Analysis of internal factors affecting the health condition of mangrove forests in the coastal area of East Lampung Regency

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Abstract. The surrounding community widely uses mangrove forests as a fulfillment of life. This requires an efforts to preserve the mangrove forest so that no damage occurs. This study aimed to determine the internal factors that affect the health condition of mangrove forests. The research method used to obtain internal factor data is by measuring the ecological indicators of forest health using the Forest Health Monitoring (FHM) method, then the data is processed by the Multiple Regression Analysis method using SPSS 20 through data on internal factors of mangrove forest health which are analyzed for their effect on health conditions of the mangrove forest. The results showed that the significant value of the regression was 0.008 (α = 0.05) > 0.008), this means that simultaneously the independent variables (tree damage, crown damage, Cation Exchange Capacity-CEC, and biodiversity have an effect on the dependent variable (mangrove forest health) at the level of = 5%. Furthermore, through individual regression coefficients from internal factor data, it is found that the internal factors of biodiversity indicators in measurements 1 and 2 and crown conditions in the second measurement do not affect forest health conditions. Therefore, this research concludes that the internal factors that affect the level of forest health in the first measurement are vitality indicators (tree damage/cluster Plot Index-CLI and crown condition) and site quality indicators (CEC). Meanwhile, in the second measurement, there was a change in the crown condition parameters, which did not significantly affect forest health.

1. Introduction
Mangroves are forest vegetation that grows between tidal lines, so that mangrove forests are also called tidal forests. Mangroves are rare ecosystems because they cover only 2% of the earth's surface [1]. Nevertheless, this ecosystem has critical ecological, socio-economic, and socio-cultural roles; for example, maintaining coastal stability from abrasion, sources of fish, shrimp, and other biodiversity,
sources of firewood and building wood, and has the function of conservation, education, ecotourism, and cultural identity [2]. In addition, mangroves play a crucial role in sustainability and human livelihoods and are widely used to source food, wood, fuel, and medicine [3].

The forest formation on the coast of East Lampung Regency is dominated by mangrove vegetation; with the formation of the mangrove forest, the coastal area will be protected from the damage that occurs, both coastal abrasion, seawater intrusion, and so on, so that economic activities can run well. Although necessary, the mangrove forest in the Coastal area of East Lampung continues to experience a decline in the area. Because of the number of uses made by the community in the mangrove forest, efforts must be made to maintain the mangrove forest in order to prevent damage. Paying attention to the health of mangrove forests is one means of ensuring their function and purpose, as well as their long-term viability.

Monitoring of forest health is carried out to determine the current condition of the forest. These changes occur in the future and trends that may occur due to activities that have been carried out in the forest [4]. Forest health indicators used in various forest types include productivity, vitality, biodiversity, and site quality [5]. Monitoring forest health is considered essential to be applied to various types of forests, one of which is mangrove forests. Information on the health condition of forest ecosystems in several countries has become sustainable forest management, so it is necessary to carry out regular monitoring. This study aimed to determine the internal factors that affect the health condition of mangrove forests.

2. Methods and equipment
This research was conducted in July 2019 for the first measurement and in September 2020 for the second measurement in the coastal mangrove forest area of East Lampung Regency, which is located in three mangrove forest areas (Labuhan Maringgai District, Pasir Sakti District, and Way Kambas National Park). The tools used to determine the factors related to the health condition of mangrove forests are data on internal forest health factors, which include vitality indicators, biodiversity indicators, and site quality indicators. The internal factor variable data was obtained by measuring the ecological indicators of forest health using the Forest Health Monitoring (FHM) method carried out by [6]. The internal factor data is then calculated and analyzed using SIPUT (Sistem Informasi Pemantauan Kesehatan Hutan) Software.

The internal factor data obtained were then analyzed to determine its effect on forest health using the multiple regression analysis methods and continued with the F test using SPSS 20. Multiple linear regression analysis was conducted to determine the influence of internal factor variables on forest health values. After the analysis is done, the first hypothesis is tested, namely the F test, to test the effect of the independent variable on the dependent variable as a whole. [7], the second hypothesis testing can be shown through the t-test to partially test the effect of the independent variable on the dependent variable. The specific models used in multiple regression research are [8]:

\[ Y = a + X_1b_1 + X_2b_2 + \ldots + X_i b_i \]  \hspace{1cm} (1)

So the regression equation model in this study is:

\[ Y = a + X_1b_1 + X_2b_2 + X_3b_3 + X_4b_4 \]  \hspace{1cm} (2)

where:
- \( Y \) = Forest Health Value (NKH)
- \( a \) = Constant
- \( X_1 \) = Tree damage (CLI)
- \( X_2 \) = Crown condition (VCR)
- \( X_5 \) = Cation exchange capacity (CEC)
- \( X_4 \) = Biodiversity (H')
The relationship between the dependent variable (Y) and the independent variable (X) mathematically can be formulated as follows: \( Y = f(X_1, X_2, X_3, X_4) \). This study uses an error rate of 5% or a truth level of 95%; in this case, it is necessary to carry out a significant test and regression Analysis with the following hypothesis.

\[ H_0 = \text{The regression coefficient of the variables that affect forest health is not significantly different.} \]
\[ H_1 = \text{The regression coefficient of the variables that affect forest health is not significantly different (b1≠0)} \]

3. Results and Discussions

3.1. Forest Health Change Assessment

Assessment of changes in forest health was carried out on two measurements. The data measured in the assessment of changes in forest health are ecological indicator data of mangrove forests consisting of biodiversity indicators (tree species diversity index/\( H' \)), vitality indicators (tree damage/cluster plot index-CLI and crown conditions/Visual Crown Ratio-VCR) and site quality indicators (CEC). Based on two measurements, the average value of each parameter of the ecological indicators of forest health is obtained, presented in Table 1.

| Table 1. The average value of the ecological indicator parameters of mangrove forest health in each FHM cluster-plots |
|---------------------------------------------------------------|
| Ecological indicators of forest health | The value of ecological indicators of mangrove forest health | 1st measurement | 2nd measurement |
| CLI | VCR | CEC | CLI | VCR | CEC |
| 1.08 | 3.56 | 18.53 | 1.17 | 3.47 | 18.53 |

Information:
\( H' \) = Species diversity index
CLI = Cluster-plot Level Index
VCR = Visual Crown Ratio
CEC = Cation Exchange Capacity

The condition of changes in the CLI level (Table 1) shows that damage in the Mangrove Forest of East Lampung Regency has increased. The dominant damage that occurred in the mangrove forest in Margasari village was open wound damage. In addition to other damage, which was relatively high, there was damage to the dominant shoot loss and broken branch damage. Environmental factors and unsupportive growing places also affect the condition of tree damage to inhibit the growth of a plant. In addition, biotic factors such as pests, diseases, and the effects of other living things can also cause damage [9]. Environmental incompatibility (biotic and abiotic) with plants will give an adverse reaction so that it can cause interference [10] and become the leading cause of plant damage [11].

Changes in the mangrove forest crown in Figure 1 show that the condition of the mangrove forest crown in the East Lampung Regency is decreasing. Changes in crown conditions can occur due to environmental conditions around the mangrove forest experiencing a decline influenced by the availability of nutrients, sunlight, water, and sufficient growth space for tree crown growth. In addition, the occurrence of damage to the mangrove tree crown, such as loss of dominant shoots and damaged leaves/shoots or shoots, affects the condition of crown density. Density includes the number of plant organs that form a crown, which means the amount of sunlight blocked from entering the forest floor. So crown density represents the percentage of the total light blocked by the trees [12].

CEC is one of the chemical properties of soil closely related to the availability of nutrients for plants and is an indicator of soil fertility. CEC is influenced by clay content, clay type, and organic
matter content. Soil CEC describes soil cations such as Ca, Mg, Na and can be exchanged and absorbed by plant roots [13]. The CEC values shown in Table 1 explain that the CEC conditions in the mangrove forest have not changed. Soil with a high CEC can absorb and provide nutrients better than soil with a low CEC. Because the nutrients are present in the colloid absorption complex, these nutrients are not easily washed off by water [14].

Changes in mangrove forest biodiversity in Figure 1 show that the condition of mangrove forest biodiversity in the East Lampung Regency has decreased, although only slightly. Tree species diversity often affects tree growth positively [15]. The high diversity value reflects the stability of the growth of a community and helps the forest maintain the ecological balance [16]. Furthermore, high stability indicates a higher ability to deal with disturbances [17]. However, in the mangrove forest in East Lampung Regency, the species found in the location are only limited to one or several species in each observation location. This causes the low value of flora biodiversity.

3.2. Classical Assumption Test

Before performing the data regression analysis test, it is necessary to test the deviation of the classical assumptions; namely, the regression model must be free from multicollinearity, heteroscedasticity, and normality. The test for the deviation of the classical assumption is carried out using the SPSS 20 program, while the results of the classical assumption test are as follows:

3.2.1. Multicollinearity Test. Multicollinearity test is a test used to determine whether the independent variables contained in the model have a perfect relationship [18]. Symptoms of multicollinearity can be seen from the results of the Collinearity statistic. A VIF result greater than ten (VIF>10) and a tolerance value less than 0.01 indicate the presence of multicollinearity symptoms.

| Table 2. Multicollinearity test on the first and second measurements of each indicator of mangrove forest health |
|-----------------|-----------------|-----------------|
| Independent Variable | 1st Measurement | 2nd measurement |
|                  | Collinearity Statistics |                  |
|                  | Tolerance | VIF | Tolerance | VIF |
| Tree Damage      | 0.612     | 1,633 | 0.337     | 2,965 |
| Crown Condition  | 0.643     | 1,556 | 0.324     | 3,083 |
| CEC              | 0.517     | 1,936 | 0.465     | 2,152 |
| Biodiversity     | 0.418     | 2,395 | 0.451     | 2,216 |

The results of the multicollinearity test (Table 2) using the SPSS 20 program show that all VIF values are lower than ten (VIF <10) and the tolerance value shows a number greater than 0.01, it can be concluded that in this regression model, there is no there are signs of multicollinearity. The significance level of 0.00 ≤ 0.05 means that the X variable significantly affects the Y variable.

3.2.2. Heteroscedasticity Test. A good regression model is that there is no heteroscedasticity. One of the tests to determine this heteroscedasticity is to look at the spread of the residual variance [19]. Therefore, a heteroscedasticity test is carried out to determine whether there is an inequality of variance from the residual of one observation to another observation in a regression model. One of the heteroscedasticity tests was carried out using the Glejser method using SPSS assistance. The results of the test are shown in Table 3.
Table 3. Heteroscedasticity test in the first and second measurements of each indicator of mangrove forest health

| Independent Variable | 1st Measurement | 2nd measurement |
|----------------------|-----------------|-----------------|
|                      | Value Significance | Value Significance |
| Tree Damage          | 0.731           | 0.570           |
| Crown Condition      | 0.972           | 0.537           |
| CEC                  | 0.439           | 0.276           |
| Biodiversity         | 0.630           | 0.585           |

Based on the table above, it is known that the significant value (sig.) of each variable in the first and second measurements is more than 0.05, so according to the basis for decision making in the Glejser test, it can be concluded that there is no symptom of heteroscedasticity in the regression model.

3.2.3. Normality test. Testing the normality assumption using the Kolmogorov-Smirnov statistical test seen from the value shown if it exceeds sig > 0.5, then it fulfills the assumption. The results of the normality test are shown in table 4.

Table 4. Normality test of the first measurement and the second measurement of each indicator of mangrove forest health

|                  | 1st Measurement | 2nd measurement |
|------------------|-----------------|-----------------|
|                  | Unstandardized Residual | Unstandardized Residual |
| N                | 6               | 6               |
| mean             | 0E-7            | 0E-7            |
| Normal Parameters |                 |                 |
| Std. Deviation   |                 |                 |
| Absolute         | .01997442       | .30487518       |
| Most Extreme Differences |             |                 |
| Positive         | .272            | .263            |
| negative         | -186            | -160            |
| Kolmogorov Smirnov Z |              |                 |
| asymp. Sig. (2-tailed) | .665        | .645            |
|                  | .768            | .799            |

Based on the SPSS output table (Table 4), it is known that the significant value of Asymp. Sig (2-tailed) is 0.768 in the first measurement and 0.799 in the second measurement, where the significance value is more significant than 0.05. So, according to the basis for decision making in the Kolmogorov-Smirnov normality test above, it can be concluded that the data are typically distributed. Thus, the assumptions or requirements for normality in the regression model have been met.

3.3. Results of Multiple Linear Regression Analysis on Internal Factors of Forest Health
The effect of independent variables (tree damage, crown condition, biodiversity, and CEC) on the dependent variable (mangrove forest health) can be determined by using multiple linear regression analysis. Based on the results for more details regarding the regression analysis results using the SPSS version 20 program on mangrove forests in East Lampung Regency, it can be seen in Table 5.

Table 5. Regression analysis on the effect of independent variables on the dependent variable in the first measurement in the Mangrove Forest, East Lampung Regency
Based on the results of data analysis obtained in table 5, the following regression equation is obtained:

\[ Y = 1,390 + X10,249 + X20,169 + X30,175 + X40,357 \]

The regression analysis results showed that the tree damage factor (X1) was the most influential compared to other forest health factors. This is indicated by the value of the regression coefficient on the more excellent tree damage factor. The correlation coefficient (R) value obtained in this study is 0.983, or close to 1. This indicates that the relationship between Y and X is relatively close. This shows that the factors that affect forest health (tree damage, crown damage, CEC, and biodiversity) have a relatively immediate effect on the health value of mangrove forests.

The coefficient of determination (R2) of 0.980 means that the combined effect of tree damage, crown damage, CEC, and biodiversity on forest health can reach 98 percent. More than that, 2 percent is influenced by other factors not included in the analysis model. The larger R2 shows that the estimate will be closer to the actual reality [20]. Based on the study results, it can be concluded that the value (\( \alpha = 0.05 \) > 0.008. This means that simultaneously or together, the independent variables (tree damage, crown damage, CEC, and biodiversity) affect the dependent variable (mangrove forest health) in mangrove forests in the Coastal Region of East Lampung Regency at the level of  = 5%.

**Table 6.** The regression analysis results on the effect of the independent variable on the dependent variable in the second measurement in the Mangrove Forest, East Lampung Regency

| No. | Variable        | Regression Coefficient | Partial Test | Simultaneous test |
|-----|----------------|------------------------|--------------|------------------|
|     |                | B          | T  | Sign | F     | Sign |
| 1   | Constant       | 1,228      | 9,054* | 0.070 | 19,884 | 0.018b |
| 2   | Tree damage (X1) | 0.604      | 21,843* | 0.041 |         |       |
| 3   | Crown Condition (X2) | 0.169      | 4,400* | 0.142 |         |       |
| 4   | CEC soil (X3)  | 0.175      | 16,547* | 0.022 |         |       |
| 5   | Biodiversity    | 0.357      | 14,451* | 0.094 |         |       |

Coefficient of Determination (R2) = 0.993

R value = 0.997*  

Information:  
* = real effect  
* = no real effect

Based on the results of the analysis of the second measurement data obtained in Table 6, the following regression equation is obtained:

\[ Y = 1,228 + X10,604 + X20,169 + X30,175 + X40,357 \]

(3)

The regression results obtained in the second measurement show that the tree damage factor still plays the most crucial role in its influence on forest health. This is indicated by the value of the
regression coefficient on the more excellent tree damage factor. The correlation coefficient (R) value obtained in this study is 0.997, or close to 1. This indicates that the relationship between Y and X is relatively close and increased compared to the value of the correlation coefficient in the first measurement. The coefficient of determination (R2) of 0.993 means that the combined effect of tree damage, crown damage, CEC, and biodiversity on forest health can reach 99.3 percent.

3.4. Regression Coefficient

3.4.1. Tree Damage/CLI (X1). Based on the regression analysis results on the first measurement, it shows that the regression coefficient value on tree damage is 0.249 with a significant level of 0.021 (<0.05). Meanwhile, it is not much different in the second measurement, which shows the regression coefficient value of 0.604 with a significant level of 0.041 (<0.05). The regression coefficient values from the two measurements indicate that different tree damage/CLI will produce different forest health values because these results indicate that tree damage plays a vital role in improving the health of mangrove forests obtained from the two measurements. This shows that the trees that make up the forest stand must be in a healthy condition so that the health condition of the conservation forest is healthy. Furthermore, the condition of the damaged tree will affect the growth of the tree. Therefore, tree damage is significant to know as an early warning and will provide information about the flexibility and sustainability of the forest [21]. Symptoms of tree damage can be seen from the shape, size, color, and texture [22].

The difference in the value of the regression coefficient in the first and second measurements shows that an increase in mangrove forest damage by 1% will increase the value of forest health by as much as the regression coefficient value of each measurement. Tree damage can be caused by pests and pathogens so that it has an impact on declining forest health [23]. The type of damage generally found at the research site is in the leaves or shoots caused by pests and diseases. Damage to leaves can inhibit the photosynthesis process so that it can inhibit plant growth [24].

3.4.2. Crown Condition/VCR (X2). The regression analysis results on the first measurement show that the regression coefficient value is 0.216 with a significant level of 0.022 (<0.05). The significant value of the first measurement indicates that there is an influence of the condition of crown damage on the health of the mangrove forest. The condition of the tree crown will significantly affect the photosynthesis process. A broad and dense crown will support good tree growth because if the crown conditions are good, the photosynthesis process will also take place well. On the other hand, if the tree crown is damaged, then the nutrients needed for photosynthetic plants will be inhibited.

In the second measurement, the regression coefficient value obtained was 0.169 with a significant level of 0.142 (> 0.05). The results of the significant value of the second measurement showed that the crown damage factor had an insignificant effect on the health of mangrove forests. This showed different results from the first measurement. This condition is thought to occur because there are other factors such as nutrients, the environment, and others that help the tree's growth so that the individual needs of the tree are not significantly affected by the condition of the crown. The condition of trees naturally can be caused by temperature, humidity, climate, nutrients, air pollution, availability of oxygen and light [25].

3.4.3. Cation Exchange Capacity/CEC (X3). The regression analysis results on the first measurement showed that the regression coefficient value was 0.007 with a significant level of 0.027 (<0.05). Meanwhile, it is not much different in the second measurement, which shows the regression coefficient value of 0.175 with a significant level of 0.022 (<0.05). The regression coefficient values of the two measurements indicate that different soil CEC will produce different forest health values because these results indicate that soil CEC plays a vital role in improving the health of mangrove forests obtained from the two measurements. Soil with high CEC can absorb and provide
nutrients better than soil with low CEC [14]. The nutrients contained in the colloid absorption complex are not easily washed off by water.

3.4.4 Biodiversity (X4). The regression analysis results on the first measurement show that the regression coefficient value is 0.007 with a significant level of 0.080 (> 0.05). Meanwhile, it is not much different in the second measurement, which shows the regression coefficient value of 0.357 with a significant level of 0.094 (> 0.05). The regression coefficient values from both measurements indicate that there is no effect of biodiversity on the health of mangrove forests. Biodiversity indicators do not affect predictably because each cluster plot on average only has one or a few types of mangroves, so it does not show any species diversity when assessed in each of the observational clusters.

4. Conclusion
The level of forest health managed by the community is influenced by several factors, including internal and external factors. Internal factors that affect the level of forest health in the first measurement are the vitality indicator (tree damage/Cluster Plot Index-CLI) and the site quality indicator (Cation Exchange Capacity-CEC). Meanwhile, in the second measurement, there was a change in the canopy condition parameters, which did not significantly affect forest health. This condition is thought to occur because other factors such as nutrients, the environment, and others help the tree's growth so that the individual needs of the tree are not significantly affected by the condition crown. For this reason, it is necessary to carry out appropriate management so that these factors are maintained so that the health condition of the forest remains in good condition.

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