills in utilizing and managing forest products, especially not wood in the Mangrove forests of Margasari Village. The results of Spearman rank analysis showed that the correlation coefficient at all stages to the crown condition has a moderate level of relationship. Meanwhile, indicators of the stages of mangrove forest management to forest health parameters, namely the condition of damage and the site's quality, have a very low value. It can be concluded that changes or activities at the management stages will not significantly change the condition of tree damage and site quality. The strength of the high relationship has a very close relationship between the stages of mangrove forest management to forest health [14]. In previous study [41], researchers explained that the range of correlation coefficients in the range of 0.76-0.99 (strong correlation) will show a solid relationship between variables/indicators.

At the planning stage, only the parameters of the crown condition have a significant relationship. This can be due to the activeness of the community at the planning stage in the preparation of seedlings and planting activities. Margajaya group has planning activities, namely nurseries located in 2 locations so that they are able to produce seeds in large quantities at the same time. Breeding is carried out every 6 months and Margajaya groups always have seed supplies for mangrove forest planting and embroidery activities [19]. The active participation of the community in mangrove forest management is so that mangrove forests are avoided from damage and can benefit the community socially and economically [46].

Based on the study results in Table 6, the condition of good tree damage parameters is in the indicator of vitality precisely the condition of the tree crown. The condition of the tree crown in mangrove forests has been very good, with marked participation that leads to the indicator. Poor forest health leads to conditions of damage to large stands. Damage will impact the growth of the tree so that it has a negative impact on stands and ecosystems resulting in biomass loss, low crown conditions, and tree mortality [17, 47]. The condition of the stand that has a broad and tight crown condition shows that the growth process on the stand can take place optimally. Conversely, if the condition of the upright crown in bad conditions will disrupt growth, the process of photosynthesis can be inhibited and result in little and no optimal energy produced [41]. Tree growth is also affected by water conditions in the surrounding watershed.

The ecological condition of the forest is certainly influenced by the actors who play a role in the forest, including community participation. The community plays a role in the dynamics of forest management, which will lead to good or bad forest policy directions. This means that the main key to the success of sustainable mangrove management starts from the success of the community at the grassroots level [36, 40]. Based on the results of the study, several social variables affect the causality of ecological variables. This is supported by several studies [28, 37, 46], that active community participation is one of the keys to maintaining the mangrove forest ecosystem.

Sustainable forest management can be seen from the active participation of stakeholders [23]. Therefore, maintaining the condition of tree vegetation in the conservation of water resources is not only the duty of the government, but the local community has an important role [17, 48]. Therefore, the existence of an active role in the community is very important to apply. This has to do with how the sustainability of the ecosystem can run well and can benefit the wider community.

4. CONCLUSIONS

The participation level of Margasari Village people is determined based on the management stages, which include the stages of planning, implementation, utilization, maintenance and evaluation. Based on these stages, the community is active in carrying out mangrove forest management activities in the good category, with the number of respondents as many as 18 people. This participation is related to the sustainability of mangrove forests in the health condition forests. Forest health conditions with categories in plot cluster 1, medium categories on cluster plots 2 and 4, and bad categories in plot clusters 3. Thus, the final value and health condition of mangrove forests is 5.04, which is moderate. Community participation based on the stages of forest management has a significant correlation, namely, in the stage of planning, implementation, maintenance and evaluation of forest health parameters, namely the condition of tree crowns, and the results of Spearman rank analysis tests show that the correlation coefficient there is a moderate correlation that is worth 0.418; 0.410; and 0.482.

Community preferences for participation in mangrove forest management are influenced by several factors, including regulations and policy implementation. This can affect the community's perspective on forest functions. In addition, clear regulations can provide community boundaries in the utilization and management of mangrove forests. The role of stakeholders in assisting communities around mangrove forests is important. This study, in terms of quality and statistical analysis, looks at the relationship between participation variables and forest health variables. The limitations experienced by researchers are the limitations of the variables obtained so that the analysis model cannot be produced. Thus, for further research, it is necessary to expand the research variables to be able to produce a statistical model. This is important because this study is unique in observing the relationship between social and ecological phenomena.

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