Forest health study in efforts to preserve community forest agroforestry patterns in Kubu Batu Village, Gedong Tataan District, Pesawaran Regency, Lampung Province

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Abstract. The agroforestry pattern community forest in Kubu Batu Village, Gedong Tataan District, Pesawaran Regency, Lampung Province has essential values for the community, both economically, ecologically, and socially. Therefore, to ensure the sustainability of the community forest, a forest health assessment is carried out. Forest health assessment is one of the criteria for achieving community forest sustainability. This study aims to determine the condition (status) and ecological factors that affect the health level of community forests using agroforestry patterns in Kubu Batu Village, Gedong Tataan District, Pesawaran Regency, Lampung Province. The research methods used are the Forest Health Monitoring method to measure forest health with the Forest Health Assessment Information System (SIPUT) and sperm rank correlation to determine the relationship between ecological factors and the health level community forests using agroforestry patterns. The results showed the condition (status) of community forest health in agroforestry patterns with good categories in cluster plots 2, 4, 5, and 6, moderate categories in cluster plots 1 and 7, and bad categories in cluster plots 3. Strongly positive/unidirectional agroforestry patterns are the crown condition and tree species diversity. This condition illustrates that it preserves community forests using agroforestry patterns in Kubu Batu Village is necessary to focus tree species diversity attention on tree crown parameters. Thus, the health status of community forest agroforestry patterns in Kubu Batu Village is good. This proves that the people there have made efforts to maintain the sustainability of their community forests.

1. Introduction
Community forests are forests built on owned land by applying simple cultivation techniques [1]. Community forests have become an alternative in efforts to develop forest land management. In addition, community forests have essential values for people's lives, namely providing benefits both ecologically, economically, and socially [2]. Community forest management is mainly done by applying agroforestry patterns. Community forest management base on agroforestry patterns inseparable from the community's motivation to obtain these ecologically, economic, and social benefits more optimally.

Applying agroforestry patterns in community forest lands is an integrated land use management strategy [3]. One of the implementations is the agroforestry pattern community forest in Kubu Batu Village which is of significant value because it provides benefits in the form of employment, food
sources, sources of income for farmers, protection of critical land, preventing erosion and flooding, and maintaining the hydrological cycle to maintain water resources for subsistence and agricultural activities. However, based on the importance of the existence of community forests using agroforestry patterns, its sustainability needs to be maintained so that the benefits can be felt sustainably.

Preserving community forests is also a principle of community forest management in Indonesia [4]. The conservation of community forests using agroforestry patterns can support the maintenance of the existing forest area. Therefore, the sustainability of community forests also needs to be guaranteed with better management efforts. One way that needs to be done is by paying attention to the health condition of the community forests. According to Pangestu et al. (2020), forest health is one of the indicators for achieving forest sustainability [5]. Therefore, monitoring forest health conditions will be critical in managing forests in the long term [6]. Through forest health assessment, it is an effort to control the level of forest damage to ensure that the functions and benefits of community forests are maintained sustainably [7].

Community forest health monitoring based on the Forest Health Monitoring (FHM) method is carried out by assessing the ecological indicators of forest health. However, the measured forest ecosystem health indicators differ depending on the forest management efforts to be achieved [8]. Therefore, the health condition of community forests in the region is influenced differently by each parameter of forest health indicators. Therefore, the research conducted in the community forest using agroforestry patterns in Kubu Batu Village aims to determine the health condition and how the influence of ecological parameters indicator affects the health condition of the forest. The benefit is that it can provide information for farmers to manage their community forests better.

2. Research methodology

2.1. Time and location of research
This research was conducted from December 2020-January 2021. The research location is community forest land in the Kubu Batu village belonging to the Satria Rimba Forest Farmers Group (Gapoktan) located in Way Khilau District, Pesawaran Regency, Lampung Province.

2.2. Research tools and objects
The tools used consisted of a tally sheet, magic card (tree canopy density and transparency scale card), forest health book, roller meter, meter tape (150 cm), Global Positioning System (GPS), compass, binoculars, haga meter, and digital camera, permanent markers, colored mica plastic, tacks, and paralon (1.5 inches). While the research material is a community forest stands with agroforestry patterns in Kubu Batu Village.

2.3. Data collection
Data collection on community forest health indicators was carried out using FHM method. Based on the FHM method, the data was carried out by making FHM cluster plots. The FHM cluster plots made in this study were 7 clusters of FHM plots considering that the data samples were able to represent the population based on the area of the sampling area. Using the method, the data was collected in forest health ecological indicators [9]. The data on community forest ecological indicators collected include productivity, vitality, and biodiversity [10]. Each ecological indicator is measured through different measurement parameters.

In the measurement of productivity, it is seen from tree growth through the value of the base area (LBDS). The base area of a tree trunk is measured at the height of 1.3 meters to be expressed as $LBDS = \frac{1}{4\pi} (dbh)^2$ [11]. The vitality measurement parameters consisted of tree damage conditions and canopy conditions [12], targeted by damage and appearance indexes (Cluster plot Level Index-CLI and Visual Crown Ratio-VCR). Meanwhile, the biodiversity indicator is measured by a parameter in the form of a species diversity index value ($H^\prime$ tree) [13].
2.4. Data analysis

2.4.1. Assessment of community forest health condition. Assessment of community forest health is interpreted by the final score of community forest health. The calculation of the final value of community forest health is carried out by multiplying the weighted value with each community forest health indicator [4].

\[ \text{NKH} = \sum (\text{NT} \times \text{NS}) \]  

2.4.2. Assessment of the relationship of ecological indicators to community forests. To determine the relationship of each parameter of ecological indicators with the health condition of community forests. First, Spearman's rank analysis was carried out. This statistical test tool is used because the Spearman rank correlation can measure the relationship between two variables [14]. In addition, the variable in the Spearman rank correlation does not have to be normally distributed. Hence, they are not sensitive to extreme values [15]. In the Spearman rank analysis, only data in the ordinal form is needed because the analysis on the Spearman rank is based on the rank value for each variable [16]. Then forest health conditions and each parameter of ecological indicators need to be categorized and then given a score so that it is possible to do correlation analysis.

3. Results and discussions

3.1. Assessment of health status of community forest agroforestry patterns

The community forest health assessment results of the agroforestry pattern in Kubu Batu Village based on the use of three ecological indicators, namely productivity, vitality, and biodiversity, show the community forest health category for each cluster plot. In addition, the assessment results showed that the condition of forest health in each cluster plot of FHM that was made showed different conditions. In detail, the final results of the agroforestry pattern community forest health assessment are presented in Table 1.

| FHM Plot Cluster | LBDS (m²) | VCR | CLI | H’ Tree | NKHr | Category |
|------------------|-----------|-----|-----|---------|------|----------|
| 1                | 0.88      | 2.84| 2.84| 0.89    | 5.47 | Moderate |
| 2                | 0.91      | 3.14| 3.32| 1.06    | 6.6  | Good     |
| 3                | 0.55      | 2.77| 3.60| 0.60    | 1.98 | Bad      |
| 4                | 0.63      | 3.36| 2.22| 1.33    | 7.97 | Good     |
| 5                | 0.71      | 3.37| 2.93| 1.06    | 6.91 | Good     |
| 6                | 0.44      | 3.32| 2.71| 1.59    | 6.48 | Good     |
| 7                | 0.38      | 3.21| 2.64| 1.19    | 5.21 | Moderate |

The community forest health condition category is categorized into three categories: good, moderate, and bad. The calculated community forest health threshold value states that a value of (5.98-7.97) is in a good category; a value of (3.99-5.97) is in the moderate category, and the value of (1.98-3.98) is categorized as bad. Based on the information obtained from table 1, the health conditions of community forests are in good status, namely land included in the location for making cluster plots (2,4,5,6); categories are currently in cluster plots (1 and 7). Meanwhile, the health condition of the forest is in bad status, namely on land in plot clusters (3 and 7). The categorization is based on the final value of community forest health. The higher the final value of forest health, the better the health condition of community forests. Conversely, the lower the final value of forest health, the lower the level of forest health [17].
The size of the final value of community forest health is strongly influenced by each condition of each parameter of the ecological indicators in the forest land [4]. For example, the health condition of community forests with a good category in cluster plot 4 is due to high productivity, crown, and biodiversity conditions, then supported by a low level of tree damage. The health condition in the moderate category in the cluster plot (1, 2, 5, 6) occurs because there is one parameter of the ecological indicator of forest health that has a low condition. At the same time, the health of community forests is categorized as bad, for example, in cluster plot three due to low productivity, canopy and biodiversity conditions, and high tree damage.

Meanwhile, forest health is reflected in the health of individual trees in the population making up forest stand [18]. So tree damage to a certain extent will gradually affect the growth and development of trees in the forest to affect the health of the forest [19]. Damage to trees can hamper the physiological functions of trees to run optimally, thereby reducing forest productivity. This declining forest productivity is a reflection of the decline in the health of community forests. According to Safe’i et.al. (2015), the level of productivity is essential because the success of forest management can be shown from the high and low productivity [4].

3.2. Analysis of the relationship of ecological factors to forest health conditions

The Spearman rank correlation analysis results show the relationship between ecological factors and forest health levels, a case study in community forests with agroforestry patterns in Kubu Batu Village. This relationship shows how the influence of each ecological factor on the final health condition of the community forest. The results of the Spearman rank analysis are contained in Table 2 below:

| Forest health | Ecological parameter indicators of forest health |
|---------------|-------------------------------------------------|
|               | Productivity (LBDs) | Crowd Condition (VCR) | Tree Damage (CLI) | Biodiversity (H’ Tree) |
| Correlation coefficient | 0.316 | 0.854 | 0.158 | 0.791 |
| Opportunity Value | 0.490 | 0.014* | 0.735 | 0.034* |

Notes: * Significant correlation at the 0.05 level (2-tailed)
Source: Processed from field data

The results presented in table 2 show that the ecological factors that have a significant and robust relationship with the outcome of the health condition of community forests using agroforestry patterns are canopy conditions and biodiversity. Meanwhile, other factors such as productivity and tree damage were not significantly related to the health of community forests.

The results of the Spearman rank test show that the correlation coefficient between canopy conditions and biodiversity with community forest health is 0.854 and 0.791. This illustrates that the relationship that is owned is strong, and the direction of the relationship is positive/unidirectional. According to Sarwono (2006), the correlation number shows a solid relationship because it is in the range of 0.76 - 0.99 (a robust correlation). In addition, the meaning of the direction of the relationship that occurs explains that if the value of the existing canopy condition (VCR) and biodiversity (H’ tree) is getting better, the final value of the health condition of the agroforestry community forest will also be better [20].

As stated by Cavalli and Vinger (2016), canopy conditions significantly affect the process of photosynthesis so that it has a close relationship with the health of trees that make up community forest stands [21]. The canopy is an essential part of the tree where the photosynthesis process produces energy for the tree to grow and develop. The canopy condition was described by five parameters: the survival rate ratio, canopy transparency, crown density, crown diameter, and dieback. Trees with broad and dense canopy conditions will support the tree growth process to be more optimal.
It also means that the tree is in a healthy condition to carry out its physiological functions optimally.

On the other hand, if the canopy is in bad condition, it can indicate a disturbance caused by pests, diseases, or environmental factors [6]. Such conditions cause the photosynthesis process to be hampered so that the energy produced is only tiny and not optimal. This causes tree growth to be hampered, which reduces the health condition of the forest. This influence shows a strong unidirectional relationship between canopy conditions and the health condition of community forests.

Another ecological factor that has a direct and robust relationship with forest health is biodiversity. The higher the level of biodiversity in the community forest, the higher the level of species diversity in the community forest will affect improving the health of the forest. As said by Safe’i et al. (2018), the level of biodiversity is directly proportional to forest flexibility [13]. The higher the level of biodiversity with dense diversity types, the ecological condition in community forests will also be maintained [7]. Community forests with more stable conditions will increase forest resistance to disturbances such as pests and diseases. An excellent ecological balance can help the forest create an environment that is less suitable for disturbing factors such as pests or diseases. This will prevent the development and spread of pests and diseases so that the condition of the trees that make up community forest stands is maintained in good health.

In addition, the increasingly diverse biodiversity provides a more suitable environment for plant growth. The opinion of Fichtner et al. (2018) the richness of tree species has been shown to encourage ecosystem functions such as forest productivity [23]. Another statement from Hutchison et al. (2018) [24] has also mentioned that tree diversity supports tree growth positively and can lead to primary temporal productivity [24]. This happens because better biodiversity helps maintain the quality of the place to grow for plant growth. The benefits of good diversity in a community forest land will help complement each plant's needs in the growth process. Such complementarity in plant communities involves resource partitioning and facilitation to improve growing space requirements [25]. So that the growth of each tree will be more optimal and the health of the forest is maintained.

So overall, based on the research results, to maintain the health condition of community forests in Kubu Batu Village, Gedong Tataan District, Pesawaran Regency, Lampung Province, it is necessary to maintain the diversity of tree species by paying attention to tree canopy parameters. Thus, the community forest's health condition (status) using the agroforestry pattern can be maintained in good condition. This proves that the people there have made efforts to maintain the sustainability of their people's forests. The existence of good forest health conditions proves that efforts to preserve community forests have been carried out correctly. Forests with health conditions are closely related to creating a healthy ecosystem [26]; the health condition of the forest is maintained, and then its sustainability can be maintained.

4. Conclusion

The health condition (status) of community forest agroforestry patterns in Kubu Batu village with good categories in cluster plots 2, 4, 5, and 6, a moderate category in clusters plots 1 and 7, then bad category in cluster plot 3. With the threshold value of community forest health that has been calculated stating the value of (5.98-7.97) in the good category; the value of (3.99-5.97) in the medium category; and the value of (1.98-3.98) is categorized as bad. The ecological factors that have a significant strong positive correlation with the health level of community forests using agroforestry patterns are canopy conditions (VCR) and tree species diversity (H'). The results of the sperm rank test showed that the correlation coefficient between canopy conditions and biodiversity with community forest health was 0.854 and 0.791.

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