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Analysis of Changes in Health of Coastal Mangrove Forest on the East Coast of Lampung

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Abstract. The mangrove forest is a forest ecosystem that supports life for the surrounding ecosystem. However, the area of mangrove forests is decreasing. It is recorded that up to 2016, there is only 2.9 million hectares of mangrove forests in Indonesia. Mangrove forests' existence needs to be maintained in the surrounding ecosystem. One of the efforts to protect the mangrove forest ecosystem is to see changes in mangrove forest health. This effort can be used as the basis for sustainable mangrove forest management—this research's purpose—this the real aim of mangrove forests on the east coast of Lampung. The study was conducted at three locations on the east coast of Lampung (Pasir Sakti District, Labuhan Maringgai District, and Way Kambas National Park). The method used was the Forest Health Monitoring (FHM). The results showed that mangrove forests' health value on the east coast of Lampung had positively changed except for cluster plots 2 and 3. The health of mangrove forests on the east coast of Lampung has increased the forest's health value. The increase in forest health value is influenced by factors from the indicators used, especially vitality.

1. Introduction

The mangrove forest is a forest ecosystem that supports life for the coastal ecosystem. Mangrove forests are located on the coast and are affected by the tides of the seawater. Mangrove forests have many essential benefits for the surrounding ecosystem, both from an ecological and economic perspective [1]. Mangrove forests can also protect the surrounding ecosystem from exposure to strong winds from the sea, abrasion, seawater intrusion, and tsunamis. Furthermore, mangrove forests play an essential role in marine life's survival, namely as a nursery area and habitat for various kinds of fish, shrimp, shellfish, and others [1]. Therefore, mangrove forests need to be preserved.

Mangrove forest cover in Indonesia has decreased quite drastically during the past 2.5 decades. In 1990, it was reported that 3.5 million hectares along \pm 99,000 km of Indonesian coastline were covered by mangrove forests. However, in 2016 the mangrove forest cover in Indonesia decreased to 2.9 million hectares [2]. Mangrove forests need to be preserved because of their enormous benefits for the surrounding ecosystem. Therefore, it is necessary to make efforts to protect the mangrove forest. One of the steps to maintain the preservation of mangrove forests is monitoring forest health. Forest health monitoring is a monitoring method, assessing, and reporting on the current status, changes, and long-term trends in the health of forest ecosystems [3]. Forest health monitoring is necessary to obtain reliable data to achieve sustainable mangrove forest management. This is because the main objective of forest health monitoring is sustainable and sustainable forest management.



Forest health monitoring needs to be done in various types of forests, including mangrove forests on the east coast of Lampung. On the east coast of Lampung, there are mangrove forests, which are quite extensive, starting from the conservation area of Way Kambas National Park (TNWK), Labuhan Maringgai District, and Pasir Sakti District. The total area of the three locations in 2013 was 5,952.55 Ha. In 2019, Lampung's east coast had been measured to get the health status value of mangrove forests [4]. In the first measurement, the status category is "moderate" [5]. This study aims to analyze changes in the health of mangrove forests on the east coast of Lampung.

2. Method

This research was conducted in the mangrove forest on the east coast of Lampung, which includes the TNWK, Labuhan Maringgai, and Pasir Sakti areas. This study uses a forest health monitoring technique (FHM). The stages of this research involve observing the location of cluster plots, monitoring changes in forest health, categorizing, and assessing changes in mangrove forest health. The detailed research stages are as follows.

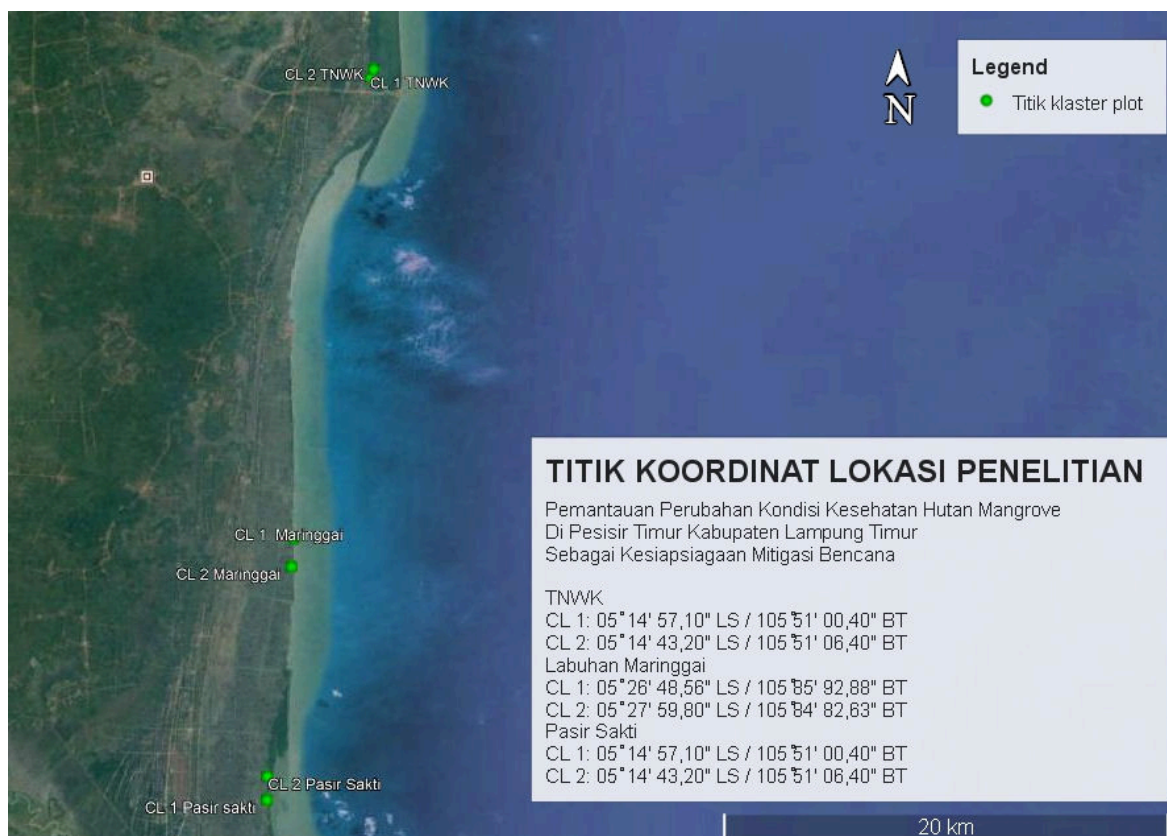


Figure 1. Research location

2.1. Observation of the Location of the Mangrove Forest Health Change Plot Cluster

The observations are intended to check the condition of the location of the six cluster plot clusters that have been built. The plot cluster was created based on forest management prescriptions. The prescriptions of forest management in the plot cluster's construction are mangrove species (*Rhizophora* sp. And *Avicennia* sp.) In three locations (Way Kambas National Park, Labuhan Maringgai District, and Pasir Sakti District), with a cluster plot design as in Figure 1.

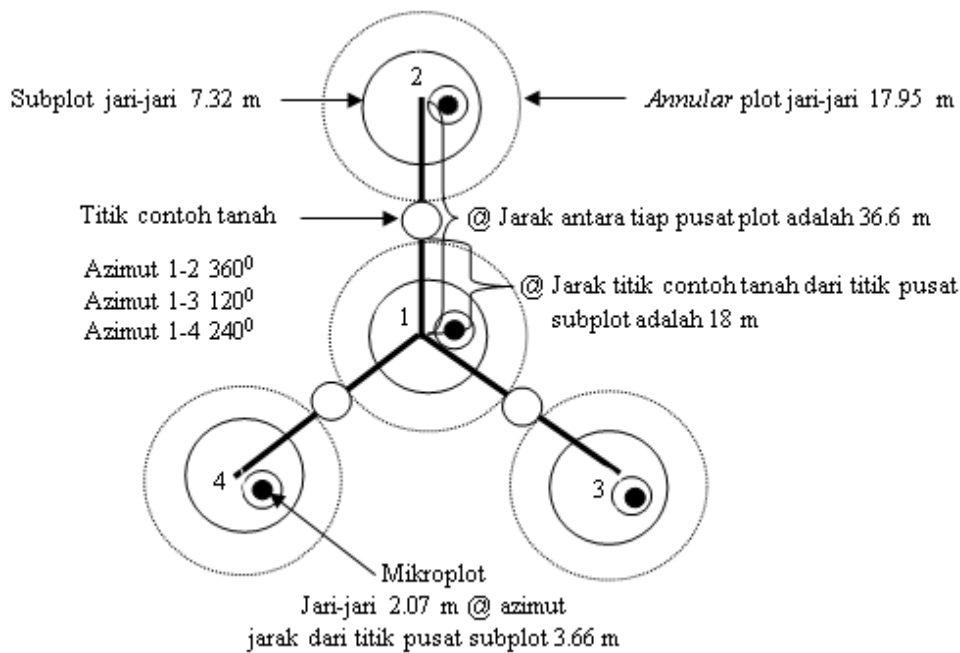


Figure 2. Plot Cluster Design [6]

2.2. Monitoring Changes in Mangrove Forest Health.

At this stage, changes in forest health are measured based on ecological indicators of mangrove forest health. Measurement of changes in mangrove forest health is carried out on indicators of ecological parameters resulting from the formulation of quality assurance indicators for mangrove forest health parameters. Ecological indicators of mangrove forest health include vitality and site quality [7]. Forest health measurements for each indicator of mangrove forest health parameters are as follows:

2.2.1. Vitality

Vitality measurements are carried out by measuring the condition of tree damage and crown conditions [8,9]. Tree damage and crown condition were measured for trees within the subplot. Damage to trees was measured based on the location where the damage was found, namely: roots, stems, branches, crowns, leaves, shoots, and shoots (Figure 3). Tree crown condition was measured based on the following parameters: Live Crown Ratio (LCR), Crown Density (Cden), Foliage Transparency (FT), crown diameter (Crown Diameter Width and Crown Diameter at 90°), and dieback (CDB).

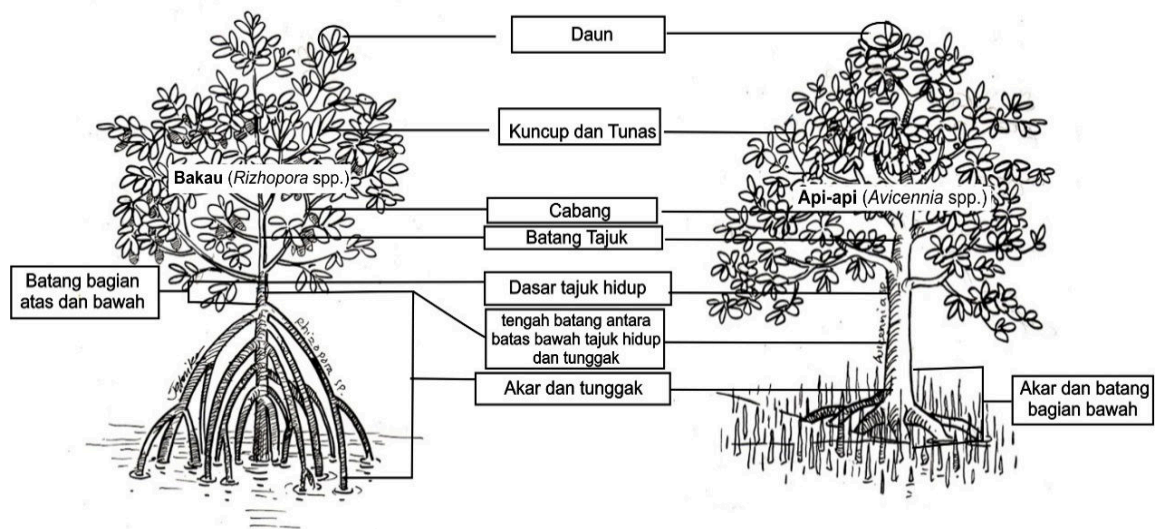


Figure 3. Location of Damage to Mangrove Trees (Adoption from Mangold, 1997)

2.2.2. Soil quality

Measurement of site quality is carried out by taking soil samples from three circular points located between two subplots, with each circle having a diameter of 15 cm.

2.3. Categorization and Assessment of Changes in Mangrove Forest Health.

2.3.1. Categorization of changes in mangrove forest health

The category of mangrove forest health change consists of 3 (three) classes: fair, medium, and foul. The category of change in mangrove forest health is obtained from the threshold value for mangrove forest health changes. The threshold value of mangrove forest health change is obtained based on the highest and lowest value of the final value of mangrove forest health change in each mangrove forest cluster.

2.3.2. Assessment of changes in mangrove forest health

The final value of mangrove forest health is obtained from the multiplication between the weighted value and the parameter score value of each indicator of mangrove forest health changes. The formula for the final value of forest health [8] is:

$$NKH = \sum (NT \times NS)$$

Information:

NKH	= final value of forest health condition
NT	= parameter weighted value of each forest health indicator
NS	= parameter score value of each forest health indicator

3. Result and Discuss

Health monitoring is a technique used to determine the current status of forest conditions, changes, and trends that may occur in the long term [6]. Forest health monitoring data can be used as a reference for managing mangrove forests sustainably and sustainably. Also, measuring forest health can be used to ensure forest functions and benefits [10]

Based on the research results, mangrove forests' health on the east coast of Lampung has changed, but the changes tend to be small. Changes occurred in the vitality indicator, while the site quality indicator did not. Changes in the value of the vitality indicator are presented in table 1.

Table 1. The results of the analysis of changes in the parameter value of the CLI (Cluster Level Index)

CL	1st measurement	2nd measurement	change
1	3.69	3.72	0.03
2	3.85	3,9	0.05
3	2.07	2.70	0.63
4	1.58	1.58	0.00
5	1.09	1.09	0.00
6	1.21	1.18	-0.03

Based on table 1, changes in negative values occur in cluster plot 6, which means there is an increase in tree damage in cluster plot 6. In clusters 1, 2, and 3, there is a change in positive values, which decreases the level of tree damage. Clusters 4 and 5 did not change.

The quality of the crown also influences forest vitality. The quality of the crown will play a role in the photosynthesis process that occurs in each tree. Changes in the value of the header quality are presented in table 2.

Table 2. The results of the analysis of changes in the value of the VCR (Visual Crown Ratio) parameter

CL	1st measurement	2nd measurement	Change
1	0.88	0.9	0.02
2	0.35	0.4	0.05
3	3.33	2.70	-0.63
4	3.72	3.58	-0.14
5	3.58	3.58	0.00
6	2.91	2.91	0.00

Table 2 shows that two plot clusters have decreased the quality of their crowns, namely the plots 3 and 4 clusters. Changes in a positive direction occur in cluster plots 1 and 2, but the changes that occur are not significant. The cluster plots that did not change in the crown's quality were cluster 5 and cluster 6.

Table 3. Results of the analysis of changes in the value of site quality indicators

CL	1st measurement	2nd measurement	Change
1	19.32	19.32	0.00
2	19.45	19.45	0.00
3	18.25	18.25	0.00
4	19.2	19.2	0.00
5	16.53	16.53	0.00
6	17.51	17.51	0.00

In the analysis of soil quality measurements in table 3, there was no change in each cluster plot. Furthermore, to obtain forest health values, this is done multiplication of the weighted value with each indicator's score. The results of the analysis of changes in forest health values are presented in table 4.

Table 4. Results of analysis of changes in forest health value

CL	Measurement 1	Measurement 2	Change
1	9.9	10.35	0.45
2	11.7	11.7	0
3	4.32	2.52	-1.8
4	8.1	8.55	0.45
5	6.57	7.47	0.9
6	4.23	5.13	0.9

Table 4 shows that the value of mangrove NKH on the east coast of Lampung has generally changed positively. This means changes in the health of mangrove forests on the east coast of Lampung are getting better. But there is one cluster plot that has changed negatively, namely cluster plot three, and there is a cluster plot that has not changed, namely cluster plot 2.

This negative change in NKH could be caused by a decrease in the quality of the forest health indicators used. Four ecological indicators can be used in monitoring mangrove forest health, namely, productivity, biodiversity, site quality, and vitality [5]. Each of these indicators influences one another. The indicators used in this study were the vitality and quality of the site. The indicator that has the most decisive influence in monitoring mangrove forest health is vitality [5]. The vitality indicator has two parameters, namely tree damage and crown condition.

Increased tree damage factors can cause changes in mangrove forest health. Pertiwi et al., 2019 explained the increase in human activity and the influence of biotic and abiotic factors that can reduce tree health conditions. A decrease in tree health can be seen based on the type of damage. The type of damage that occurs can be caused by various factors, such as disease, pest attacks, weeds, fire, weather, and animals [12]. Damage to mangrove trees affects the growth and survival of mangrove trees [12] to affect the quality of the vitality indicator [13].

Also, the decrease in this vitality indicator's quality can be caused by the low level of biodiversity so that pests and diseases can spread due to the relatively homogeneous vegetation composition. The story of biodiversity will affect forest resilience, where the higher the level of biodiversity in a forest will increase forest resilience [14]. Forest sustainability studies cannot be separated from plant or tree communities' existence, [15] explained that in terms of ecology, a healthy forest is a forest that shows a balanced interaction between all components in the woods, both biotic and abiotic. The indicator that most influences the health of mangrove forests.

A decrease in the quality of the crown condition also affects the mangrove NKH. The crown condition is indicated by the value of the LCR live crown ratio, crown density, crown transparency, crown diameter, and dieback (dieback) [13,16]. The crown condition's quality can decline due to tree damage factors or due to lack of nutrients due to low site quality. The rate of the site is directly proportional to the level of soil fertility so that that plant growth will be supported by a good site quality [17]

4. Conclusion

The health of mangrove forests on the east coast of Lampung has increased the forest's health value. The increase in forest health value is influenced by factors from the indicators used, especially vitality. The increase in vitality value was caused by an increase in the crown condition's quality and a decrease in the level of tree damage.

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